Financial market analogies of the COVID-19 pandemic:

Evidence from the Dow Jones Industrial Average Index

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Abstract

This paper tries to shed light on the historical analogies of the ongoing COVID-19 pandemic. To that end, we compare the sample distribution of Dow Jones Industrial Average Index returns for a 420-days period (from 2 January 2020 to 31 August 2021), with all historical sample distributions of returns computed using a moving window of 420-days in the 2 January 1900 to 1 May 2018 period. We find that the stock market returns distribution during the pandemic would be similar to several past sub-periods of severe financial crises that evolved into intense recessions, being the sub-sample from 3 June 1986 to 28 January 1988 the most analogous episode to the present situation. Furthermore, we also identify a period from 23 June 1931 to 24 February 1933 where the severity of the crisis overcome the pandemic situation having sharper tail events. Finally, we find that the current stock market CVaR risk is not higher than that observed during the 1930s.

KEYWORDS: COVID-19 pandemic, Financial crisis, Stock Markets, Analogies.

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1. Introduction

After the official declaration of the COVID-19 outbreak as a global pandemic, it has had dramatic impacts on financial markets all over the world (see, e. g, Ashraf, 2020, and Goodell, 2020). This paper tries to shed light on the historical analogies of the current crisis by detecting past sub-periods where the distribution of the Dow Jones Industrial Average (DJIA) Index returns are similar to the most recent sub-sample covering the current COVID-19 outbreak. To that end, we use several tests to assess whether two independent samples come from the same probability distribution.

The remainder of this paper is as follows. Section 2 presents the econometric methodology. Section 3 reports the results of our analysis, and Section 4 concludes.

2. Econometric methodology.

We first detect analogies to the current crisis using the two sample Anderson-Darling test (hereafter, *TSAD*), introduced by Darling (1957) and studied in detail by Pettitt (1976). The *TSAD* test, based on the empirical distribution function, avoids the arbitrary binning of histograms and the small number of entries per bin in the χ^2 test for homogeneity (Cohran, 1952). The *TSAD* test is a refinement of the Kolmogorov-Smirnov test, and it is especially sensitive at the tails of the distribution than near the center or the median, being better capable of detecting very small differences, even between large sample sizes. The null hypothesis that the two sub-samples come from the same continuous distribution is rejected if *TSAD* is larger than the correspondent critical value[1].

As additional evidence for detecting analogies to the current crisis, we use the test proposed by Diebold *et al.* (1998) (*DGT*, hereafter) for comparing densities of subsamples. They suggest a graphical analysis to visually compare the estimated density of the probability integral transformation to a *U*(0,1) density and by computing confidence intervals under the null hypothesis of i.i.d. *U*(0,1).

[1] Under the null hypothesis, *TSAD* converges to the same limiting distribution that the *AD* one-sample test statistic (Pettitt, 1976).

3. Empirical results

We use daily data of DJIA Index returns covering the period 2 January 1900 to 31 August 2021. This series have been provided by Thomson Reuters Datastream.

Given that January 2, 2020, was the first market day after the report detected by the WHO China Country Office (WHO, 2020), we take this date as the beginning of the pandemic on the stock market.

Figure 1 shows the past sub-periods longer than approximately 250-days where the *TSAD* test cannot reject the null hypothesis of equal distribution of stock returns to the last 420-days (from 2 January 2020 to 31 August 2021), with all historical sample distributions of returns computed using a moving window of 420-days in the 2 January 1900 to 1 May 2018 period.

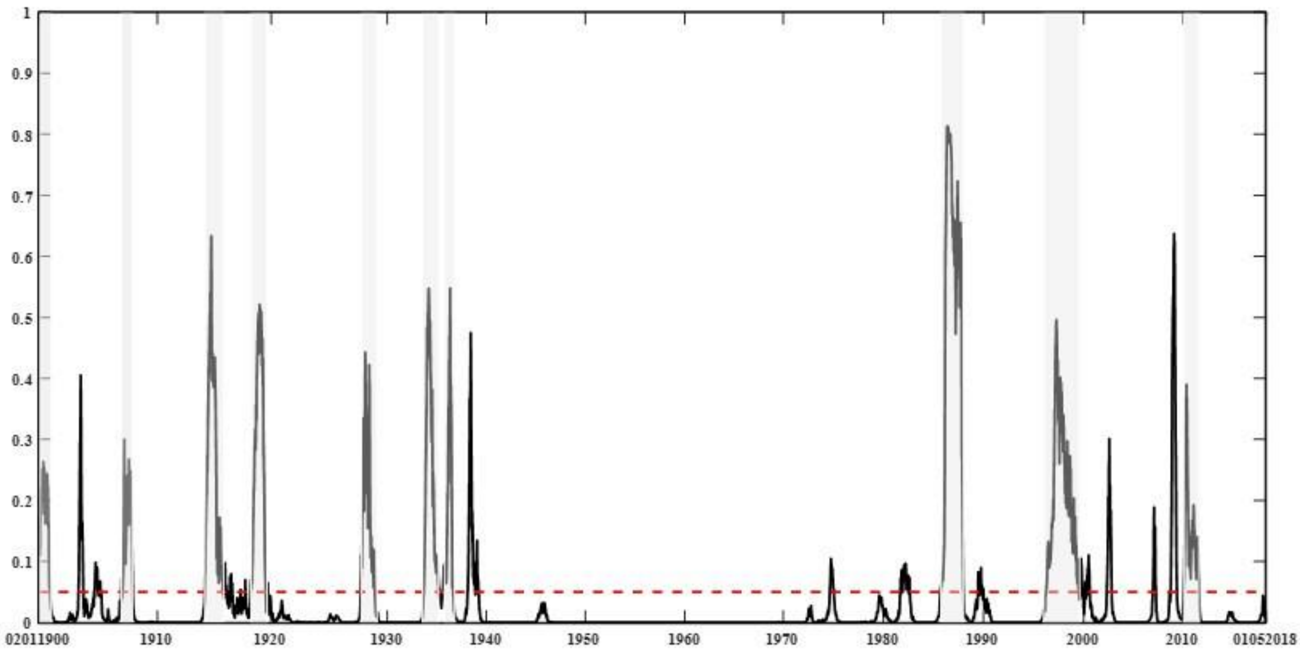

Figure 1: Historical evolution of *p*-values of the *TSAD* test comparing the DJIA returns in the ongoing crisis with past sub-periods. The dashed line corresponds to the significance level of 5%

Table 1 reports the sub-periods of more than 250-days where the *AD* test cannot reject the null hypothesis and we conclude with 95% confidence that the two samples come from the same distribution. The final dates of these periods are also indicated, including the 420-days in the window. As can be seen, we detect analogies with major financial crises (the Panic of 1901 and

1997, the Wall Street Crash of 1929, the Asian financial crisis, the Global Financial and European Debt crises, among others), some of them having severe effects on the real economy.

Table 1. Sub-periods where the *TSAD* test cannot reject the null hypothesis.

Sub-period	Start date of the sub-period	End date of the sub-period	End date of the total sub-period including the 420-days window
I.	2 January 1900	20 December 1900 (293)	26 May 1902 (713)
II.	25 January 1907	30 November 1907 (256)	27 April 1909 (676)
III.	9 January 1914	15 November 1915 (449)	9 April 1917 (869)
IV.	1 April 1918	9 July 1919 (380)	8 December 1920 (800)
V.	15 July 1927	19 September 1928 (353)	23 May 1930 (773)
VI.	12 September 1933	11 March 1935 (371)	6 November 1936 (791)
VII.	21 August 1935	24 August 1936 (256)	29 April 1938 (676)
VIII.	18 September 1985	31 December 1987 (578)	29 August 1989 (998)
IX.	28 March 1996	30 June 1999 (822)	28 February 2001 (1242)
X.	25 January 2010	8 August 2011 (389)	11 April 2013 (809)

Note: In parenthesis, we show the number of days

We applied the graphic framework developed by *DGT* to the sub-periods detected in Table 1 where the *p*-value of the *TSAD* test takes an extreme value (a local maximum, or a local minimum). In all cases, we compare the empirical distribution of our last 420-days sub-sample starting on 2 January 2021 (the ongoing COVID-19 crisis) with the detected historical sub-period returns.

Figure 2, Panel C, shows the histograms of the probability integral transformation corresponding to the sub-sample beginning on 3 June 1986 where the *p*-value of the *TSAD* test takes the absolute maxima; the dashed lines are the binomial confidence bands for a confidence level of 99%. This histogram corresponds to a $U(0,1)$ variable. It suggests that the empirical density corresponding to the last sub-sample running from 2 January 2020 to 31 August 2021 and the density associated with the sub-sample covering from 3 June 1986 to 28 January 1988 are similarly distributed. The histogram obtained using the *DGT* procedure is also close to the uniform in the rest of the local maxima *p*-values (for example, Panels A, B and D).

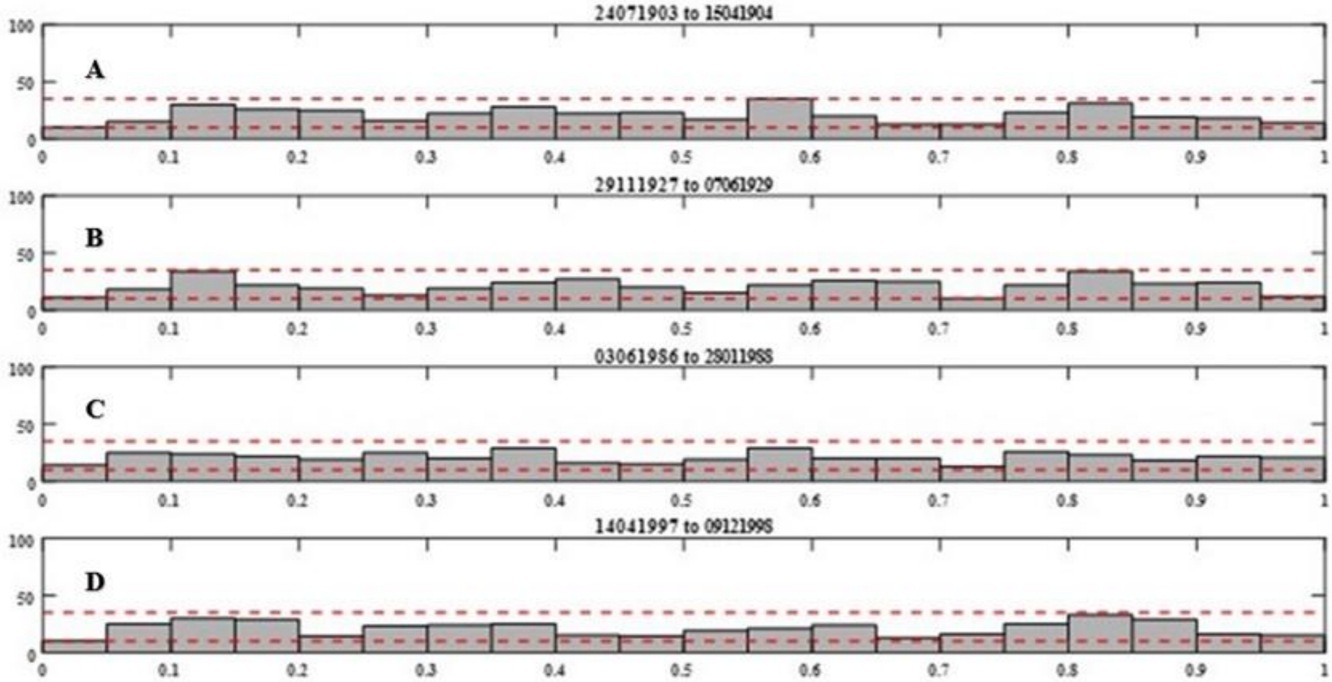

Figure. 2. Histograms of *DGT* test

Now let us consider the histogram where the null is strongly rejected. Although the *TSAD* test does not specify the reason for rejection, the *DGT* test does, and two patterns emerge in the histograms rejecting the uniformity. On the one hand, the *TSAD* test rejection of similarity with the current COVID-19 pandemic could occur because the returns in the sub-sample analysed to have lower volatility, the tail events are less frequent, and the market risk is lower. For instance, Panel A in Figure 3 represents the case of a local minimum of this *p*-value, being the histogram associated with the sub-sample beginning on 18 May 1911, where the *TSAD* test rejects an equal distribution compared to the current COVID-19 episode. In this case, the histogram has a non-uniform inverted U shape, suggesting that the empirical density corresponding to the last sub-sample running from 2 January 2020 to 31 August 2021 has a different density than the sub-sample covering the period from 18 May 1911 to 8 October 1912, since both empirical densities have completely different tails. The pattern shown in the histogram in Panel A of Figure 3 is also present in all the local minimum reached by the *p*-value of the *TSAD* test (for example, Panels C and D) with one exception. This exception corresponds to a global minimum of the *p*-value of the *TSAD* test in Figure 1 and is related to the sub-sample from 23 June 1931 to 24 February 1933, an extremely severe financial crisis. Panel B in Figure 3 shows the U shape of the histogram, suggesting that the tail events are more frequent, and the risk is higher.

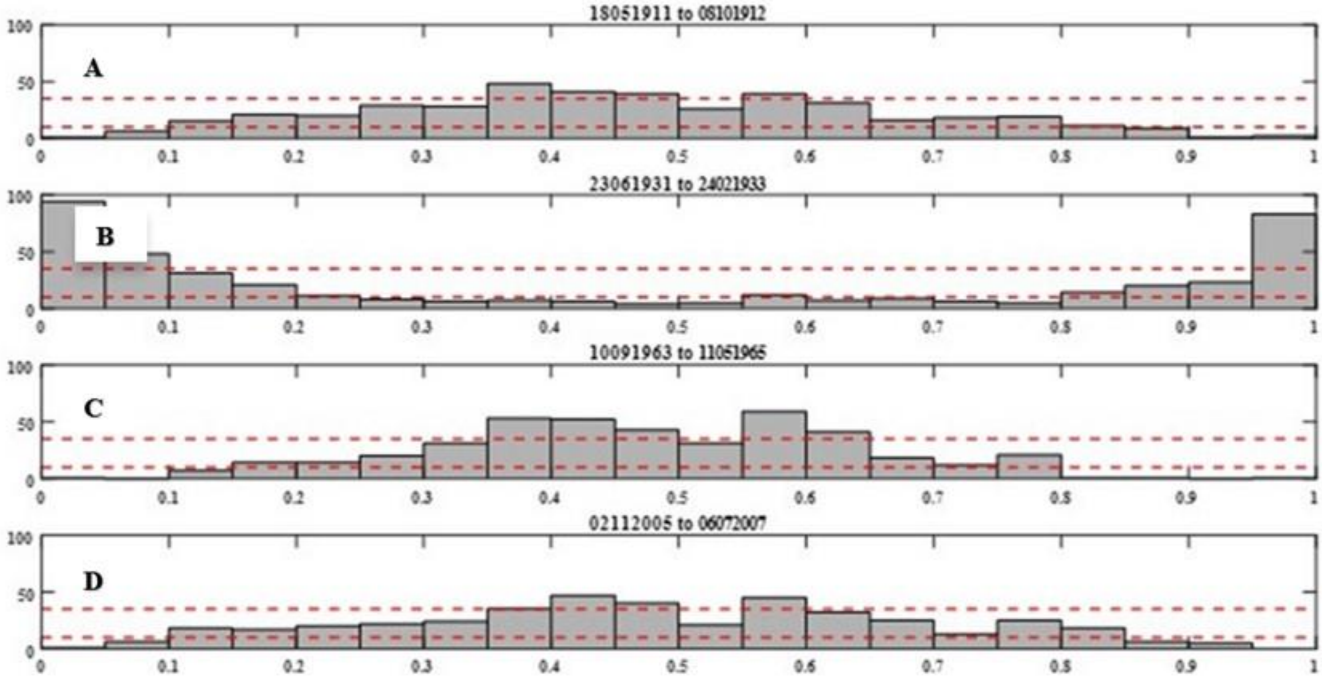

Figure. 3. Histograms of *DGT* test

Figure 4 plots a contour plot for the *DGT* test in all the 420-days moving windows considered. In the graph, the coldest regions (blue) correspond to the lowest bars of the *DGT* statistic and the warmer regions (red) with the largest ones. The sub-periods where the hypothesis of equality of the *TSAD* test suggest that the two samples come from the same distribution correspond to the areas of more balanced colouration (shadow white).

As can be seen, during the current COVID-19 pandemic sub-sample, stock market risk has increased as dark blues predominate in the upper and lower edges of Figure 4. There are wider tails in the profit distributions of the current period than in previous sub-sample (dark blues are in the upper and lower edges), which corresponds with heavier tails in the current sub-sample and therefore with an increased risk. Only in the sub-samples close to the 1930s there has been a higher risk than the current one (red colours appear in the upper and lower edges in Figure 4).

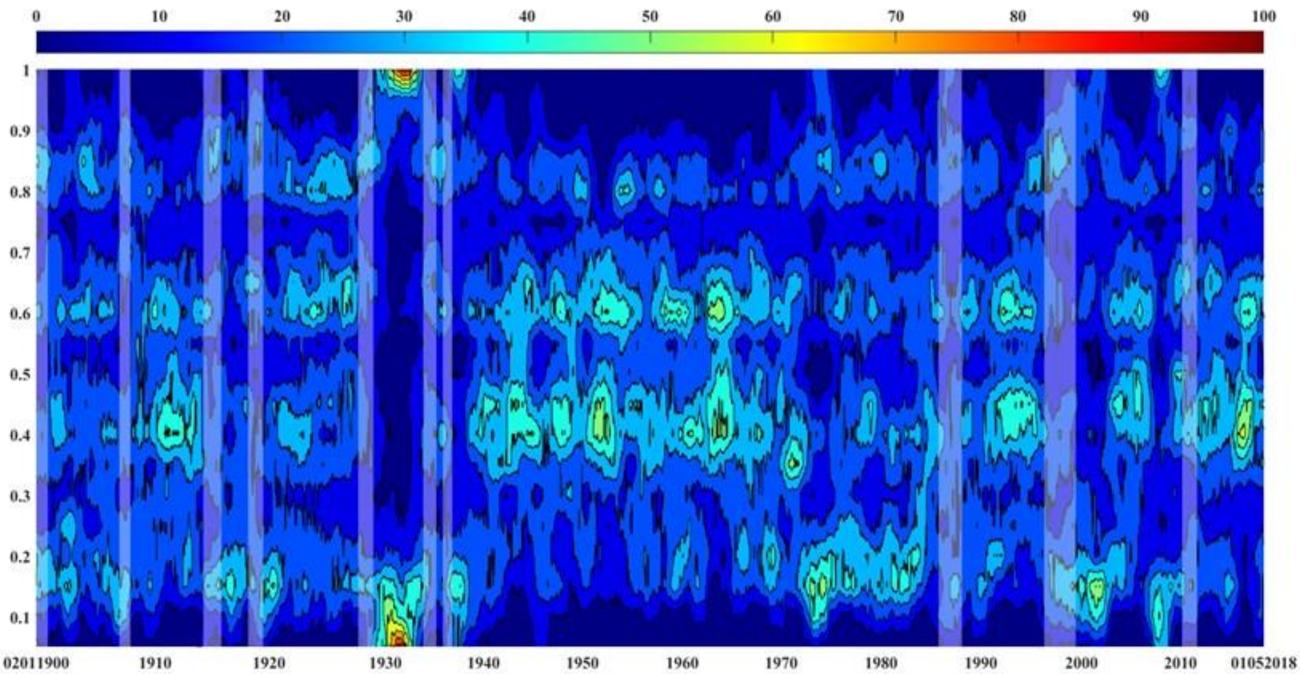

Figure 4. Contour plot in *DGT* test

Finally, we have also compared the historical evolution of market risk with its level during the COVID-19 crisis, using the conditional Value at Risk (CVaR) (see Artzner *et al*., 1999), a risk assessment measure that quantifies the amount of tail risk an investment portfolio has. While VaR_α represents a worst-case loss associated with a probability $1-\alpha$ and a time horizon, $CVaR_\alpha$ is the expected loss L if that worst-case threshold is ever crossed. That is,

$$CVaR_\alpha = E\left[L / L > VaR_\alpha\right]$$

Figure 5 displays the historical behaviour of the estimated one-day 95% CVaR. The horizontal dashed line represents the CVaR corresponding to the 420-days current COVID-19 pandemic sub-sample. As seen, the current market risk assessment has only been exceeded in sub-periods covering the periods 2 April 1928 to 4 November 1929, 29 January 1930 to 24 February 1933, and 3 April 2007 to 6 October 2008. The maxima level of CVaR is reached in the 23 June 1931-24 February 1933 sub-sample during the Great Depression, corresponding with a global minimum of the *p*-value of the *TSAD* test in Figure 1.

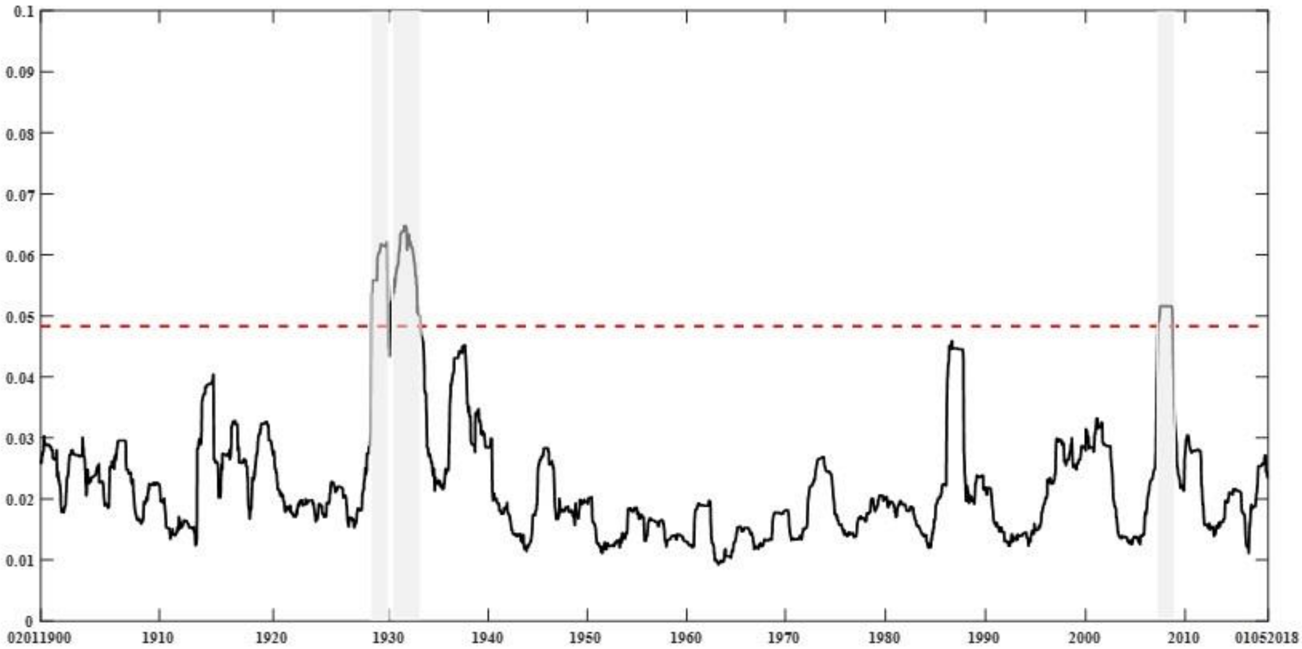

Figure 5. Historical one-day CVaR

4. Conclusion

Comparing stock returns distribution during the 420-days of the COVID-19 pandemic with all historical 420-days returns in the DJIA Index from 1900, we find that the sub-periods that are most similar to the ongoing COVID-19 episode occur persistently in the late nineties and early twenty-first century, suggesting that it may have features in common with similar financial-stress driven recession events in the past. We also show that stock market risk has increased, although this risk is not higher than that recorded during the 1930s, indicating that wide-ranging fiscal, monetary, and financial policies have this time been essential to safeguard economic and financial stability and to prevent the emergence of adverse macro-financial feedback loops.

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References

Artzner, P., Delbaen, J., Ebert, M., and Heath, D. (1999). Coherent measures of risk. Mathematical Finance 9, 203-228.

Ashraf, B. A. (2020). Stock markets' reaction to COVID-19: Cases or fatalities? Research in International Business and Finance 54, 101249.

Cohran, W.G. (1952). The χ^2 Test of Goodness of Fit. The Annals of Mathematical Statistics 23(3), 315-345.

Darling, D.A. (1957). The Kolmogorov-Smirnov, Cramer-von Mises Tests. Annals of Mathematical Statistics 28, 823-838.

Diebold, F., Gunther, T. and Tay, A. (1998). Evaluating density forecasts with applications to financial risk management. International Economic Review 39, 863-883.

Goodell, J. W. (2020). COVID-19 and finance: Agendas for future research. Finance Research Letters 35, 101512.

Pettitt, A.N. (1976). A two-sample Anderson-Darling rank statistic. Biometrika 63, 161-168.

WHO (2020), Novel Coronavirus (2019-nCoV) Situation Report–1 22 January 2020.