The short-run response of Saudi Arabia stock market to the outbreak of COVID-19 pandemic: An event-study methodology

Omer Ahmed Sayed1 | Hussein Eledum2,3

1Department of Finance and investment, University of Tabuk, Tabuk, Saudi Arabia
2Department of Statistics, University of Tabuk, Tabuk, Saudi Arabia
3Department of Applied Statistics, University of Shendi, Shendi, Sudan

Abstract
This paper investigates the short-term response of the Saudi stock market (Tadawul) to the COVID-19 outbreak. Event study methodology applied to data derived from the 21 industry groups that constitute the Saudi stock market to calculate abnormal returns for the trading days after the announcement of the COVID-19 in both China and Saudi Arabia. The results indicate that the estimated CARs for the industry groups and their sum on the event day were not statistically significant. Furthermore, the formal announcement of the first case of the COVID-19 in China had a negative but not significant impact on the Saudi stock market. In contrast, in the first 9-days event window, the announcement of the first confirmed case in Saudi Arabia had a negative and significant effect. Moreover, the most negatively affected industry groups were banks, consumer services, capital goods, transportation and commercial services, whereas telecommunication services and food and beverage were positively affected at the event window (+1, +9). In general, the Saudi stock market’s response had become weaker in the event windows come after (+1, +9), and different industry groups were found to have different responses to the COVID-19 outbreak.

KEYWORDS
abnormal returns, announcement date, industry group, stock market indices, Tadawul

1 | INTRODUCTION

The announcement of the World Health Organization (WHO) that an unknown virus was found in Wuhan City in China was on the 31 December 2019. On the 20 January 2020, 282 confirmed cases of COVID-19 and six deaths had been reported from four countries, including China, Thailand, Japan and the Republic of Korea (WHO, 2020). On the 11 March 2020, officially, WHO has declared that COVID-19 can be characterized as pandemic disease.

From March, the outbreak began to appear widely outside China; as of the 30 June 2020, the number of cases of COVID-19 worldwide is 10,417,063 confirmed cases, and the number of deaths is 509,474 persons. The most affected countries are: the USA is 2,682,897, Brazil is 1,368,195, Russia is 646,929, India is 566,840 and the United Kingdom is 313,470, respectively. The number of confirmed cases in Saudi Arabia is 186,436. The countries that recorded the highest number of deaths from the COVID-19 outbreak are: the USA is 129,544, Brazil is 58,314, the United Kingdom is 43,660, Italy is 34,744 and
France is 29,816. The number of deaths in Saudi is 1,599 persons.

The COVID-19 outbreak on global economics began to increase rapidly and consistently with its rapid geographical expansion, and the high contamination rates increase. Figure 1 displays confirmed deaths and recovery cases in Saudi Arabia from the 2nd of March to the 30 June 2020. International Stock markets suffered historic losses, especially in the first 3 months of the year, due to the COVID-19 outbreak. The Dow Jones index and London’s FTSE 100 saw their biggest quarterly drops since 1987, plunging 23% and 25%. The S&P 500 lost 20% during the same period, its worst since 2008. The drops come as authorities order a halt to most activity to slow the spread of the virus. This situation explains the importance of studying the impact of the COVID-19 outbreak on stock markets globally and at a country level.

On the 2 March 2020, the Saudi Ministry of Health confirmed the first case in Saudi Arabia. Up to the 9 March 2020, only imported cases were reported in KSA. On the 10 March 2020, with 20 COVID-19 cases and five new confirmed cases, local transmission was documented in the country. The Saudi government has responded boldly and swiftly to the COVID-19 pandemic and has been very active in communicating with the public through social media awareness campaigns. It has set up various support systems, including call centers and medical care for all affected, regardless of their residency status. Saudi Arabia, also, has taken strict measures to contain the spread of COVID-19 and has implemented partial and complete curfew, domestic and international travel restrictions, suspending prayers at mosques, the closure of all schools and universities and suspending government and private employees' attendance at workplaces (Yezli & Khan, 2020).

In this study, the event study method was employed to examine the impact of the COVID-19 outbreak on the Saudi stock markets. Stock markets can reflect the direct and the quick impact of a pandemic on the economy. Twenty-one industry groups’ indices were selected to examine the short-term cumulative abnormal returns in the Saudi stock market in the trading days after the announcement of the COVID-19 in both China and Saudi Arabia. It was found that the formal announcement of the first case of the COVID-19 in China had a negative but not significant impact on the Saudi stock market. Whereas, the announcement of the first case of the COVID-19 in Saudi Arabia had a negative and significant impact on the Saudi stock market in the first 9-days event window. The Saudi stock market's response had become weaker in the event windows come after (+1, +9).

The rest of this study is organized as follows. Section 2 discusses the related theoretical and empirical literature, and Section 3 outlines the research methodology; Section 4 outlines the data and event study approach set up. Section 5 analyses the empirical findings, and Section 6 concludes the study.

2 LITERATURE REVIEW

An event study proposed by Ball and Brown (1968) is a statistical method used to evaluate the impact of an event through changes in stock price. The basic idea of this method is to find the abnormal return attributable to the event being studied by adjusting for the return that stems from the price fluctuation of the market as a whole (Gilson & Black, 1995). Many authors have been concerned with the presentation and stages of event studies.
| Reference                  | Event nature                      | Sample                                                                 | Dependent variable | Model       | Findings                                                                                                                                 |
|----------------------------|-----------------------------------|------------------------------------------------------------------------|--------------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Loh (2006)                 | SARS outbreak                     | Canada, Hong Kong, Singapore, China and Thailand                      | Airline stock      | Market Model | The airline stocks are more sensitive to news about SARS relative to the average non-airline stock.                                  |
| Chen, Jang, and Kim (2007) | SARS outbreak                     | Seven publicly traded hotel companies in the stockprice in Taiwan     | Taiwanese hotel stock price | Market Model | Taiwanese hotel stocks showed significantly negative cumulative mean abnormal returns because of SARS outbreak.                     |
| Chen, Chen, Tang, and Huang (2009) | SARS outbreak                        | Taiwan                                                                | Taiwan's stock market | Market Model | The biotechnology sector saw positive shocks and the stocks of the T& W sector (hospitality industry) were sensitive to the SARS outbreak. |
| Pendell and Cho (2013)     | Five foot-and-mouth disease (FMD) outbreaks | Korean agribusiness companies                                          | The market         | Market Model | The outbreaks of FMD caused the stock market to react negatively and positively.                                                         |
| Wang, Yang, and Chen (2013) | Different infectious diseases      | 38 biotech listed companies                                            | Performance of biotechnology stocks | Market Model | The effect is more substantial for small companies, who are less likely to engage in the development of new vaccines.                    |
| Donadelli, Kizys, and Riedel (2016) | COVID-19 outbreak                      | Pharmaceutical companies in the United States                        | Stock market indices in different countries | Market Model | The cumulative abnormal returns were negative in all the examined event window periods.                                                  |
| Liu, Manzoor, Wang, Zhang, and Manzoor (2020) | COVID-19 outbreak                         | 21 Leading stock market indices in major affected countries         | Chinese and Asian stock markets | Market Model | The markets did not show significant reactions. That is, the economic impact of the diseases on a global scale during this time is relatively low, except for COVID-19. |
| Liu, Wang, et al. (2020)   | Public Health Risk Emergency of International Concern | 26 Stock market indices across the world                               | COVID-19 outbreak   | Stock market Model | The uncertainty of the COVID-19 cause in all the G7 stock markets. Also, the flow of goods and services were interrupted.           |
| Schell, Wang, and Huynh (2020) | COVID-19 outbreak                              | 26 Stock market indices across the world                               | COVID-19 outbreak   | Stock market Model | The uncertainty of the COVID-19 cause in all the G7 stock markets. Also, the flow of goods and services were interrupted.           |
| Selmi and Bouoiyour (2020) | COVID-19 outbreak                         | G7 countries: France, Germany, Japan, the United Kingdom, the United States, Italy and Canada | Stock market Model | Market Model | Stock market models |
(see: Binder, 1998; Brown & Warner, 1980; Brown & Warner, 1985; Peterson, 1989). Further authors have introduced methodological improvements (e.g., Boehmer, Masumeci, & Poulsen, 1991). Many studies have been made on testing the efficiency of stock market in relation to event announcement like dividend, bonus, right issue, option listing, stock split, annual earning and Merger and Acquisitions, but a few studies have been carried out in recent years to evaluate the impact of epidemic diseases outbreak in the efficient of stock market. Today variety studies examined the economic impacts of the COVID-19 outbreak on supply and demand sides, financial markets, the labour market and food security. Different methodologies used, and many series of data utilized to have a clear overview of COVID-19 economic and financial impacts. The event study approach adopted in a wide range of previous studies related to public health emergencies; therefore, reviewing studies on the economic impact of the different infectious diseases is essential to forecast and analyse the effects of COVID-19. Table 1 shows the important studies conducted recently using the event study approach, taking into account viruses or disease outbreak as an event.

This survey provided a clue that the event study methodology is very effective in assessing the impact of public health emergencies on stock markets. Basing on this, the recent study utilizes this methodology to accomplish its objective.

3 | RESEARCH METHODOLOGY

Fama, Fisher, Jensen, and Roll (1969) introduced an event study method to analyse the impact of emergencies on the financial market. As method effectiveness is based on an assumption of market rationality, it is expected that the event impact would be reflected in price changes in a relatively short time after the event. Delattre (2007) summarized the implementation of an event study in specific stages and includes an inventory of events, identification of announcement dates, data cleaning and selecting the final sample, choosing an event window, choosing a model for determining the abnormal return, measuring the impact of the event on the stock market and evaluating the significance of the results. Therefore, this section pertains to discuss the structure of an event study approach, including estimation period and event window, estimating the normal return model and computing and testing the abnormal returns.

Following MacKinlay (1997), the initial task of conducting an event study is defining the event of interest and identifying the event period (test period) or the event window, which represents the period during which the event’s impact will be measured. Moreover, the estimation period or the pre-event period also should be determined. Letting \( t = 0 \) as the event date or announcement date of the event, \( t = T_1 + 1 \) to \( t = T_2 \) represents the event window and \( t = T_0 + 1 \) to \( t = T_1 \) constitutes the estimation window, while \( t = T_2 + 1 \) to \( t = T_3 \) demonstrates the post-event if applicable. Figure 2 illustrates the event study with the three windows include the estimation window, the event window and the post-event window. Yusoff, Salleh, Ahmad, and Idris (2015) demonstrated that the event window (actual window) and the post-event window are determined to capture the stocks’ abnormal returns.

3.1 | Estimating normal return model

The normal returns would be estimated over the estimation period. This period explains that there is a trade-off in selecting a longer and shorter estimation period. There will be higher precision with a more extended period, but there will also be out-of-date data. Armitage (1995) claimed that the average range of estimation period is [100, 300] for daily studies and [24, 60] for monthly series. MacKinlay (1997) proposed that 120 days before the event study is suitable for daily studies. Armitage (1995) mentioned that the estimation period could be either before or after the event window (or both periods).

MacKinlay (1997) stated that there are two statistical models used to model the normal return; the constant mean return model which assumes that the mean return of a given security is constant and the market model.
assumes a stable linear relation between the market return and the security returns. For the two models, there are given assumptions concerning the returns that should be satisfied; these are jointly multivariate normal and independently and identically distributed through time is imposed. In practice, it generally does not lead to problems because the assumption is empirically reasonable, and inferences using the normal return models tend to be robust to deviations from the assumption.

3.1.1 Constant mean return model

This is the simplest model and given as

$$R_{k,t} = \mu_k + u_{k,t},$$

where $\mu_k$ is the mean return for stock $k$ and $u_{k,t}$ is the random error for stock $k$ on day $t$ which should be normally distributed with a mean of 0 and variance $\sigma^2_k$ that is $u_{k,t} \sim N(0, \sigma^2_k)$.

3.1.2 The market model

The market model, which defines theoretical return as a linear function of the return of the market index, is the most frequently used. Based on this model, the stock return is regressed against the return of the market index, so the model is given as

$$R_{k,t} = \alpha_k + \beta_k R_{m,t} + \epsilon_{k,t},$$

where $\alpha_k$ and $\beta_k$ are the parameters of the regression equation. $\epsilon_{k,t}$ represents the statistical error with zero mean and constant variance, that is, $E(\epsilon_{k,t}) = 0$ and $\text{Var}(\epsilon_{k,t}) = \sigma^2_{\epsilon_k}$.

The market model has two advantages over the constant mean return model. In addition to having a smaller variance of abnormal residuals, resulting in more reliable statistical tests, it also removes the part of the return on stocks that is related to variations in market returns, which in turn generally leads to greater sensitivity to the effects of specific events (Henson & Mazzocchi, 2002).

Under certain assumptions, the Ordinary Least Squares (OLS) regression used to estimate the parameters of the market model results in efficient parameter estimates and consistent test statistics based on them. One of these assumptions is the homoscedasticity of the OLS residuals, that is, their distribution has constant variance. Giacotto and Ali (1982) pointed out that if this is not the case, the standard tests to measure the effect of a specific event on stock prices have to be adjusted due to the presence of heteroscedasticity. Many studies, for example, see Corhay and Rad (1994) and Akgiray (1989) stated that the presence of time dependence in stock return series would lead to inefficient parameter estimates and inconsistent test statistics. These studies pointed out that the empirical characteristics of return series can be characterized by Autoregressive Conditional Heteroscedasticity (ARCH) proposed by Engle (1982) and Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models, developed by Bollerslev (1986), which allow for non-linear intertemporal dependence in the residual series. Bera, Bubny, and Park (1988) observed that the market model estimates under ARCH processes are more efficient. Collins and Dent (1984) used the generalized least squares model to evaluate the impact of heteroscedasticity. One can easily modify the statistical framework so that the analysis of the abnormal returns is autocorrelation and heterosexuality consistent by using a generalized method-of-moments approach.

3.2 Measuring abnormal returns and hypothesis

Abnormal return (AR) is the difference between observed return and expected return in the absence of the event (Martinez, 2002). Based on the parameter estimates of the market model of Equation (2), one can measure and analyse the abnormal returns. The estimated model corresponding to model (2) is given as

$$E(R_{k,t}) = \hat{\alpha}_k + \hat{\beta}_k R_{m,t},$$

where $\hat{\alpha}_k$ and $\hat{\beta}_k$ are estimates of the true parameters obtained via an ordinary least squares regression or under GARCH processes. In term of the data used in this study, abnormal return for stock industry group $k$ at time $t$ ($AR_{k,t}$) is therefore defined as:

$$AR_{k,t} = R_{k,t} - E(R_{k,t}),$$

where $E(R_{k,t})$ is the expected return if the event has not occurred.

Abnormal return for stock industry group $k$ at time $t$ in Equation (4) can be rewritten as:

$$AR_{k,t} = R_{k,t} - (\hat{\alpha}_k + \hat{\beta}_k R_{m,t}),$$

The concept of a cumulative abnormal return is necessary to accommodate a multiple period event window.
The sample cumulative abnormal return (CAR) within the event window \((t_1, t_2)\) where \(T_1 < t_1 \leq t_2 < T_2\) is the sum of included abnormal returns,

\[
CAR_{k(t_1,t_2)} = \sum_{t=t_1}^{t_2} AR_{k,t}.
\]  

(6)

The average abnormal return for day \(t\) is computed as:

\[
AR_{k,t} = \frac{1}{n(t)} \sum_{t=t_1}^{t_2} AR_{k,t}.
\]  

(7)

where \(n(t)\) is the window length.

Individual industry group’s abnormal return in a period does not tell us very much, so the average over all the industry groups in the sample on time \(t\) for window \((t_1, t_2)\) can be computed as

\[
AARM_{t(t_1,t_2)} = \frac{1}{k} \sum_{j=1}^{k} AR_{j,t}.
\]  

(8)

Cumulative average returns (CAARM) can also be considered

\[
CAARM_t = \sum_{t=t_1}^{t_2} AARM_t.
\]  

(9)

Plotting the CAARM allows to see visually the impact of the event and whether the market is efficient.

To test the significance of abnormal returns, most event studies use a parametric test of \(t\)-statistics (e.g., Barber & Lyon, 1996; Brown & Warner, 1985), whereas, non-parametric tests, such as a sign test, or a rank test can be used to confirm the results or evaluate the influence of outliers (e.g., Benco & Prather, 2008; Benkraiem, Louhichi, & Marques, 2009; Liu, Wang, He, & Wang, 2020).

The distribution of any single abnormal return under \(H_0\) is

\[
AR_t \sim N\left(0, \sigma_{AR_t}^2\right).
\]  

(10)

Therefore, for an individual industry group \((K)\), whether or not the abnormal return \(AR\) is different from zero can be tested by \(t\)-statistics as

\[
t_{\text{stat}} = \frac{AR_{k,t}}{\hat{\sigma}_{AR_t}},
\]  

(11)

where \(\hat{\sigma}_{AR_t}\) is the estimate of standard deviation of the abnormal returns in the estimation period. The distribution of the cumulative abnormal return under \(H_0\) is

\[
CAR_{k(t_1,t_2)} \sim N\left(0, \sigma_{AR_{k(t_1,t_2)}}^2\right).
\]  

(12)

Therefore, the \(t\)-statistic can be written as

\[
t_{\text{stat}} = \frac{CAR_{k,t}}{\sqrt{n(t) \times \hat{\sigma}_{AR_t}}},
\]  

(13)

where \(\sigma_{AR_{k(t_1,t_2)}}^2 = n \sigma_{AR_t}^2\) and \(\sigma_{AR_t}^2\) is the variance of the one-period mean abnormal return.

## 4 DATA AND EVENT STUDY APPROACH SETUP

This section demonstrates the sample of data used in this study and the application of event study approach to this data.

### 4.1 Data and sample

To assess the impact of COVID-19 spread on the performance of the stock market in Saudi Arabia (Tadawul), using Event Study methodology, we relied on a sample of data covering the 21 industry groups in the stock market. The main index in the stock market (TASI), which reflects the stock market’s performance in Saudi Arabia, is selected as the benchmark index to calculate the abnormal returns of the industry group indices (sectoral indices). We collected daily closing prices of these indices from the 23 September 2019 to the 11 June 2020. The data sources used for this study are the Saudi Arabia Stock Market and investing.com website.\(^1\) The computations were done by Excel and Eviews 11.

### 4.2 Event study setup

According to all news sources across the world, in late December 2019, a new disease outbreak was recorded in Wuhan (China). Later, on the 31 December, the virus was first identified to the WHO. In this research, we try to investigate the impact of the outbreak of COVID-19 on the stock market of Saudi Arabia. Thus, we select the 20 January 2020 as a secondary event day for this study. The first confirmed COVID-19 case in Saudi Arabia was on the 2 March 2020. So, this is considered the main event day of the study. According to Brown and
Warner (1985) and MacKinlay (1997), a parameter estimation period of 120 days is adequate since daily returns data for the 120 days before the event date are sufficient in formulating a benchmark for normal returns, we define the estimation window of 120 trading days before the secondary event day (the announcement of first confirmed case of COVID-19 in China). To study the influence in different periods, we set up seven event windows consisting of 90 trading days. We start first event windows on the 2nd of February and ending before the main event day (the announcement of the first confirmed case of COVID-19 in Saudi Arabia), which consists of 21 trading days (−21, −1). Then, we define the other five event windows beside the event day, which sum up to 68 trading days, and they are as shown in Table 2.

After collecting the data for 21 industry groups of the stock market of Saudi Arabia (Tadawul), we have calculated the return of industry group (Rk, k = 1, 2, ...21) and the corresponding industry group.

\[
R_{k,t} = \frac{P_{k,t} - P_{k,t-1}}{P_{k,t-1}} \quad \text{and} \quad R_{m,t} = \frac{P_{m,t} - P_{m,t-1}}{P_{m,t-1}}, \quad (14)
\]

where: \( R_{k,t} \) and \( R_{m,t} \) represent the observed return of the industry group \( k \) on day \( t \) and the market return on day \( t \), respectively. \( P_{k,t}, P_{m,t} \) refer to the closing price of stock \( k \) on day \( t \) and closing price of stock market on day \( t \). \( P_{k,t-1}, P_{m,t-1} \) refer to the closing price of stock \( k \) and the closing price of stock market on the previous day, respectively.

After the data have been cleaned and prepared, the next step is to estimate the normal returns on the estimation window using the market model of Equation (2), before doing that we carried on ADF root test to determine whether the estimation window time series is stationary, the result of ADF unit root test is given in Table A2 in Appendix A. Based on the results of this table, it is observed that all variables are stationary at the level, therefore the regression can be done. To test whether the ordinary least squares residuals in the market model exhibit no conditional heteroscedasticity, the ARCH tests were conducted. Table A3 in Appendix A summarizes the results of ARCH tests for the 21 models, this table also provides the values of Durbin–Watson test which used to detect the presence of autocorrelation at lag 1 (AR(1)) in the residuals. According to the results in Table A3, we conclude that there is no ARCH effect except on the models that include the dependent variables R5, R6, R12, R15, R16, R17 and R18, and no AR(1) except models that involve dependent variables R3, R8, R17 and R19. Consequently, the ordinary least squares method used to estimate the parameters of the market model of Equation (2) with no ARCH effect or AR(1). Whereas, for those have ARCH effect the stock returns modelled according to the ARCH(1) estimation to control for time-varying volatility. Moreover, the generalized least squares method (GLS) used to estimate the model with AR(1) (see Appendix B). The estimated parameters \( \hat{\alpha} \) and \( \hat{\beta} \) for 21 models shown in Table A4 in Appendix A.

To assess the impact of the pandemic spread on the stock market behaviour, the estimated parameters \( \hat{\alpha} \) and \( \hat{\beta} \) in Table A4 in Appendix B used to compute the abnormal returns within the test period include the seven event windows presented in Table 2. To do that, first we have computed the expected returns for each event window (\( E(R_{k,t}) \)) by substitute \( \hat{\alpha} \) and \( \hat{\beta} \) in each 21 models using Equation (3). After that the abnormal returns ARs were computed using Equation (5), the aggregation and average for each ARs were obtained. T-test was applied to CARs in order to examine the effect of COVID-19 epidemic outbreaks on the stock market of Saudi Arabia. The null hypothesis for the t-test is that CAR is not significantly different from zero. The results of positive (or negative) significance indicate that the COVID-19 epidemic outbreaks positively (or negatively) affect the stock market.

5 | ANALYSIS AND RESULTS

This section first gives summary statistics for the stock returns of the industry groups in Saudi stock market and then reports and discusses the results obtained from the application of the event study approach on the data collected from the mentioned industry groups.

5.1 | Descriptive statistics

The mean and standard deviation of the stock returns for the 21 industry groups and the market before and after the event of COVID-19 are given in Table 3.

From Table 3, it can be seen that the mean of stock returns for 18 industry groups out of 21 decreased after COVID-19 pandemic outbreak in Saudi Arabia, 11 of them were positive before COVID-19 pandemic, have become negative after virus outbreak, while four industry groups remained negative before and after COVID-19 pandemic. Moreover, the mean of stock returns for the rest industry groups increased after COVID-19 pandemic outbreak, Three of them involve Telecommunication Services, Software & Services and Health Care...
Equipment and Services moved from negative to positive, while Food and Staples Retailing, Pharma, Biotech and Life Science and Food and Beverage kept positive before and after COVID-19 pandemic. Furthermore, the mean of stock market returns decreased and remained negative before and after COVID-19 pandemic outbreak.

5.2 Cumulative abnormal returns analysis

Table 4 presents the cumulative abnormal returns (CARs) for the 21 industry groups and their sum within the (−21, −1) event window (event windows before the COVID-19 outbreak in Saudi Arabia). As shown in Table 4, the estimated CARs during the 21 days (between the first case of COVID-19 reported in Saudi Arabia and students evacuated from China and all international flights suspended) were not statistically significant for all industry groups in Saudi stock market and their sum, except Software and Services group (significant at 10% level). Thus, these results indicate that, except for the mentioned industry group, the value of CAR for the industry groups as well as their sum was not different from zero in the absence of the COVID-19 influence, and no significant abnormal returns were witnessed before COVID-19 outbreak. Nevertheless, all industry groups at that time responded negatively, except Real Estate Mgmt and Dev, Pharma, Biotech and Life Science, Banks, Software and Services, Health...
Care Equipment and Services, Food and Beverage, which responded, as expected, positively.

Table 5 shows the CARs for the industry groups and their sum within the three event windows including the event day (day 0), (+1, +9) and (+10, +17). As shown in this table, the estimated CARs for the event day and the sum of the industry groups were not statistically significant except Diversified Financials (significant at 10%). The result indicates that the Saudi stock market did not respond rapidly when the authorities announced the first case of the COVID-19 in Saudi Arabia. Moreover, the estimated CARs over the event window (+1, +9), that is, the 8-day period after COVID-19 outbreak, the negative CARs were found to be statistically significant at the 1% level for Banks, Consumer Services, Capital Goods, and Transportation, in addition the Commercial Services was significant at 5%. Whereas, Telecommunication Services and Food and Beverage were found to be statistically significant at the 1% but with a positive response as excepted. The sum of industry groups for this event was found negative and statistically significant at the 10% level. Generally, we can agree that all these results were consistent with the common perception of the world. In comparison, the estimated CARs over the event window (+10, +17) have lower significance than that of event windows (+1, +9). Capital Goods industry group continued to be statistically significant but at a 5% level. Also, the Retailing and REITs were found to be negatively and statistically significant at the 5% level. Whereas, Food and Staples Retailing, Pharma, Biotech and Life Science, Media and Entertainment and Health Care Equipment and Services were found to be statistically significant at the 10% level. The sum of industry groups over this event was found to be negative but not statistically significant.

Table 6 demonstrates the CARs for the industry groups and their sum within the three event windows involve (+18, +38), (+39, +58) and (+59, +68). Generally, CARs for all industry groups across the three event windows and their sum were found to be not statistically significant, except Banks and Food and Beverage in the event window (+18, +38), Retailing, Real Estate Mgmt and Dev and Diversified Financials in event window (+39, +58).
Figure 3 illustrates the change of cumulative average returns CAARM for the periods before and after announcement date. It can be noticed that the CAARM for the period after announcement date has dropped rapidly compared to that for the period before the announcement date. This result is consistent with that obtained from the event window (+1, +9) in Table 5.
6 | CONCLUSIONS

This study adds to the literature as it explores the COVID-19 outbreak impact on the emergent stock markets, represented in Saudi Stock market. To attain this objective, indices of the 21 industry groups that constitute the Saudi stock market were utilized using the event study methodology. The results indicate that:

**TABLE 6** Cumulative abnormal returns (CAR) for industry groups within the event windows (+18, +38), (+39, +58) and (+59, +68)

| Industry group                  | CAR (+18, +38) | t-stat | CAR (+39, +58) | t-stat | CAR (+59, +68) | t-stat |
|---------------------------------|----------------|--------|----------------|--------|----------------|--------|
| Food and Staples Retailing      | −0.0289        | −0.31  | 0.1345         | 1.49   | −0.0663        | −1.04  |
| Retailing                       | 0.0878         | 1.31   | −0.1344**      | −2.06  | 0.0052         | 0.11   |
| Real Estate Mgmt and Dev.       | −0.0275        | −0.60  | −0.1263***     | −2.83  | −0.0357        | −1.13  |
| Telecommunication Srv           | 0.0267         | 0.50   | −0.0095        | −0.18  | −0.0297        | −0.81  |
| Pharma, Biotech and Life Sci    | −0.1213        | −1.01  | −0.0372        | −0.32  | 0.06           | 0.67   |
| Diversified Financials          | −0.0132        | −0.31  | −0.0829**      | −2.02  | 0.0166         | 0.57   |
| Media and Entertainment         | 0.0245         | 0.32   | −0.0725        | −0.96  | −0.0014        | −0.03  |
| Banks                           | −0.0609***     | −2.68  | −0.0153        | −0.69  | −0.0090        | −0.57  |
| Insurance                       | 0.0565         | 1.17   | −0.0434        | −0.92  | −0.0145        | −0.44  |
| Software and Services           | 0.1315         | 1.25   | −0.0261        | −0.25  | −0.0629        | −0.86  |
| Consumer Services               | −0.0272        | −0.39  | −0.0416        | −0.61  | 0.0038         | 0.08   |
| Commercial_Srv                  | 0.0362         | 0.48   | 0.0155         | 0.21   | 0.0182         | 0.35   |
| Health Care Equip. and Svc      | 0.0012         | 0.02   | 0.0463         | 0.77   | 0.0526         | 1.23   |
| Capital Goods                   | 0.0101         | 0.16   | 0.0007         | 0.01   | 0.0569         | 1.31   |
| Consumer Dur. and Apparel       | −0.0195        | −0.28  | 0.0313         | 0.46   | 0.0281         | 0.58   |
| REITs                           | −0.0228        | −0.52  | −0.0059        | −0.14  | −0.0171        | −0.56  |
| Energy                          | −0.0056        | −0.11  | 0.0427         | 0.88   | −0.0309        | −0.90  |
| Utilities                       | 0.0530         | 0.75   | −0.0134        | −0.19  | −0.0733        | −1.50  |
| Materials                       | 0.0249         | 0.82   | 0.0282         | 0.96   | 0.0268         | 1.28   |
| Transportation                  | −0.0053        | −0.07  | 0.0132         | 0.18   | −0.0158        | −0.31  |
| Food and Beverage               | 0.0916*        | 1.76   | −0.0443        | −0.87  | 0.0572         | 1.60   |
| Sum of industry groups           | 0.0101         | 0.41   | −0.0162        | −0.68  | −0.0017        | −0.10  |

*Significant at the .10 level.  
**Significant at the .05 level.  
***Significant at the .01 level.

**FIGURE 3** Cumulative average returns (CAARM)  
[Colour figure can be viewed at wileyonlinelibrary.com]
(1) estimated CARs for the industry groups and their sum at the event day were not statistically significant, that is, Saudi stock market did not response rapidly when the authorities announced the first case of the COVID-19 in Saudi Arabia; (2) the formal announcement of the first case of the COVID-19 in China had a negative but not significant impact on the Saudi stock market; (3) the announcement of the first confirmed case of the COVID-19 in Saudi Arabia had a negative and significant impact on the Saudi stock market; (4) the most negatively affected industry groups were Banks, Consumer Services, Capital Goods, Transportation and Commercial Services, whereas Telecommunication Services, and Food and Beverage were affected positively at the event window (+1,+9) and (5); the Saudi stock market's response had become weaker in the next event windows.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are openly available in: (a) Tadawul site at [https://www.tadawul.com.sa/wps/portal/tadawul/home?locale=en]. (b) Investing.com site at [https://www.investing.com/].

ENDNOTE
1 The data that support the findings of this study are openly available in:
(a) Tadawul site at [https://www.tadawul.com.sa/wps/portal/tadawul/home?locale=en].
(b) Investing.com site at [https://www.investing.com/]

REFERENCES
Akgiray, V. (1989). Conditional heteroscedasticity in time series of stock returns: Evidence and forecasts. Journal of Business, 62, 55–80.
Armitage, S. (1995). Event study methods and evidence on their performance. Journal of Economic Surveys, 9(1), 25–52.
Ball, R., & Brown, P. (1968). An empirical evaluation of accounting income numbers. Journal of Accounting Research, 6, 159–178.
Barber, B. M., & Lyon, J. D. (1996). Detecting abnormal operating performance: The empirical power and specification of test statistics. Journal of Financial Economics, 41(3), 359–399.
Benco, D. C., & Prather, L. (2008). Market reaction to announcements to invest in ERP systems. Quarterly Journal of Finance and Accounting, 47(4), 145–169.
Benkraiem, R., Louhiichi, W., & Marques, P. (2009). Market reaction to sporting results: The case of European listed football clubs. Management Decision, 47(1), 100–109.
Bera, A., Babnys, E., & Park, H. (1988). Conditional heteroscedasticity in the market model and efficient estimates of betas. Financial Review, 23(2), 201–214.
Binder, J. (1998). The event study methodology since 1969. Review of Quantitative Finance and Accounting, 11(2), 111–137.
Boehmer, E., Masumeci, J., & Poulsen, A. B. (1991). Event-study methodology under conditions of event-induced variance. Journal of Financial Economics, 30(2), 253–272.
Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. Journal of Econometrics, 31(3), 307–327.
Brown, S. J., & Warner, J. B. (1980). Measuring security price performance. Journal of Financial Economics, 8(3), 205–258.
Brown, S. J., & Warner, J. B. (1985). Using daily stock returns: The case of event studies. Journal of Financial Economics, 14(1), 3–31.
Chen, C. D., Chen, C. C., Tang, W. W., & Huang, B. Y. (2009). The positive and negative impacts of the SARS outbreak: A case of the Taiwan industries. The Journal of Developing Areas, 43, 281–293.
Chen, M. H., Jang, S. S., & Kim, W. G. (2007). The impact of the SARS outbreak on Taiwanese hotel stock performance: An event-study approach. International Journal of Hospitality Management, 26(1), 200–212.
Collins, D. W., & Dent, W. T. (1984). A comparison of alternative testing methodologies used in capital market research. Journal of Accounting Research, 22, 48–84.
Corhay, A., & Rad, A. T. (1994). Statistical properties of daily returns: Evidence from European stock markets. Journal of Business Finance & Accounting, 21(2), 271–282.
Delattre, E. (2007). Event study methodology in marketing. Recherche et Applications en Marketing (English Edition), 22(2), 57–75.
Donadelli, M., Kizys, R., & Riedel, M. (2016). Globally Dangerous Diseases: Bad News for Main Street, Good News for Wall Street?. SAFE Working Paper No. 158, Available at SSRN: https://ssrn.com/abstract=2881220 or http://dx.doi.org/10.2139/ssrn.2881220
Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. Econometrica: Journal of the Econometric Society, 50, 987–1007.
Fama, E. F., Fisher, L., Jensen, M. C., & Roll, R. (1969). The adjustment of stock prices to new information. International Economic Review, 10(1), 1–21.
Giacotto, C., & Ali, M. M. (1982). Optimal distribution-free tests and further evidence of heteroscedasticity in the market model: A comment. The Journal of Finance, 37(5), 1247–1257.
Gilson, R. J., & Black, B. S. (1995). The law and finance of corporate acquisitions, (2nd ed., pp. 1603). Westbury, NY: Foundation Press.
Henson, S., & Mazzocchi, M. (2002). Impact of bovine spongiform encephalopathy on agribusiness in the United Kingdom: Results of an event study of equity prices. American Journal of Agricultural Economics, 84(2), 370–386.
Liu, H., Manzoor, A., Wang, C., Zhang, L., & Manzoor, Z. (2020). The COVID-19 outbreak and affected countries stock markets response. International Journal of Environmental Research and Public Health, 17(8), 2800.
Liu, H., Wang, Y., He, D., & Wang, C. (2020). Short term response of Chinese stock markets to the outbreak of COVID-19. Applied Economics, 52(53), 1–14.
Loh, E. (2006). The impact of SARS on the performance and risk profile of airline stocks. International Journal of Transport Economics/Rivista internazionale di economia dei trasporti, 33(3), 401–422.
MacKinlay, A. C. (1997). Event studies in economics and finance. *Journal of Economic Literature, 35*(1), 13–39.

Martinez, I. (2002). De l’influence du caractère familial des sociétés sur le cours de bourse. *Revue Française de Gestion, 3*, 91–106.

Pendell, D. L., & Cho, C. (2013). Stock market reactions to contagious animal disease outbreaks: An event study in Korean foot-and-mouth disease outbreaks. *Agribusiness, 29*(4), 455–468.

Peterson, P. P. (1989). Event studies: A review of issues and methodology. *Quarterly Journal of Business and Economics, 28*(3), 36–66.

Schell, D., Wang, M., & Huynh, T. L. D. (2020). This time is indeed different: A study on global market reactions to public health crisis. *Journal of Behavioral and Experimental Finance, 27*, 100349.

Selmi, R., & Bouoiyour, J. (2020) Global Market’s Diagnosis on Coronavirus: A Tag of War between Hope and Fear. https://hal.archives-ouvertes.fr/hal-02514428.

Wang, Y. H., Yang, F. J., & Chen, L. J. (2013). An investor’s perspective on infectious diseases and their influence on market behavior. *Journal of Business Economics and Management, 14*(sup1), S112–S127.

WHO. (2020) Coronavirus disease 2019 (COVID-19): Situation report, 72. Retrieved from https://apps.who.int/iris/handle/10665/331685.

Wilder-Smith, A., Chiew, C. J., & Lee, V. J. (2020). Can we contain the COVID-19 outbreak with the same measures as for SARS? *The Lancet Infectious Diseases, 20*, e102–e107.

Yezli, S., & Khan, A. (2020). COVID-19 social distancing in the Kingdom of Saudi Arabia: Bold measures in the face of political, economic, social and religious challenges. *Travel Medicine and Infectious Disease, 37*(5), 101692.

Yusoff, W. S., Salleh, M. F. M., Ahmad, A., & Idris, F. (2015). Short-run political events and stock market reactions: Evidence from companies connected to Malaysian bi-power business-political elite. *Procedia - Social and Behavioral Sciences, 211*, 421–428.

**How to cite this article:** Sayed OA, Eledum H. The short-run response of Saudi Arabia stock market to the outbreak of COVID-19 pandemic: An event-study methodology. *Int J Fin Econ*. 2021; 1–15. [https://doi.org/10.1002/ijfe.2539](https://doi.org/10.1002/ijfe.2539)
### APPENDIX A.

#### TABLE A1  Variables and their corresponding industry groups

| Variable | Industry group                  | Variable | Industry group                  |
|----------|---------------------------------|----------|---------------------------------|
| R1       | Food and Staples Retailing      | R12      | Commercial_Srv                  |
| R2       | Retailing                      | R13      | Health Care Equipment and Svc    |
| R3       | Real Estate Mgmt and Development| R14      | Capital Goods                    |
| R4       | Telecommunication Services      | R15      | Consumer Durables and Apparel   |
| R5       | Pharma, Biotech and Life Science| R16      | REITs                            |
| R6       | Diversified Financials         | R17      | Energy                           |
| R7       | Media and Entertainment         | R18      | Utilities                        |
| R8       | Banks                           | R19      | Materials                        |
| R9       | Insurance                       | R20      | Transportation                   |
| R10      | Software and Services           | R21      | Food and Beverage                |
| R11      | Consumer Services               |          |                                  |

#### TABLE A2  Results of the unit root test at level

| Variable | $t$-test   | Prob. | Variable | $t$-test   | Prob. |
|----------|------------|-------|----------|------------|-------|
| R1       | −10.1685   | .0000 | R12      | −9.8574    | .0000 |
| R2       | −9.4539    | .0000 | R13      | −10.9880   | .0000 |
| R3       | −8.6256    | .0000 | R14      | −8.7220    | .0000 |
| R4       | −9.4556    | .0000 | R15      | −10.3157   | .0000 |
| R5       | −11.0136   | .0000 | R16      | −10.9680   | .0000 |
| R6       | −13.1356   | .0000 | R17      | −10.0929   | .0000 |
| R7       | −11.3741   | .0000 | R18      | −12.8700   | .0000 |
| R8       | −9.8089    | .0000 | R19      | −10.0400   | .0000 |
| R9       | −10.2068   | .0000 | R20      | −9.9558    | .0000 |
| R10      | −9.6773    | .0000 | R21      | −9.7225    | .0000 |
| R11      | −10.7853   | .0000 | Rm       | −9.9133    | .0000 |

#### TABLE A3  Heteroscedasticity test: ARCH and AR(1) test: Durbin-Watson

| Indep. var | ARCH test |       | DW test | Indep. var | ARCH test |       | DW test |
|------------|-----------|-------|---------|------------|-----------|-------|---------|
|            | $F$       | Prob. |         |            | $F$       | Prob. |         |
| R1         | 0.1003    | .7521 | 2.0008  | R12        | 10.3823   | .0017 | 2.0147  |
| R2         | 1.5929    | .2095 | 2.0642  | R13        | 0.3454    | .5579 | 2.0325  |
| R3         | 0.3391    | .5615 | 1.4539  | R14        | 0.1863    | .6668 | 1.7969  |
| R4         | 1.5101    | .2216 | 2.0302  | R15        | 4.2543    | .0414 | 1.9069  |
| R5         | 8.1568    | .0051 | 2.0381  | R16        | 7.8097    | .0061 | 2.2007  |
| R6         | 6.7879    | .0104 | 2.3420  | R17        | 7.8621    | .0059 | 1.6208  |
| R7         | 0.9433    | .3335 | 2.0435  | R18        | 9.4813    | .0026 | 2.2567  |
| R8         | 0.8777    | .3508 | 1.5625  | R19        | 0.1522    | .6971 | 1.6534  |
| R9         | 0.0416    | .8388 | 2.1770  | R20        | 1.9789    | .1622 | 2.0472  |
| R10        | 0.3461    | .5575 | 1.7898  | R21        | 0.4405    | .5082 | 1.7586  |
| R11        | 1.0202    | .3146 | 2.2088  |            |           |       |         |

Note: Bold F value indicates reject $H_0$ of no ARCH effect against the presence of ARCH effect at $\alpha = \text{Prob}$; Bold DW value denotes rejecting $H_0$ of no autocorrelation against the existence of positive autocorrelation at $\alpha = 0.5$. Durbin Watson's critical values at a significance level of 5% are $d_L = 1.720$ and $d_U = 1.747$. 
TABLE A4  The estimated parameters $\hat{\alpha}$s and $\hat{\beta}$s for the 21 models

| Indep. var | $\hat{\alpha}$ | $\hat{\beta}$ | Indep. var | $\hat{\alpha}$ | $\hat{\beta}$ |
|------------|----------------|---------------|------------|----------------|---------------|
| R1         | 0.0014         | 0.9768        | R12        | -0.00005       | 0.4758        |
| R2         | 0.0005         | 0.4666        | R13        | -0.0001        | 0.6557        |
| R3         | -0.00003       | 0.6644        | R14        | 0.0016         | 0.6462        |
| R4         | -0.0008        | 1.0580        | R15        | 0.0003         | 0.5377        |
| R5         | 0.00058        | 0.5602        | R16        | 0.00055        | 0.2280        |
| R6         | 0.00028        | 0.5352        | R17        | -0.00001       | 0.5630        |
| R7         | -0.0007        | 1.1948        | R18        | -0.000004      | 0.5499        |
| R8         | 0.0001         | 1.2341        | R19        | -0.00004       | 0.9769        |
| R9         | 0.0009         | 0.7038        | R20        | 0.0019         | 0.6956        |
| R10        | -0.0008        | 0.6509        | R21        | 0.0006         | 0.8535        |
| R11        | 0.0019         | 0.7226        |

APPENDIX B.

The ARCH(1) can be depicted as

$$R_{k,t} = \alpha_k + \beta_k R_{m,t} + \epsilon_{k,t},$$

$$\epsilon_{k,t} \mid \Omega_{t-1} \sim N(0, h_{k,t}) ,$$

$$h_{k,t} = \omega + \alpha_1 \epsilon_{k,t-1}^2$$  \hspace{1cm} (B1)

where $\omega > 0$ and $\alpha_1 \geq 0$.

The generalized least squares can be summarized as

$$R_{k,t} = \alpha_k + \beta_k R_{m,t} + \epsilon_{k,t}$$

$$\epsilon_t = \rho \epsilon_{t-1} + u_t$$  \hspace{1cm} (B2)

where $|\rho| < 1$, $E(u_t) = 0$, $E(u_t^2) = \sigma_u^2$ and $E(u_t u_s) = 0$ if $t \neq s$.

Model (B2) is to be transformed to get

$$R^*_{k,t} = \alpha_k + \beta_k R^*_{m,t} + \epsilon^*_{k,t},$$

where $R^*_{k,t} = R_{k,t} - \rho R_{k,t-1}$, $R^*_{m,t} = R_{m,t} - \rho R_{m,t-1}$ and $\epsilon^*_{k,t} = \epsilon_{k,t} - \rho \epsilon_{k,t-1}$. Thus, the error vector $\epsilon^*_{k,t}$ has mean $E(\epsilon^*_{k,t}) = 0$ and covariance $E(\epsilon^*_{k,t} \epsilon^*_{s,t}) = \sigma^2 \Omega$, which lead us to an uncorrelated and identical random error process. Thus, we can estimate the model (B4) by the OLS estimation to get

$$\hat{R}^*_{k,t} = \hat{\alpha}_k + \hat{\beta}_k R^*_{m,t},$$

The autocorrelation coefficient $\rho$ is estimated as

$$\hat{\rho} = \frac{\sum_{t=1}^{n} (\epsilon_t \epsilon_{t-1})^2}{\sum_{t=1}^{n} \epsilon_t^2},$$

and the first observation is computed as

$$R^*_{k,1} = R_{k,1} \sqrt{1 - \rho^2}$$

and

$$R^*_{m,1} = R_{m,1} \sqrt{1 - \rho^2}.$$