



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



The impact of investor attention during COVID-19 on investment in clean energy versus fossil fuel firms

Daoxia Wan^a, Rui Xue^b, Martina Linnenluecke^b, Jinfang Tian^a, Yuli Shan^{c,*}

^a School of Statistics | Shandong University of Finance and Economics, Jinan, Shandong, China

^b Centre for Corporate Sustainability and Environmental Finance, Department of Applied Finance | Macquarie University, Sydney, New South Wales, Australia

^c Integrated Research on Energy, Environment and Society (IREES), Energy and Sustainability Research Institute Groningen | University of Groningen, Groningen, 9747 AG, the Netherlands

ARTICLE INFO

JEL Classifications:

H12
Q43
Q42
G41

Keywords:

COVID-19
Clean energy
Fossil fuel
Investor attention
Green recovery

ABSTRACT

The outbreak of the COVID-19 pandemic has had significant negative impacts on financial markets, including energy stock markets. However, recently proposed and implemented green recovery plans may mean that clean energy firms demonstrate better performance than fossil fuel firms after the pandemic. As more voices call for the update of clean energy, theory on investor attention suggests investors will pay more attention to the potential to invest in clean energy stocks. Using a sample period of eight weeks before and during the pandemic, we find that the negative impact of the outbreak on both clean energy and fossil fuel firms is more significant for fossil fuel firms. Our results further show that during the pandemic there have been improved returns for clean energy firms as a consequence of investor attention, but not for fossil fuel firms. Our findings provide empirical evidence for the advantages of green recovery schemes in influencing financial markets, especially for clean energy stocks. These results suggest there are benefits for further promotion and implementation of green recovery stimulus measures post-pandemic.

1. Introduction

The impact of the COVID-19 pandemic around the world has been dramatic. According to the latest statistics from the World Health Organisation (WHO), there have been more than 25 million COVID-19 cases globally, and the death toll continues to rise (WHO, 2020). The global economic repercussions also continue to be felt, with a large number of countries experiencing significant economic loss in the first quarter of 2020. For example, the economies of China, the United States, the European Union and Japan shrank by 6.8%, 4.8%, 3.8% and 3.4%, respectively. Erken et al. (2020) estimate that the global economy will shrink by 4.1% in 2020.

Although the ultimate impact of COVID-19 on the global economy remains unknown, the uncertainty has already had negative consequences for the energy market. The latest Global Energy Review from the International Energy Agency (IEA) reports that global energy demand fell by 3.8% in the first three months of 2020 (IEA, 2020). Interestingly, while the demand for coal, oil and natural gas has dropped, the demand for renewable energy has increased. For example, Iberdrola, a leading clean energy company, has

* Corresponding author.

E-mail addresses: wandaoxia858@163.com (D. Wan), rui.xue@mq.edu.au (R. Xue), martina.linnenluecke@mq.edu.au (M. Linnenluecke), tianjinfang@126.com (J. Tian), y.shan@rug.nl (Y. Shan).

<https://doi.org/10.1016/j.frl.2021.101955>

Received 22 September 2020; Received in revised form 17 November 2020; Accepted 30 January 2021

Available online 2 February 2021

1544-6123/© 2021 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY license

(<http://creativecommons.org/licenses/by/4.0/>).

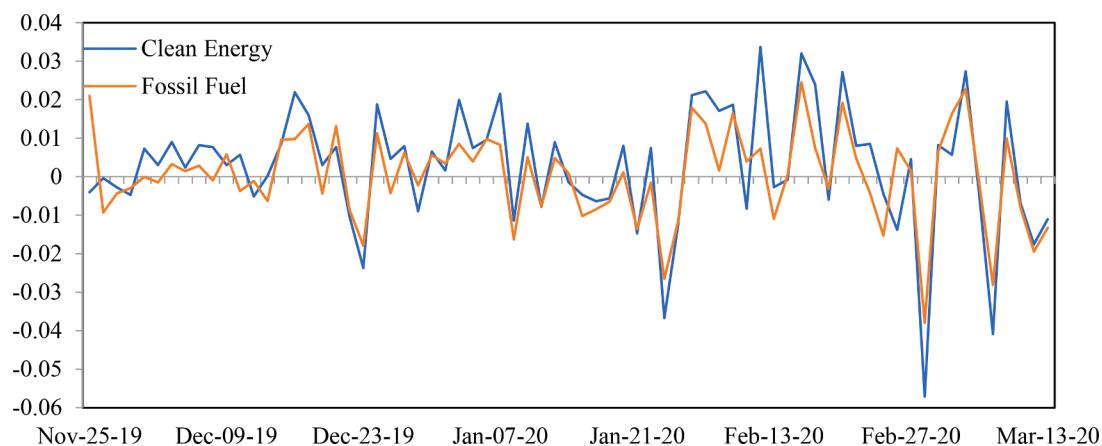


Figure 1. Average daily returns of clean energy and fossil fuel stocks

demonstrated a robust financial performance in the first quarter of this year. As the director of the IEA highlights, “only renewables are holding up during the previously unheard-of slump in electricity use” (Fawthrop, 2020).

The financial markets have also been heavily impacted by the outbreak of the pandemic (Zhang et al., 2020; Goodell, 2020) and, in turn, the energy stock market has fluctuated during the crisis. However, with “green recovery” stimulus measures being introduced in some countries (Nicolás, 2020), renewable energy firms have experienced the pandemic somewhat differently. More voices are calling for the need to rapidly transition to a clean energy future, which suggests investors will pay more attention to the potential to invest in clean energy stocks. This hypothesis is supported by theory on investor attention (Barber and Odean, 2008; Zhang and Wang, 2015) and the adaptive markets hypothesis (Lo, 2005, 2012), which propose that investors are information-intensive and will pay more attention to event-related stocks, adapting their investment strategies to new market patterns when an unexpected event occurs.

Prior research has documented the importance of investor attention to the stability of stock markets (Da et al., 2015; Han et al., 2017; Qadan and Nama, 2018; Li et al., 2019). The disruptive forces of the COVID-19 crisis have shifted public attention towards the potential for a green recovery and so green investments are attracting more investor attention. A comparison between the financial performance of clean energy and fossil fuel firms is timely and likely to have important practical implications.

Using Chinese listed energy firms as the research setting, this paper analyses and compares the financial performance of clean energy and fossil fuel firms. We further examine investor attention to both types of firms during the period of the pandemic. Overall, our results show that clean energy firms have outperformed fossil fuel firms during the pandemic in our study period. Although the impact of COVID-19 on firms’ financial performance is negative for both types of firms, the negative impact has been felt more deeply by fossil fuel firms. Notably and importantly, investor attention to the disruptive effects of COVID-19 has had a significant and positive effect on clean energy stocks’ returns, while a similar effect was not evident for fossil fuel firms. Taken together, our findings suggest superior financial performance for clean energy firms during and after the global crisis and highlight the potential for a green recovery post-pandemic.

2. Data

We select China as the research setting to investigate the impact of COVID-19 on energy firms’ performance. The pandemic in China has slowly receded, allowing for comparison of the impact of COVID-19 on firm performance in distinct phases. The sample period ranges from 25 November 2019 to 16 March 2020, with 20 January 2020 as the event date,¹ and covers a symmetrical window of eight weeks before and after the event date. The sixteen-week trading information enables *ex-ante* and *ex-post* comparisons for the impact of the pandemic on clean energy firms versus fossil fuel firms. For purposes of robustness, we also extend the ending date by sixteen weeks to 6 July 2020 and re-estimate the baseline regressions and the generalised method of moments (GMM) regressions (see Appendix). The results are highly consistent to the key findings.

The classification of clean energy firms and fossil fuel firms is based on the China Energy Industry Classification Standard. Similar to Zhang et al. (2016) and Gao et al. (2020), 91 clean energy firms and 110 fossil fuel firms were included in the sample based on their reported main business activity. We then collected daily stock returns for these 201 firms during the study period. To eliminate the influence of extreme values, we have implemented 1% data winsorization. To control for the impact of the stock market on individual stocks, we also collected the data of stock market returns and volatilities. The stock data were all sourced from the *China Stock Market & Accounting Research* (CSMAR) database.

Following Fang et al. (2020) and Shen et al. (2017), we used web scrapping techniques to construct a variable that reflects investor

¹ On 20 January 2020, the leading expert of the National Health Commission of the People’s Republic of China, Nanshan Zhong, confirmed the human-to-human transmission of COVID-19, hence we treat this as the outbreak date of COVID-19.

Table 1
Descriptive statistics

Firm Type	Before Obs.	Mean	After Obs.	Mean	Difference Mean	t-value
Clean Energy	3487	0.0032	2970	0.0003	0.0029	3.9144***
Fossil Fuel	4288	0.0008	3621	-0.0009	0.0017	3.8918***

Note: *** $p < 0.001$. Difference measures the difference between the returns before and after the pandemic outbreak: Difference = Mean(Before) – Mean(After).

Table 2
Results for regression models

Variables	(1) Clean Energy	(2) Fossil Fuel	(3) Clean Energy	(4) Fossil Fuel	(5) Clean Energy	(6) Fossil Fuel	(7) IV Regression
<i>Intercept</i>	-0.0102† (0.0052)	-0.0049† (0.0027)	0.0005 (0.0008)	-0.0030*** (0.0004)	-0.0079** (0.003)	-0.0030† (0.0016)	
<i>covid</i>	-0.0065† (0.0034)	-0.0040* (0.0017)	-0.0064† (0.0027)	-0.0040*** (0.0010)	0.0003 (0.0014)	-0.0028*** (0.0007)	-0.0488*** (0.0095)
<i>attention</i>	0.0019* (0.0009)	0.0003 (0.0005)					0.0084*** (0.0022)
<i>att_Dummy</i>			0.0069** (0.0022)	0.0013 (0.0008)			
<i>att_coronavirus</i>					0.0049** (0.0016)	-0.0000 (0.0007)	
<i>marketR</i>	2.8251*** (0.1123)	2.0886*** (0.0649)	2.8234*** (0.1116)	2.0792*** (0.0650)	2.8185*** (0.1117)	2.0882*** (0.0644)	0.3360** (0.1180)
<i>marketVol</i>	-0.4374 (0.4459)	0.6719** (0.2118)	0.1944 (0.2776)	0.7894*** (0.1362)	0.1973 (0.2778)	0.8191 (0.5529)	0.6597 (0.5703)
<i>crash1</i>	-0.0052 (0.0031)	-0.0018 (0.0022)	-0.0062† (0.0032)	-0.0021 (0.0021)	-0.0063* (0.0032)	-0.0020 (0.0024)	0.0232*** (0.0038)
<i>crash2</i>	-0.0007 (0.0028)	-0.0071*** (0.0018)	-0.0017 (0.0028)	-0.0074*** (0.0023)	-0.0017 (0.0028)	-0.0074*** (0.0018)	-0.0115*** (0.0034)
<i>crash3</i>	-0.0046 (0.0033)	0.0133*** (0.0017)	-0.0039 (0.0033)	0.0133*** (0.0017)	-0.0042 (0.0034)	0.0134*** (0.0019)	
<i>Firm Effect</i>	YES	YES	YES	YES	YES	YES	YES
Obs.	6457	7909	6457	7909	6457	7909	4928
Adjusted R ²	0.243	0.282	0.243	0.282	0.242	0.282	0.032
F-Statistic	135.57***	199.45***	138.24***	189.06***	148.67***	194.00***	21.15***

Note: † $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. All standard errors (provided in parentheses) were clustered at the firm level. Models (1) and (2) are baseline models, and Models (3) - (6) are robustness tests with alternative measures of explanatory variable *attention*. Model (7) is an IV regression for mitigating endogeneity issue, using daily confirmed cases of COVID-19 as an instrumental variable for *attention*.

attention to the COVID-19 pandemic based on the Baidu search index (BSI)², the most popular web search tool in China. Consistent with existing measurements of attention variables (Han et al., 2017; Qadan and Nama, 2018; Li et al., 2019), we then aggregated the daily BSI of nine COVID-19 related keywords and used the logarithm of the aggregated score to construct the attention variable (*attention*).

3. Data analysis

3.1. Descriptive statistics

Figure 1 illustrates the average daily returns of clean energy and fossil fuel stocks. Overall, the stock returns of clean energy firms are higher than those of fossil fuel firms. It is also apparent that there have been substantial fluctuations in the returns of all energy firms during the study period, suggesting the pandemic has had a significant impact on both clean energy and fossil fuel firms. We seek to understand the degree to which clean energy firms and fossil fuel firms have been affected by the pandemic and the role of attention from investors as a consequence of the disruptive influence of the pandemic.

To further explore whether the returns of clean energy and fossil fuel firms have changed significantly during our study period, we

² Baidu search index is the total searching volume of a key word in China through Baidu search. In this study, we scrapped for nine COVID-19 related key words as the basis for attention to COVID-19, including *coronavirus*, *COVID-19*, *wildlife*, *symptoms of COVID-19*, *news of COVID-19*, *nucleic acid tests*, *pandemic map*, *public health emergency*, and *COVID-19 vaccine*.

conduct t -tests on the returns of clean energy and fossil fuel firms, respectively. Table 1 reports the results. Consistent with the findings from Figure 1, the average daily returns for clean energy firms are higher than those for fossil fuel firms. The results of the t -tests indicate that both clean energy firms and fossil fuel firms have experienced significant drops after the outbreak of the pandemic ($p < .001$). Specifically, the average daily returns of fossil fuel firms have decreased by more than 200%, which is much larger than that of clean energy firms (90.62%). We use regression modelling to now examine the influence of investor attention on the performance of clean energy versus fossil fuel firms.

3.2. Regression modelling

We examine the impact of the pandemic outbreak and investor attention to the pandemic on stock returns of energy firms by the following regression modelling method:

$$R_{it} = \beta_0 + \beta_1 covid + \beta_2 attention_t + \beta_3 marketR_t + \beta_4 marketVol_t + \beta_5 crash1 + \beta_6 crash2 + \beta_7 crash3 + firmFE + \varepsilon_{it}$$

where R_{it} refers to the stock return of firm i at time t , $covid$ is a dummy variable representing the outbreak of COVID-19, and $attention_t$ denotes attention to the pandemic measured by BSI. The remaining five variables are control variables, representing the stock market returns ($marketR_t$), stock market volatilities ($marketVol_t$), and three crashes of the US stock market during the sample period ($crash1$, $crash2$, and $crash3$) respectively. During the period of our study, these three stock market crashes that took place on 9 March, 12 March, and 16 March 2020 substantially influenced the global stock market, and this inevitably affects the returns of energy firms (Mazur et al., 2020). We also control for firm fixed effects. ε is the error term.

Table 2 reports the results for the regression models. Models (1) and (2) are baseline models, with stock returns of clean energy firms and fossil fuel firms as dependent variables, respectively. We also implemented robustness checks with alternative measures of attention in Models (3) - (6). To mitigate endogeneity concerns, we introduced an instrumental variable (IV) and employed the Two-Stage Least Squares (2SLS) regression analysis in Model (7). As displayed in Models (1) and (2), the coefficient of $covid$ is negative and statistically significant for both clean energy and fossil fuel firms, suggesting the pandemic negatively impacted the energy sector. This finding may be largely attributed to the lockdown of many businesses during the pandemic, which has substantially reduced the demand for energy (Chen et al., 2020). However, the impact of COVID-19 is more significant for fossil fuel firms ($p < .05$), while the effect for clean energy firms is just slightly significant at the 10% level. This is consistent with the findings in Section 3.1 that stock returns of fossil fuel firms have suffered a much larger drop than those of clean energy firms.

The results for attention reveal differences for clean energy and fossil fuel firms. The coefficient of attention in Model (1) is significantly positive ($\beta = 0.0019$, $p < .05$), while the figure in Model (2) is not significant at any conventional statistical levels, implying that the attention of investors to COVID-19 has significantly improved the performance of clean energy firms, but has had no significant impact on fossil fuel firms. Moreover, the magnitude of the coefficient for clean energy firms is much higher than that for fossil fuel firms. Taken together, our results indicate a strong and positive impact of investor attention on clean firms' performance during the period of our study. This may be largely due to governments around the world proposing and implementing green recovery schemes as a mean to stimulate national economies post-pandemic (Chen et al., 2020). As a result, clean energy firms are more likely to have benefitted from investor attention to the potential for green recovery from the pandemic, demonstrating a more growth pattern in the post-COVID-19 economic recovery.

To test the robustness and validity of our results, we use two alternative measures of attention to implement robustness checks. First, in Models (3) and (4), we use the medium value of attention as the cut-off point, and code attention as 1 where there is an attention value higher than the medium, and 0 otherwise. Second, in Models (5) and (6), we only use the BSI of "coronavirus", which is the most relevant keyword of the pandemic, to construct the attention variable. The attention variable is thus replaced with att_Dummy and $att_coronavirus$, respectively, and we re-estimate the baseline models with the alternative attention measures. The results in Models (3) - (6) provide evidence that our key findings are robust and valid. Another concern might be reverse causality between investor attention and stock returns of clean energy firms. The superior performance of clean energy stocks might likely attract increased attention from investors. To mitigate this issue, we select daily confirmed cases of COVID-19 as an instrument for attention and entered the IV in the regression. Daily confirmed cases have a high correlation with attention to COVID-19 but are less likely to be associated with the performance of clean energy firms. The coefficient of attention ($\beta = 0.0084$, $p < .001$) in Model (7) suggests that endogeneity is not a concern in our study.

4. Conclusions

This paper has investigated the impact of investor attention to COVID-19 on the financial performance of clean energy firms versus fossil fuel firms. We find that the COVID-19 outbreak negatively impacted both clean energy and fossil fuel firms, but that the negative impact was more significant for fossil fuel firms. Our results further show that investor attention had a significant impact on the performance of clean energy firms, but that this was not the case for fossil fuel firms. We thus contribute to theory on investor attention by highlighting the attention shift in investor behaviour during unexpected crisis and the capitalisation of investor attention. Given that governments around the world are proposing and implementing green recovery plans, it is likely that investor attention has shifted to clean energy investments, possibly driving the superior performance of these firms. Our study provides initial empirical evidence for the positive impact of green recovery schemes on financial markets, particularly on clean energy stocks, and such positive impact will become stronger over long time periods. Prevalent green recovery policies include tax deduction for clean energy, subsidies for electric

Table A1
Results for extended sample periods

Variables	(1) Clean Energy	(2) Fossil Fuel	(3) GMM: Clean Energy	(4) GMM: Fossil Fuel
<i>Intercept</i>	-0.0056 (0.0036)	-0.0049† (0.0020)	-0.0310*** (0.0075)	-0.0076 (0.0045)
<i>covid</i>	-0.0073† (0.0028)	-0.0036* (0.0015)	-0.0244*** (0.0060)	-0.0066* (0.0033)
<i>attention</i>	0.0010* (0.0005)	0.0004 (0.0003)	0.0048*** (0.0012)	0.0008 (0.0007)
<i>marketR</i>	2.4120*** (0.0845)	1.7735*** (0.0229)	2.6258*** (0.0739)	1.7812*** (0.0395)
<i>marketVol</i>	0.2329 (0.1330)	0.3307*** (0.0664)	-0.0461 (0.2689)	0.4137** (0.1467)
<i>crash1</i>	-0.0095** (0.0031)	-0.0030† (0.0013)		
<i>crash2</i>	-0.0023 (0.0028)	-0.0049*** (0.0013)	-0.0013 (0.0014)	-0.0038*** (0.0009)
<i>crash3</i>	-0.0080† (0.0031)	0.0095*** (0.0013)		
<i>Firm Effect</i>	YES	YES	YES	YES
Obs.	12816	14749	9583	9398
Adjusted R ²	0.209	0.322		
F-Statistic	145.27***	992.7***	1703.12****	2098.43***

Note: † $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. All standard errors (provided in parentheses) were clustered at the firm level. Models (1) and (2) are re-estimated baseline regressions for extended sample periods, and Models (3) and (4) are the GMM regressions for extended sample periods.

vehicles, funding for public transport, creating jobs in clean energy industries, etc. The evidence collected in this study supports recommendations for these green recovery stimulus measures around the world.

CRedit authorship contribution statement

Daoxia Wan: Methodology, Writing - review & editing. **Rui Xue:** Conceptualization, Writing - review & editing, Supervision. **Martina Linnenluecke:** Methodology, Writing - review & editing, Supervision. **Jinfang Tian:** Software, Data curation. **Yuli Shan:** Data curation, Visualization, Writing - review & editing.

Acknowledgements

This research was supported by the National Social Science Foundation of China (Grant Number: 20BTJ030). We thank Zhouhao Sha from Shandong University of Finance and Economics for his assistance in the early stage of this research.

Appendix

Table A1

References

- Barber, B.M, Odean, T., 2008. All that glitters: The effect of attention and news on the buying behavior of individual and institutional investors. *The Review of Financial Studies* 21, 785–818.
- Chen, Z., Marin, G., Popp, D., Vona, F., 2020. Green stimulus in a post-pandemic recovery: The role of skills for a resilient recovery. *Environmental and Resource Economics* 76, 901–911.
- Da, Z., Engelberg, J., Gao, P., 2015. The sum of all FEARS investor sentiment and asset prices. *The Review of Financial Studies* 28 (1), 1–32.
- Erken, H., Hayat, R., van der Veen, M., 2020. Global economic outlook: Coronavirus will cause the sharpest contraction since the Great Depression. <https://economics.rabobank.com/publications/2020/june/global-economic-outlook/> accessed June 09, 2020.
- Fang, J., Gozgor, G., Lau, C-K.M., Lu, Z., 2020. The impact of Baidu Index sentiment on the volatility of China's stock markets. *Finance Research Letters* 32, 101099.
- Fawthrop, A., 2020. Is clean energy better placed than fossil fuels to navigate the coronavirus crisis? <https://www.nsenegybusiness.com/features/coronavirus-clean-energy-fossil-fuels/> accessed May 05, 2020.
- Gao, H., Guo, L., Zhang, L., 2020. Does oil price uncertainty affect renewable energy firms' investment? Evidence from listed firms in China. *Finance Research Letters* 33, 101205.
- Goodell, J.W., 2020. COVID-19 and finance: Agendas for future research. *Finance Research Letters* 35, 101512. Article.
- Han, L., Lv, Q., Yin, L., 2017. Can investor attention predict oil prices? *Energy Economics* 66 (8), 547–558.
- IEA, 2020. *Global Energy Review 2020*. <https://www.iea.org/reports/global-energy-review-2020/> accessed April, 2020.
- Lǐ, S., Zhang, H., Yuan, D., 2019. Investor attention and crude oil prices: Evidence from nonlinear Granger causality tests. *Energy Economics* 84, 2–9.
- Lo, A., 2005. Reconciling efficient markets with behavioral finance: The adaptive markets hypothesis. *Journal of Investment Consulting* 31 (1), 21–44.
- Lo, A., 2012. Adaptive markets and the new world order. *Financial Analysts Journal* 68, 18–29.

- Mazur, M., Dang, M., Vega, M., 2020. COVID-19 and the march 2020 stock market crash. Evidence from S&P1500. *Finance Research Letters*, 101690. Article.
- Nicolás, E.S., 2020. Germany ready to lead green recovery post coronavirus. <https://euobserver.com/green-deal/148206> accessed July 28, 2020.
- Qadan, M., Nama, H., 2018. Investor sentiment and the price of oil. *Energy Economics* 69 (1), 42–58.
- Shen, D., Li, X., Zhang, W., 2017. Baidu news coverage and its impacts on order imbalance and large-size trade of Chinese stocks. *Finance Research Letters* 23, 210–216.
- WHO, 2020. Coronavirus disease 2019 situation report-133. World Health Organization, <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/> accessed August 31, 2020.
- Zhang, B., Wang, Y., 2015. Limited attention of individual investors and stock performance: Evidence from ChiNext market. *Economic Modelling* 50, 90–104.
- Zhang, D., Gao, H., Dickinson, D.G., Kutan, A.M., 2016. Free cash flow and overinvestment: Further evidence from Chinese energy firms. *Energy Economics* 58, 116–124.
- Zhang, D., Hu, M., Ji, Q., 2020. Financial markets under the global pandemic of COVID-19. *Finance Research Letters*, 101528. Article.