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Impact of COVID-19 on stock market efficiency: Evidence from developed countries

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A B S T R A C T

This study investigates the impact of the novel coronavirus (COVID-19) pandemic on stock market efficiency for six hard-hit developed countries, namely, the United States (US), Spain, the United Kingdom (UK), Italy, France, and Germany. Applying the wild bootstrap automatic variance ratio test on daily stock market data from July 29, 2019 to January 25, 2021, it is found that all stock markets used in this study deviate from market efficiency during some periods of the pandemic. Deviations from market efficiency are seen more in the stock markets of the US and UK during the COVID-19 outbreak than in other stock markets. These results are strengthened when a different econometric method, the automatic portmanteau test, is used. The findings of this study indicate an increasing chance for stock price predictions and abnormal returns during the COVID-19 pandemic.

1. Introduction

The novel coronavirus (COVID-19), which was reported as a cluster of cases of pneumonia by the Wuhan Municipal Health Commission on December 31, 2019 in Wuhan City, Hubei Province, China, spread to many regions around the world in a very short time. On March 11, 2020, the World Health Organization (WHO) characterized COVID-19 as a global pandemic (WHO, 2020a) and warned countries to take urgent and aggressive action to stem its spread at a media briefing (WHO, 2020b). Although many countries have taken strict measures, the spread of the COVID-19 pandemic has not yet stopped. As of January 27, 2021, COVID-19 has been detected in a total of 99,864,391 people, and 2,149,700 people from 224 territories have died from COVID-19 (WHO, 2021a).

The COVID-19 pandemic has severely damaged not only human lives but also the global economy and financial markets. While the short-term economic impact of COVID-19 is the limited economic activity resulting from strict quarantine policies, its long-term economic impact is mass unemployment and business failure (Zhang et al., 2020). The International Monetary Fund (2020) reported in *World Economic Outlook* that the global economy is projected to contract by 3 % in 2020 because of the COVID-19 pandemic. The World Bank (2020) forecast a 5.2 % contraction in global gross domestic product (GDP) in *Global Economic Prospects*, and the Organisation of Economic Cooperation and Development (OECD) (2020) forecast a 6% fall in global GDP with a single-hit scenario and a 7.6 % decline with a double-hit scenario due to COVID-19 in *Economic Outlook*. According to Goodell (2020), COVID-19 causes more unprecedented damage to a country's economy than other natural and human-made crises like climate change, nuclear wars, natural disasters, and local tragedies, and it has a relatively wide range of impacts on financial markets. In comparison to the global financial

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crisis of 2008, the COVID-19 pandemic caused more severe and abrupt damage to the global economy. While the 2008 global financial crisis started in the United States (US) and gradually spread to the rest of the world with a significant time delay, the COVID-19 pandemic instantaneously brought the global economy to a standstill by simultaneously disrupting demand and supply lines around the world because of widespread lockdowns. Baker et al. (2020) reported that stock markets were more affected by COVID-19 than any previous infectious disease outbreak. In March 2020, the circuit breaker mechanism, which had not been used for over two decades, was activated four times in 10 days in the US stock market (World Economic Forum, 2020), global stock markets plunged,[1] and oil prices hit the ground.[2]

Stock market efficiency is commonly affected by different occurrences, to different degrees. Machmuddah et al. (2020) stated that corporate actions such as splits, right issues, and warrants can affect stock market efficiency, albeit slowly, while unexpected black swan occurrences such as economic embargoes, boom explosions, mass chaos, and pandemics can trigger very strong one-time impacts in the stock markets. It is a widely accepted concept in behavioral finance that occurrences instigating widespread panic, such as wars, elections, economic, political and financial crises, terrorist events, depressions, bubbles, exchange rate regimes, shocks, crashes, and pandemics, often lead to a breakdown of the efficient market hypothesis by causing asset prices to deviate from their fundamental values (see Kim et al., 2011; Lim et al., 2013; Niemczak and Smith, 2013; Urquhart and Hudson, 2013; Rodriguez et al., 2014; Charles et al., 2015; Khediri and Charfeddine, 2015; Verheyden et al., 2015; Charfeddine and Khediri, 2016; Rahman et al., 2017; Charfeddine et al., 2018; Lalwani and Meshram, 2020). To this end, this study empirically examines the impact of the COVID-19 pandemic on the efficiency of selected stock markets. The findings from this study will go a long way in laying an economic foundation for necessary policy interventions.

Although there are a growing number of studies investigating the empirical impact of the COVID-19 pandemic on financial markets (see, for example, Akhtaruzzaman et al., 2020; Al-Awadhi et al., 2020; Ashraf, 2020; Aslam et al., 2020; Baker et al., 2020; Chowdhury and Abedin, 2020; Ozdurak et al., 2020; Mensi et al., 2020; Sharif et al., 2020; Zhang et al., 2020), only Aslam et al. (2020) and Mensi et al. (2020) investigated the impact of COVID-19 on financial market efficiency. Aslam et al. (2020) examined foreign exchange market efficiency during COVID-19. After using multifractal detrended fluctuation analysis (MF-DFA) on the data of six major currencies—the Australian dollar, the Canadian dollar, the Swiss franc, the euro, the British pound, and the Japanese yen—they reported that foreign exchange market efficiency declined during the COVID-19 pandemic. Mensi et al. (2020) investigated the impact of COVID-19 on the efficiency of the gold and oil markets using asymmetric MF-DFA and found that the gold and oil markets became more inefficient during the COVID-19 pandemic compared to the period preceding COVID-19.

The existing literature provides some useful information about the impact of the COVID-19 pandemic on the efficiency of commodities and foreign exchange markets; however, nothing is known about stock market efficiency. Therefore, this study investigates the impact of the COVID-19 pandemic on stock market efficiency using the wild bootstrap automatic variance ratio (WBAVR) test developed by Kim (2009) on daily stock market data from July 29, 2019 to January 25, 2021 from the six developed countries—the US, Spain, the United Kingdom (UK), Italy, France, and Germany—most hard-hit by the COVID-19 outbreak. The WBAVR test is preferred for use in this study because it provides robust and reliable results against non-normality and conditional heteroskedasticity, which are widely observed in financial data. The WBAVR test results indicate that the COVID-19 outbreak caused deviations from market efficiency for stock markets of all of the developed countries used in this study during some period. Another important finding is that the most deviations from market efficiency that occurred during the COVID-19 pandemic are observed in the US and UK stock markets. For robustness, the analyses were repeated using a different econometric method, the automatic portmanteau test developed by Escanciano and Lobato (2009), and the results of the study are supported.

The contributions of this study to the literature are as follows. First, to the best of our knowledge, this is the first study to investigate the impact of the COVID-19 outbreak on stock market efficiency. Second, this study uses a different econometric method, the WBAVR test, than studies in the existing literature that have investigated the impact of COVID-19 on market efficiency using the MF-DFA method.

The remainder of this study proceeds as follows. The next section explains the methodology. Section 3 provides information about the data. The empirical results are presented and discussed in Section 4. Section 5 includes robustness analysis, and Section 6 concludes.

2. Methodology

In this study, the WBAVR test developed by Kim (2009) is applied to examine the impact of the COVID-19 outbreak on stock market efficiency. Lo and MacKinlay's (1988) variance ratio (VR) test is frequently used in the empirical finance literature to evaluate returns predictability (i.e., market efficiency). However, the VR test reveals unsuccessful results in small samples due to insufficient properties, particularly, under conditional heteroskedasticity, a typical feature of financial time series. Because it requires *ad hoc* choices for lag length and holding period, this also weakens its small-sample properties. Kim (2006) developed the wild bootstrap VR test to improve its small-sample properties, especially under conditional heteroskedasticity. To overcome the problem of choosing lag length or holding period in an *ad hoc* way, Kim (2009) developed the WBAVR test in which the optimal holding period was automatically chosen with a fully data-dependent procedure. Charles et al. (2011) in their study using the Monte Carlo test, stated that the WBAVR test showed quite sufficient small-sample (size and power) properties and was more successful than other VR tests for returns predictability

[1] See https://www.bbc.com/news/51860099.
[2] See https://www.bbc.com/news/business-51796806.

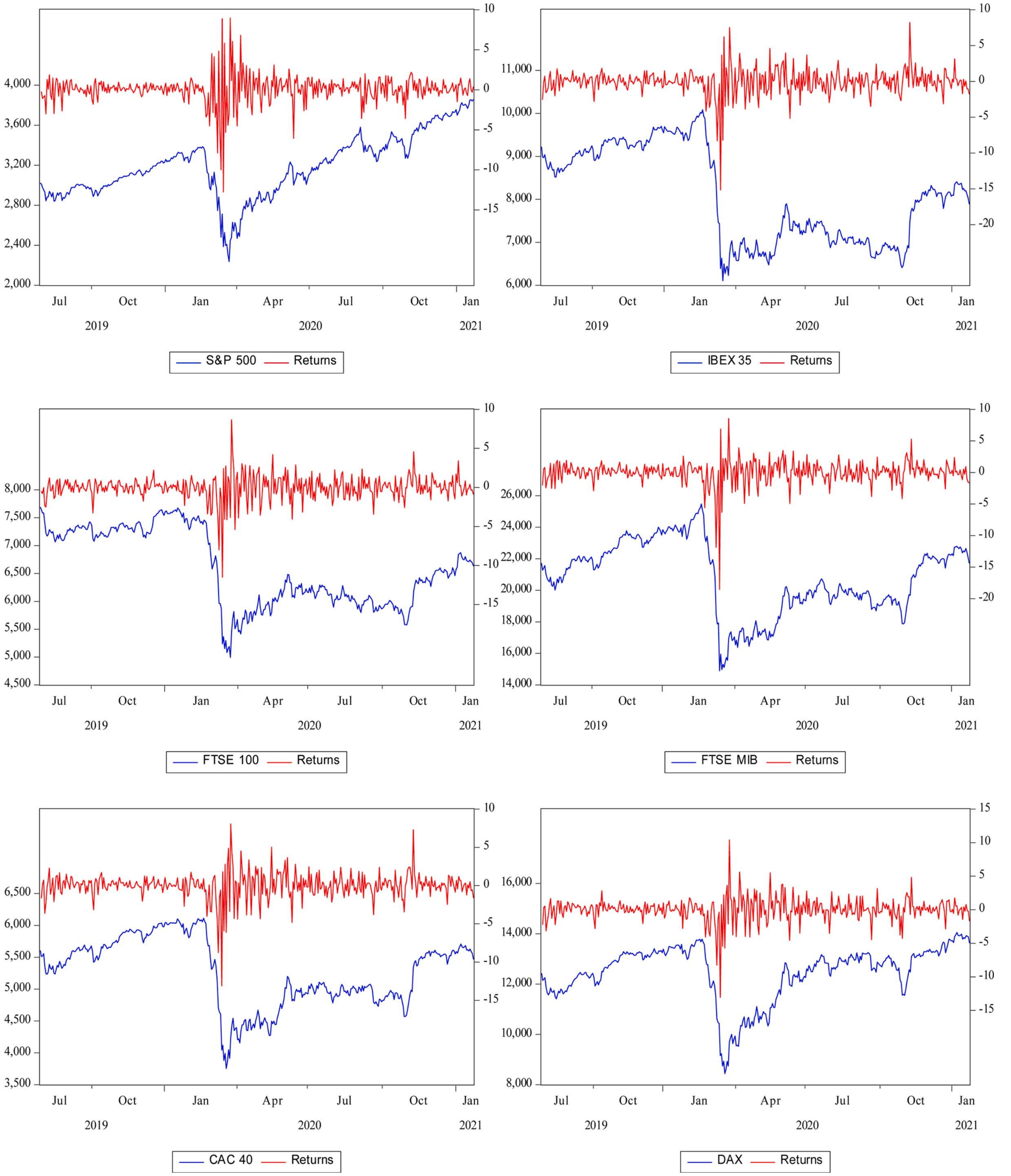

Fig. 1. Graphical presentation of stock market indices.

(or market efficiency). This part of the study briefly presents details about the WBAVR test.

The statistical form of the original VR test is shown as follows:

$$\widehat{\mathrm{VR}}(\mathrm{k}) = 1 + 2\sum_{\mathrm{i}=1}^{\mathrm{k}-1}\left(1 - \frac{\mathrm{i}}{\mathrm{k}}\right)\widehat{\rho}(\mathrm{i}) \quad (1)$$

Table 1
Descriptive Statistics.

	Indices					
	S&P500	IBEX 35	FTSE 100	FTSE MIB	CAC 40	DAX
Mean	0.065	−0.040	−0.039	0.001	−0.006	0.025
Minimum	−12.765	−15.151	−11.512	−18.541	−13.098	−13.055
Maximum	8.968	8.225	8.667	8.549	8.056	10.414
Std. Dev	1.852	1.836	1.600	1.942	1.764	1.792
Skewness	−0.992	−1.481	−1.083	−2.821	−1.267	−0.983
Kurtosis	15.051	17.794	13.458	28.924	14.245	14.607
Jarque–Bera	2336.823***	3623.479***	1796.494***	11057.19***	2114.743***	2171.279***
ADF	−5.081***	−11.438***	−6.844***	−11.671***	−6.711***	−12.028***
ARCH LM	27.910***	7.617***	13.274***	6.487***	11.428***	11.273***

Notes: *** Denote significance at the 1% level. ADF indicates the Augmented Dickey-Fuller unit root test. ARCH LM indicates the Lagrange Multiplier test for Autoregressive Conditional Heteroskedasticity with 10 lags.

where k denotes the holding period. Under the null hypothesis of no returns predictability, a standardized version of Eq. (1) asymptotically follows the standard normal distribution (Lo and MacKinlay, 1988). Choi (1999) proposed the automatic variance ratio (AVR) test in which the holding period is chosen optimally using the fully data-dependent method of Andrews (1991), as the original VR test requires an *ad hoc* holding period choice. Kim (2009) developed the WBAVR test using the wild bootstrap method of Mammen (1993) to overcome the deficiency of Choi's (1999) AVR test of data showing conditional heteroskedasticity. The WBAVR test is performed in the following three stages:

Stage 1: Form a bootstrap sample of size T as $Y_t^* = \eta_t Y_t (t = 1, \ldots, T)$, where η_t is a random variable with zero mean and unit variance;

Stage 2: Calculate $AVR^*(k^*)$, the $AVR(k^*)$ statistic calculated from $\{Y_t^*\}_{t=1}^{T}$; and

Stage 3: Repeat Stage 1 and Stage 2 B times to produce the bootstrapped distribution of the AVR statistic $\{AVR^*(k^*; j)\}_{j=1}^{B}$.

It can be shown that the bootstrap sample $\{Y_t^*\}_{t=1}^{T}$ is serially uncorrelated, while effectively replicating the heteroskedastic structure of asset return Y_t. As a result, the bootstrapped distribution $\{AVR^*(k^*; j)\}_{j=1}^{B}$ provides a small-sample approximation of the sampling distribution of the $AVR(k^*)$ statistic under the null hypothesis.

If the probability value obtained because of the WBAVR test is lower than the value determined as the level of significance (in this study, 10 %), the null hypothesis of no returns predictability is rejected at the value determined as the significance level. In this study, the number of bootstrapped replications, B, is set to 500 as in Charles et al. (2015).

3. Data

In this study, daily data of the stock market indices (i.e., S&P 500, IBEX 35, FTSE 100, FTSE MIB, CAC 40, and DAX) of the six most affected developed countries (i.e., the US, Spain, the UK, Italy, France, and Germany) by the COVID-19 pandemic are used. These countries had about 39 % of the total confirmed cases in the world as of January 27, 2021 (WHO, 2021b). The daily closing prices of stock market indices cover the period from July 29, 2019 to January 25, 2021 were downloaded from www.investing.com website. The returns are calculated as follows:

$$r_{it} = \ln(P_{it}/P_{i(t-1)}) \times 100$$

where ln() indicates the natural logarithm, and P_{it} and $P_{i(t-1)}$ are the closing prices of a given index *i* on day *t* and *t* −1, respectively.

Fig. 1 shows time series plots of daily closing prices and returns of the six indices from July 29, 2019 to January 25, 2021. It is clearly seen that the index prices and returns sharply decreased in March 2020 due to the COVID-19 outbreak. It is also seen that both prices and returns are more volatile during the COVID-19 pandemic. The descriptive statistics of the returns series are reported in Table 1. From the table, it is observed that the average returns of the IBEX 35, FTSE 100, and CAC 40 indices are negative, while the other indices are positive. According to standard deviation values, the FTSE MIB is the most volatile index and the FTSE 100 is the least volatile index for the period under review. As observed in Table 1, all returns series are not normally distributed with negative skewness and excess kurtosis. Furthermore, the non-normality of the returns series is confirmed by Jarque–Bera test statistics. The Augmented Dickey-Fuller unit root test results indicate that all returns series are stationary during the sample period and can be used directly for analysis without further transforms. The LM test of Engle (1982) for the presence of the ARCH effect indicates that all of the returns series show strong conditional heteroskedasticity. The evidence of non-normality and conditional heteroskedasticity suggests that the WBAVR test employed in this study is well-suited for the returns series.

4. Empirical results

In this study, the WBAVR test is applied using the rolling fixed-length sub-sample window method. The rolling sub-sample window method allows us to see time-varying returns predictability (i.e., market efficiency). This method also mitigates data snooping bias

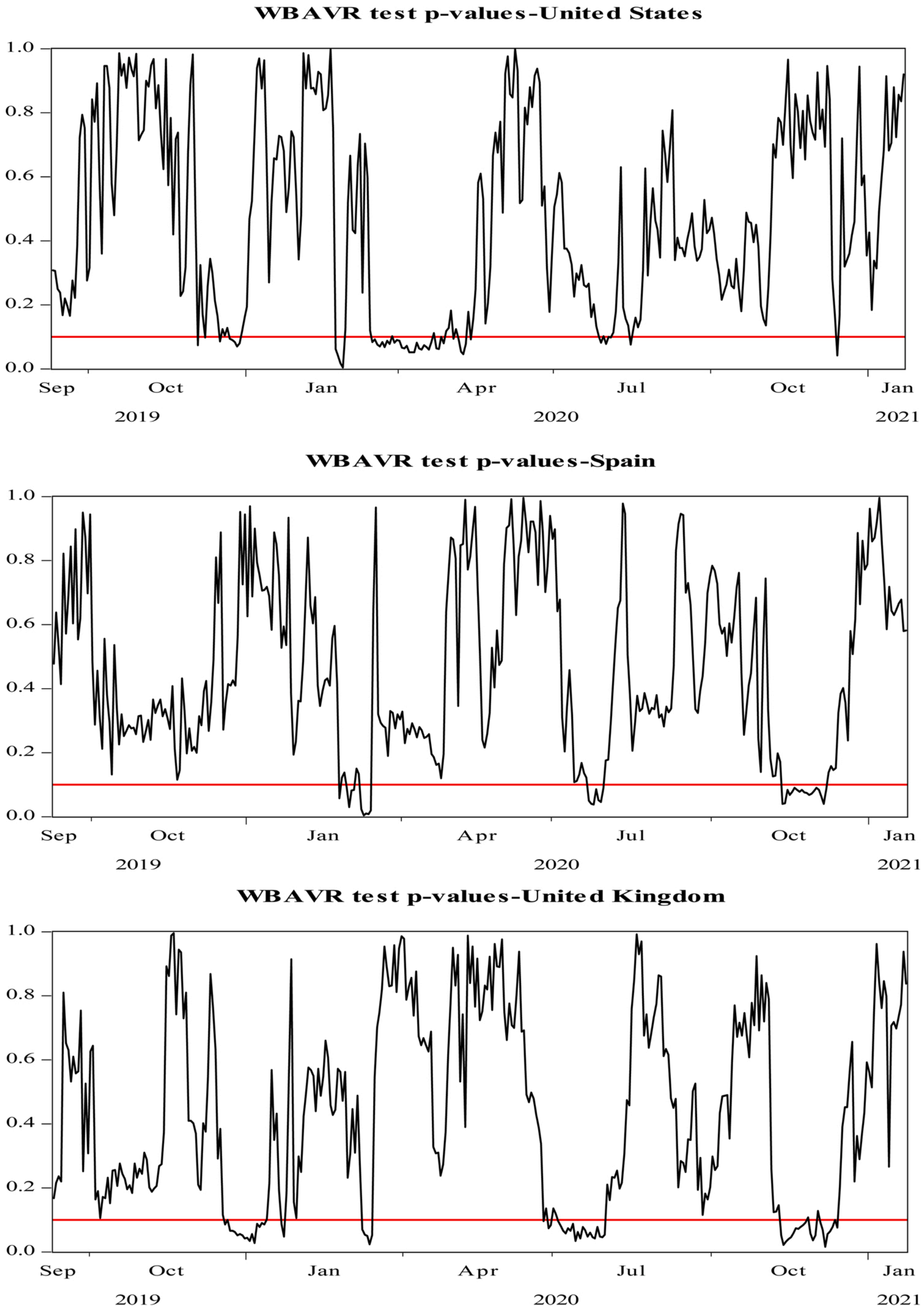

Fig. 2. WBAVR test p-values.
Note: The horizontal line indicates the 10 % significance level.

(Rahman et al., 2017) and is robust to possible structural changes in the time series (Lazăr et al., 2012). The length of the sub-sample window that is sufficient to make statistical inferences (Mooney, 1996)[3] is determined to be 30 daily observations. After the WBAVR test is applied to the first sub-sample window, the window is moved one daily observation forward, and the WBAVR test is reapplied.

[3] Because Kim et al. (2011); Charles et al. (2017), and Khuntia and Pattanayak (2018) report that the test results are not sensitive to the window length, different window lengths are not used.

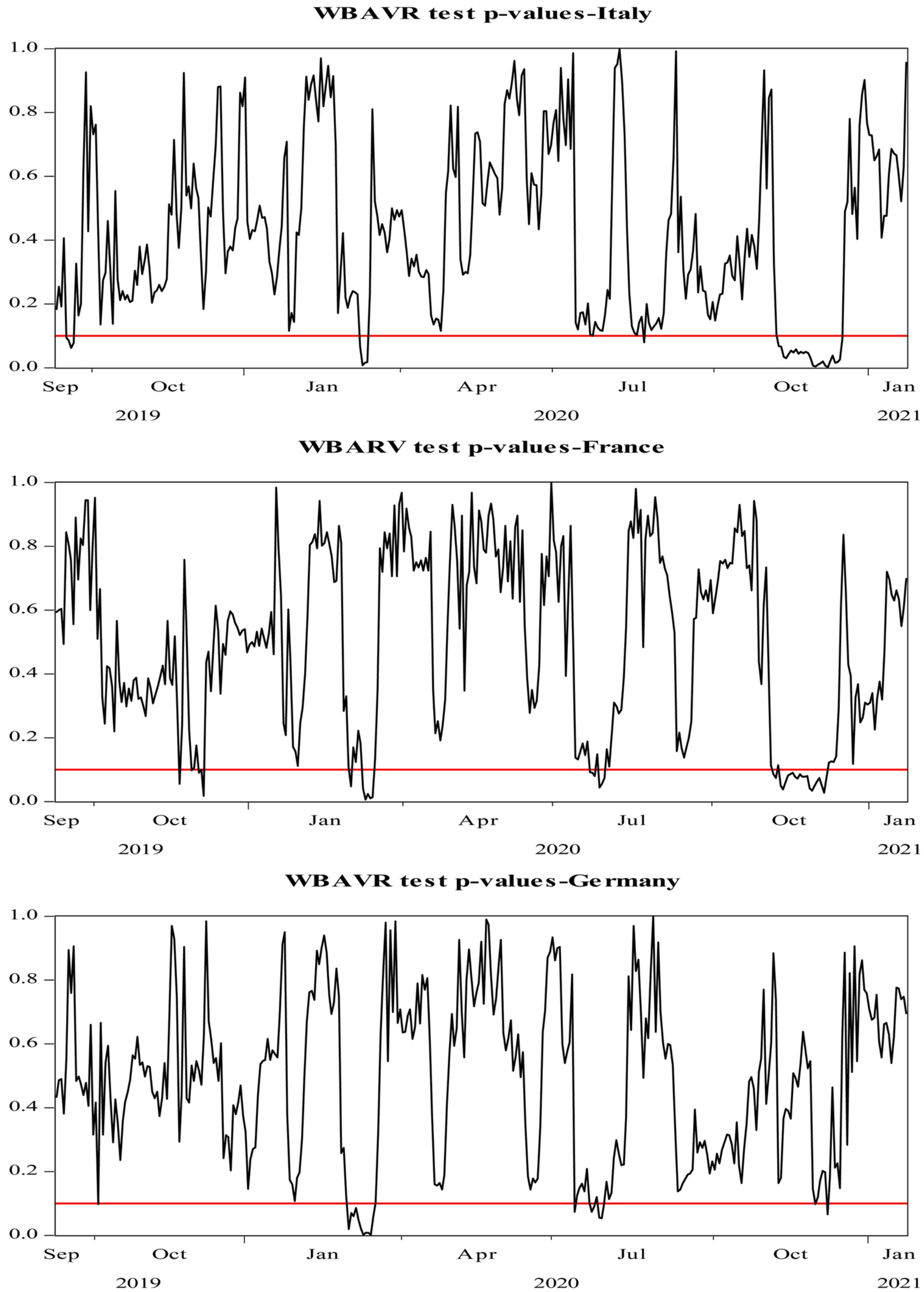

Fig. 2. (*continued*).

This process is continued until the end of the sample period, and the probability (p) values of each window are obtained. The p-values of the WBAVR test for each country are plotted in Fig. 2.

A p-value below the horizontal line indicates the rejection of the null hypothesis of no returns predictability at the 10 % significance level, which is statistical evidence of significant returns predictability (i.e., market inefficiency). A quick glance at Fig. 2 reveals that the null hypothesis of no returns predictability is rejected for all countries used in the study during some periods of the COVID-19 outbreak. In other words, the stock markets of the US, Spain, the UK, Italy, France, and Germany deviate from market efficiency during some periods. The deviation from market efficiency for stock markets in the US, the UK, and France is first seen in December 2019, when the COVID-19 pandemic first appeared in China. All stock markets deviate from market efficiency in March 2020, when COVID-19 was declared a global pandemic by the WHO. The deviation from market efficiency is also observed in July 2020 for the

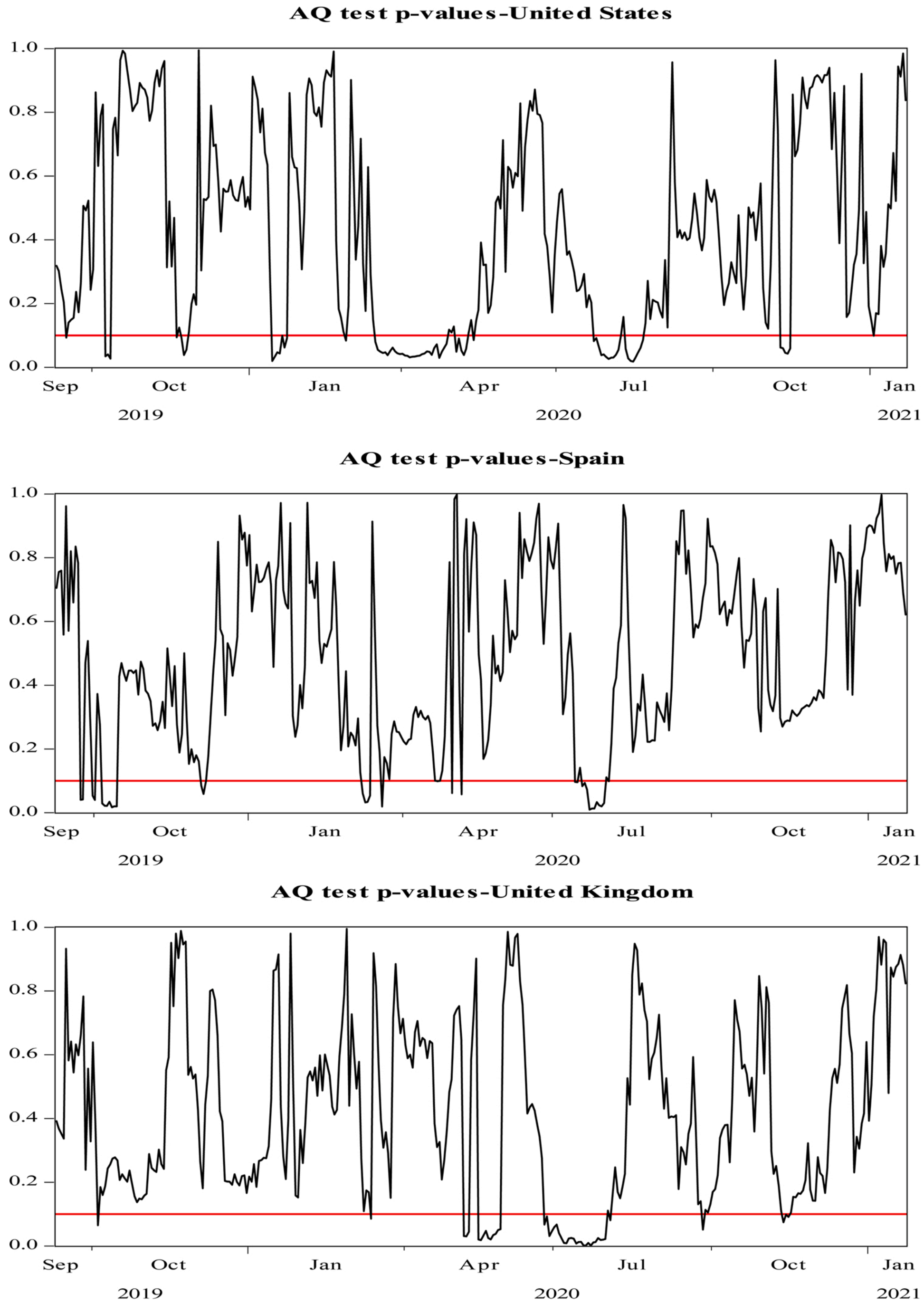

Fig. 3. AQ test p-values.
Note: The horizontal line indicates the 10 % significance level.

stock markets of all countries used in the study. This deviation can be attributed to the increasing daily confirmed cases in the related period.[4] The last deviation from market efficiency in the sample period is seen between mid-November and early-December for almost all countries. The onset of the second wave is thought to cause this deviation. Examining the periods during which the null of no returns predictability was rejected, it is found that the US and UK stock markets exhibited the most deviations from market efficiency during

[4] Detailed information can be found in WHO (2021b).

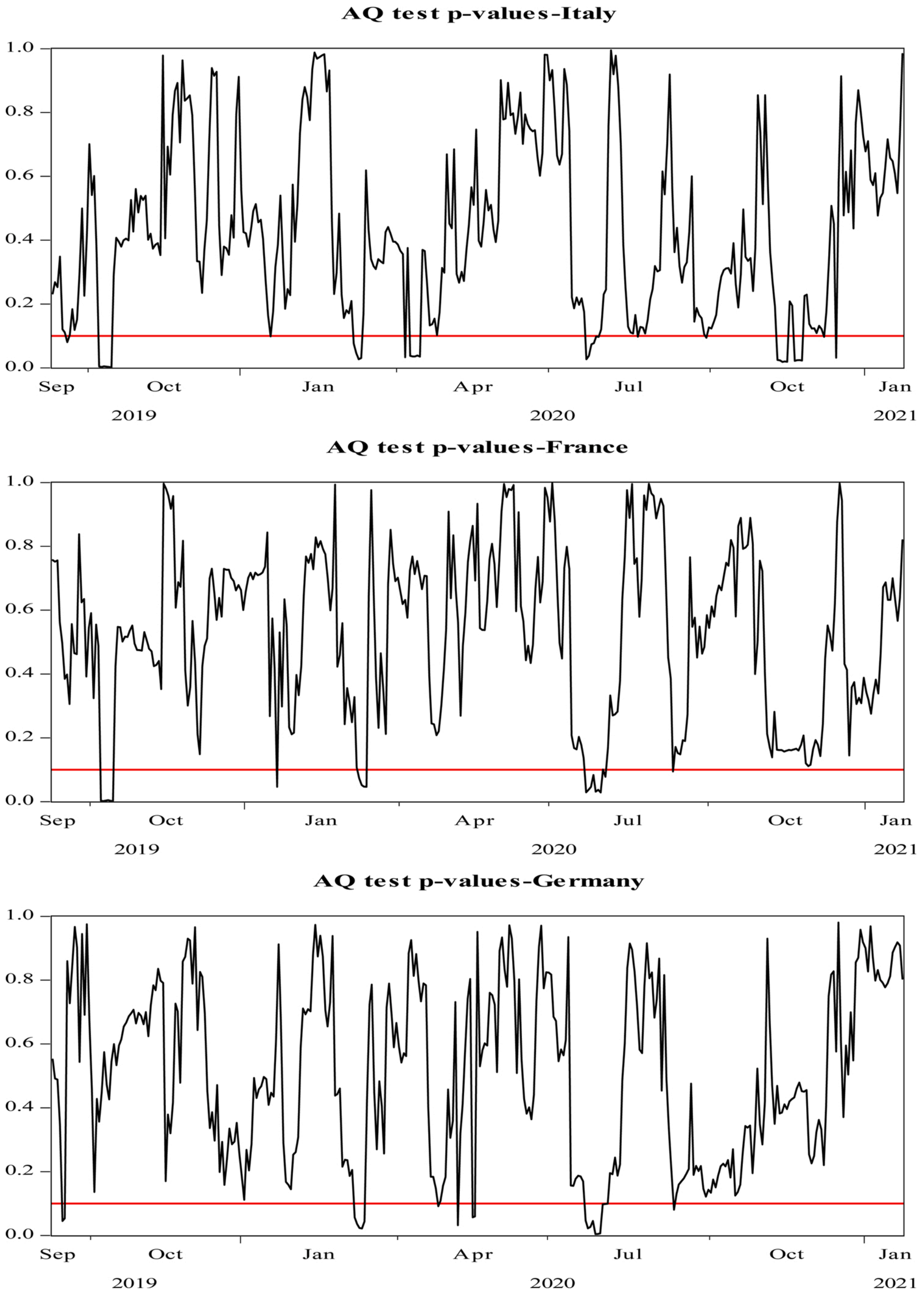

Fig. 3. (*continued*).

the COVID-19 outbreak.

5. Robustness analysis

To check the robustness of the study findings, the analyses were conducted again with the automatic portmanteau (AQ) test of Escanciano and Lobato (2009). The AQ test can also be used to investigate returns predictability and is robust to non-normality and conditional heteroskedasticity (Lim et al., 2013).[5] The main difference between the AQ and WBAVR tests is that the AQ test treats all sample autocorrelations to the optimal order with equal weights, while the WBAVR test provides higher weights to lower-order sample autocorrelations (Charles et al., 2015). [6] The p-values of the AQ test for each country are plotted in Fig. 3. When the graphs are examined, it can be clearly observed that the AQ test results support the findings of the study.

6. Conclusion

This study is the first to investigate the impact of the COVID-19 outbreak on stock market efficiency. The analyses were conducted using the WBAVR test on daily data of the six most affected developed countries (the US, Spain, the UK, Italy, France, and Germany) from the COVID-19 pandemic during the period from July 29, 2019 to January 25, 2021. The results of the analysis demonstrate that the stock markets of these countries deviated from market efficiency in some periods during the COVID-19 pandemic. The results also show that during the COVID-19 period, the US and UK stock markets deviated more from market efficiency than the stock markets of other countries. To check the robustness of these findings, the analysis was also performed using another econometric method, the automatic portmanteau test, and the findings were found to be robust. The findings of this study indicate that (1) stock markets became more speculative during the COVID-19 pandemic and policymakers need to be more proactive during this period; (2) financial models based on the assumption that returns are unpredictable are also insufficient for explaining stock market behavior in the COVID-19 period; and (3) mispricing of stocks during the COVID-19 pandemic increased the likelihood of abnormal returns (i.e., gains).

CRediT authorship contribution statement

Oktay Ozkan: Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Formal analysis.

Declaration of Competing Interest

The authors report no declarations of interest.

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[5] It should be noted that although the WBAVR and AQ tests are used for returns predictability, Charles et al. (2011) reported that the WBAVR test provides more reliable results. For this reason, the WBAVR test is preferred as the main method of the study, and the AQ test is preferred for the robustness check.

[6] For simplicity, the methodology of the AQ test is not provided. For detailed information about the AQ test, see Escanciano and Lobato (2009).

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