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Journal of Economic Studies

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King Saud University – College of Business Administration

Saudi Economic Association

P.O. Box: 71115, Riyadh: 11587

Tel: 0114674141, Fax: 0114674142

Email: esj@ksu.edu.sa

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The Impact of COVID-19 on the Saudi Stock Market across Different Sectors (TADAWUL) (An Empirical Study Using the NARDL Model)

Nouf S. Alnafisah [(1)]

(Received: April 24, 2023 – Accepted for publication: October 30, 2023)

Abstract: This study scrutinizes the asymmetric impact of COVID-19 on the Saudi stock market and various sectors, specifically focusing on the TASI (Tadawul All Share Index) and their response to policies restricting international mobility. The analysis employs the NARDL (Non-Autoregressive Distributed Lag) model, covering the period from March 5, 2020, to August 26, 2020. The findings suggest that the TASI index, including the media and food sectors, does not demonstrate a significant long-term response to confirmed COVID-19 infections. Conversely, the health, energy, and insurance sectors exhibit asymmetric and significant relationship with the health crisis. Additionally, the study reveals a significant and positive effect of international travel restrictions on the insurance, banking, and telecommunication sectors.

Keywords: impact, covid-19, TASI, travel restrictions, NARDL.

تأثير فايروس كورونا (كوفيد-١٩) على سوق الأسهم السعودي في قطاعات مختلفة (دراسة تجريبية باستخدام نموذج NARDL)

نوف سعود النفيسة (1)

(قُدِّم للنشر 1444/10/03هـ - وقُبِل 1445/04/15 هـ)

المستخلص: أجريت هذه الدراسة لاستكشاف التأثير غير المتماثل لفيروس COVID-19 على المؤشر العام TASI (مؤشر تداول لجميع الأسهم) وقطاعات مختلفة في سوق الأسهم السعودي. تم ذلك من خلال تقدير ٥ نماذج، بالإضافة إلى قياس مدى استجابة السوق للسياسات التي تحد من حركة التنقل الدولي. تستخدم الدراسة نموذج NARDL (نموذج الانحدار الذاتي الموزع غير الخطي) وتغطي الفترة من 5 مارس 2020 إلى 26 أغسطس 2020. وتشير النتائج التي تم التوصل إليها إلى أن مؤشر سوق الأسهم السعودي TASI، وقطاع الأعلام والأغذية لا يظهر استجابة طويلة المدى لحالات الإصابة المؤكدة بكرونا بينما في قطاع الصحة والطاقة والتأمين يظهر علاقة معنوية غير متماثلة مع الأزمة الصحية في الأجل الطويل. كذلك تظهر النتائج أن تأثير زيادة حالات الإصابة بفيروس كورونا أكبر من تأثير انخفاضها. وتوضح الدراسة أن قيود السفر الدولية كان لها تأثيراً إيجابياً على قطاعات التأمين والبنوك والاتصالات.

الكلمات المفتاحية: فايروس كرونا، أثر، سوق الأسهم، قيود السفر، انحدار غير خطي.

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(1)Princess Nourah bint Abdulrahman University, Economics Department, Lecturer
PHD Student at King Saud University, Economics Department.

(1) محاضرة في قسم الاقتصاد، جامعة الأميرة نورة بنت عبد الرحمن.
طالبة دكتوراه في قسم الاقتصاد، جامعة الملك سعود.

E-mail: noufsaud1506@gmail.com

Introduction

The recent outbreak of the SARS-CoV-2 virus has garnered significant attention due to its broad spectrum of symptoms and high transmission rate. Throughout history, humanity has faced numerous diseases and pandemics. In recognition of the severity and global reach of the situation, the World Health Organization (WHO) declared COVID-19 a global pandemic on March 11, 2020.

According to Youssef et al. (2021). the COVID-19 pandemic has had a substantial impact on financial markets worldwide, surpassing the effects of the SARS pandemic in 2003 and the Global Financial Crisis in 2008 in terms of both scope and significance. Government-imposed restrictions, implemented to minimize person-to-person contact and address public health concerns, have had adverse consequences on businesses' cash flow and have led to a surge in unemployment rates, further exacerbating the situation.

He et al. (2020), Al-Awadhi et al. (2020), Ashraf and Badar Nadeem (2020), and Goodell and John (2020) have conducted extensive research and provided documented evidence of the effects of the pandemic on financial markets, showcasing the far-reaching impact it has had. The COVID-19 outbreak is resulting in unparalleled economic devastation worldwide, and there are indications that the health crisis will be followed by a subsequent economic crisis, as previously observed by Qiu et al. (2017).

Governments across the globe are taking significant measures to support markets in response to the profound threat posed by the pandemic to public health and the global economy at both national and international levels. However, the economic impact of COVID-19 extends beyond its magnitude; it has also resulted in adverse consequences such as permanent market closures, enduring employment losses, and other challenges during the ongoing pandemic, as outlined by Evans (2020). Similarly, the current coronavirus outbreak has been observed to have widespread and substantial effects on financial markets, as highlighted by Zhang et al. (2020). Alber and Saleh (2020).

This study seeks to analyze the effects of COVID-19 on the Saudi stock market, specifically the TASI (Tadawul All Share Index), and evaluate its impact on the market's eight sectors. The primary objective is to provide guidance to investors during the health pandemic and assess the influence of policy restrictions, particularly international travel restrictions, on the stock market. The study aims to contribute by examining how COVID-19 has affected the Saudi Arabian stock market across different sectors, as well as analyzing the responses of the financial market to government measures implemented to mitigate the impacts of the pandemic, such as travel restrictions.

The remaining sections of this paper are structured as follows: The first section provides an overview of COVID-19 in Saudi Arabia. The second section reviews previous research in this field, which forms the basis for the theoretical arguments presented in this study. The third section explains the data and methodology employed. The fourth section delivers the results from the empirical analysis. Finally, the fifth section concludes the paper by summarizing the key findings and their implications.

1. COVID-19 in Saudi Arabia:

The first documented cases of COVID-19 in Saudi Arabia were reported on March 2, 2020. Figure 1 illustrates a significant surge in the number of cases during March, coinciding with the implementation of international travel restrictions aimed at containing the rapid spread of the virus. Internal travel restrictions were also imposed and gradually intensified until they reached their peak by the end of June 2020, during which the country witnessed a daily peak of approximately 5000 cases. However, starting from July 2, 2020, there was a gradual decline in the daily number of cases.

In addition to the transmission of the disease, various mitigation measures were implemented in Saudi Arabia to curb the spread of COVID-19. These measures encompassed the closure of schools and workplaces, travel restrictions, implementation of stay-at-home requirements, and the introduction of mandatory vaccination campaigns. These policies have proven effective in controlling the spread of the virus within the country, as evidenced by the downward trend in the number of reported cases.

This study focuses on analyzing the influence of the aforementioned policies on the Saudi stock market (Tadawul All Share Index - TASI) and its eight sectors. It specifically examines the impact of international travel restrictions on the stock market and evaluates how the financial market has responded to these policy measures. This study's results are anticipated to offer significant insights to investors, enabling them to make informed decisions amid the ongoing pandemic. Additionally, policymakers can utilize these findings to develop more effective strategies and policies to mitigate the economic impacts of the pandemic.

The COVID-19 pandemic has indeed had a profound impact on the global economy, including the financial markets. Its effects have been widespread and have necessitated extraordinary measures by governments worldwide to support markets and ensure public health. This study makes a valuable contribution by examining the specific influence of COVID-19 on the Saudi Arabian stock market. It further analyzes how the market has responded to policies implemented to mitigate the adverse impacts of the pandemic.

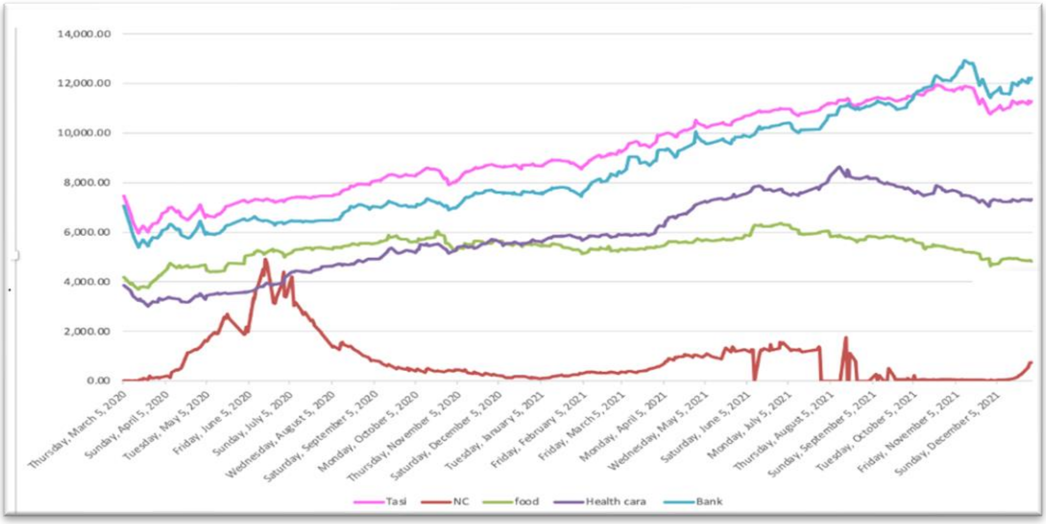

Figure 1: COVID-19 confirms new cases and TASI with a group of industries Source Author's calculation based on WHO data.

2. literature review

In this section, we will review the existing literature on the impact of COVID-19 on the financial market. We will organize our review around three primary areas. First, we will summarize studies that have examined how the financial market responded to the health pandemic. Next, we will provide an overview of the policies that have been implemented to minimizing the negative effects of the pandemic on the stock market. Finally, we will present the sectors most affected by the health pandemic and represent studies of Saudi Arabia, focusing on how COVID-19 has impacted the financial stock market, specifically the Tadawul. Our review will provide a comprehensive understanding of the current state of knowledge on the impact of COVID-19 on the financial market and highlight areas for further research.

The financial markets in the USA displayed direct reactions to the pandemic as early as March. Ramelli and Wagner (2020) identified three distinct phases from early January to the end of March. The cross-sectional methodology of international firms to estimate COVID-19 stock market responses was used in the study, which concluded just before the Federal Reserve's announcement. Recent studies, such as those conducted by Gormsen and Koijen (2020) and He et al. (2020), indicate a significant increase in risks for all countries in March as COVID-19 spread to over 200 locations.

Other studies have demonstrated that the health pandemic caused stock market fluctuations due to investor concerns and pessimism regarding future earnings, resulting in significant financial consequences for markets (Liu et al., 2020). When comparing the recent health pandemic with previous outbreaks, YH Saif-Alyousfi (2022) found unclear results regarding the epidemic's impact on the stock market. in 88 countries across the Americas, Europe, Asia-Pacific, the Middle East, and Africa used panel technique . However, Nippani and Washer (2004) discovered that the SARS outbreak had a negative impact on the stock markets of China and Vietnam.

Regarding policy and government restrictions, Baker et al. (2020) conducted an assessment of the stock market's reaction to the COVID-19 pandemic and suggested that government restrictions played a significant role in the strong reaction of the U.S. stock market compared to previous periods. Zhang et al. (2020) confirmed the positive impact of government policies on stock market returns. Regarding international restrictions, Sinaga et al. (2022) found that the impact of such restrictions was relatively minor.

In terms of sectors and the influence of the health pandemic, Ichev and Marinč (2018) stated that industries such as biotechnology, food and beverage, healthcare supplies, and pharmaceuticals were positively affected by the Ebola outbreak, while other industries experienced significantly negative effects. Schoenfeld (2020) found that in U.S industries such as gas and oil, clothing, automobiles, transportation, machinery, and hospitality were most negatively impacted by COVID-19 on stock markets. Additionally, Goodell and John (2020) noted that the financial sector, including banks and other financial institutions, was significantly affected by the pandemic due to an increase in non-performing loans resulting from income losses among borrowers and a substantial number of depositor withdrawals in the short run. Chen et al. (2007) and Chen et al. (2009) investigated the impact of the SARS epidemic on the Taiwan stock market and discovered a negative relationship between the disease outbreak and stock returns in the hotel business, tourism, wholesalers, and the retail sector.

Indeed, several studies have examined the impact of COVID-19 on the Saudi Arabian economy through stock market indicators. Tissaoui et al. (2021) conducted research on the Saudi stock market during the COVID-19 outbreak and focused on analyzing the relationship between realized volatility and stock market illiquidity. They found that both the direct and long-term effects of market volatility on liquidity were significant.

Sayed and Eledum (2021) employed an event study methodology to investigate the short-term impact of COVID-19 on various sectors of the business world in Saudi Arabia. The study revealed that different sectors reacted differently to the pandemic, with positive results observed in the food and beverage production industry.

The main counternutation of this study is investigating the relationship between stock market indexes and COVID-19 new cases. It utilizes the closing values of a specific set of stock market indexes. Our analysis makes a valuable contribution to the existing literature on the correlation between index prices and COVID-19 by employing the nonlinear autoregressive distributed lag (NARDL) approach. This methodology enables the investigation of potential asymmetry in both the short and long run.

The main hypothesis

The main hypotheses of this study are as follows:

1. There is asymmetric impact of COVID-19 on the Saudi stock market ((Tadawul All Share Index - TASI)) and other sector indexes.
2. International travel restrictions have negative effects on the Saudi stock market index.

3. Data and Methodology

This study applies the Non-Autoregressive Distributed Lag (NARDL) framework, developed by Shin, et al. (2014). It utilizes daily time series data from March 5, 2020, when the first confirmed COVID-19 cases were recorded in Saudi Arabia, until August 26, 2020. Daily confirmed cases of COVID-19, serving as an indicator of the pandemic's severity, are used as an independent variable following the approach outlined by Sansa (2020). It concentrates on the impact of COVID-19 on the Saudi Arabian stock market, specifically the TASI stock market index, and eight sectoral stock market indices. These sectors include energy, materials, media and entertainment, food production, healthcare equipment and services, banks, insurance, and telecommunication services. These sectors were selected based on the assumption that they would be more negatively affected by the pandemic. To incorporate the influence of government regulations and restrictions, a dummy variable named "external movement restrictions" (ITR) is included in the analysis. This variable assumes a value of 0 when no policy is in place and 1 when the policy is implemented. Data for this variable are sourced from the Oxford COVID-19 Government Response Tracker database (Hale et al., 2021).

Recognizing the importance of oil prices to the Saudi stock market, crude oil prices are included as an additional independent variable, with data obtained from the Energy Information Administration (EIA). From March 16, 2020, the international restriction variable will take a value of 1, and before that, it will assume a value of 0.

The Non-Autoregressive Distributed Lag (NARDL) approach is employed to estimate asymmetry in short- and long-run relationships between the pandemic and the stock market. This study extends the research conducted by Pesaran et al. (2001), who initially proposed a non-linear NARDL cointegration approach to analyze both short-term and long-term impacts. Subsequently, Shin et al. (2014) introduced an alternative methodology demonstrating both long-run and short-term asymmetric effects within the variables.

The assumed asymmetric long-run equation represents some sectoral market indexes employed. The methodology begins by examining the non-linearity of the relationship using the BSD test before conducting a unit root test to ascertain the presence of cointegration among a group of variables, which may have different orders of integration (I(0), I(1), or a combination thereof). The NARDL model offers the advantage of determining the asymmetric effects, both in the short-run and long-run, of independent variables on the dependent variable. This methodology has emerged as a crucial approach for explaining the presence of asymmetric effects among variables. The methodology has emerged as an important approach for explaining the presence of asymmetric effects among variables. The asymmetric long-run equation between the Market index (IN_{ti}) and number of cases (NC_{it}) and Oil price (OIl_{it})is formulated based on the studies conducted by Shin et al. (2014) and Sahin and Berument (2019). The study estimates the following model:

$$LIN_t = \theta_0 + \theta_1 NC_t^+ + \theta_2 NC_t^- + \theta_3 Oil_t^+ + \theta_4 Oil_t^- + \beta ITR_t + e_t \quad (1)$$

In this analysis, the variable IN denotes the market index, which comprises various sectors in addition to the main market index such as energy, materials, media and entertainment, food production, healthcare equipment and services, banks, insurance, and telecommunication services. The main market index is represented by TASI. Moreover, NC signifies the number of confirmed COVID-19 cases, and ITR stands for international restrictions. The crude oil price is yet another variable considered in this study to test the asymmetry. Here, 'i' denotes the different indices within the estimation, and 't' represents time.

The analysis takes into account the diverse market indices that cover various industries, thereby reflecting the comprehensive scope of the study. By integrating the confirmed COVID-19 cases (NC), the research can probe into the pandemic's impact on market indices. Furthermore, the incorporation of international restrictions (ITR) provides a complete understanding of how policies influence the market.

Crude oil prices (Oil), which play a significant role in the global economy and particularly in the Saudi economy (Azar & Loucine Basmajian, 2013), are also included in the study. These variables facilitate researchers to investigate the relationship between market indices, COVID-19 cases, restrictions, and fluctuating oil prices. $\theta_1, \theta_2, \theta_3, \theta_4$ represent the cointegration vector for the long-run coefficient, while ., e_t is the error correction term.

$$NC_t^+ = \sum_{i=1}^{t} \Delta NC_t^- = \sum_{i=1}^{t} \max(\Delta NC_i, 0). \quad (2)$$

$$Oil_t^+ = \sum_{i=1}^{t} \Delta OIl_t^+ = \sum_{i=1}^{t} \max(\Delta Oil_i, 0). \quad (3)$$

Moreover,

$$NC_t^- = \sum_{i=1}^{t} \Delta NC_t^- = \sum_{i=1}^{t} \max(\Delta NC_i, 0). \quad (4)$$

$$Oil_t^- = \sum_{i=1}^{t} \Delta Oil_t^- = \sum_{i=1}^{t} \max(\Delta Oil_i, 0) \quad (5)$$

The long-term relationship between the progression of NC (number of confirmed COVID-19 cases) and sectoral stock market indices is signified. $\theta_1, \theta_2, \theta_3, and\ \ \theta_4$ Assumed to be negative in equation (1), it suggests a negative long-term relationship between declines in NC (number of confirmed COVID-19 cases) and sectoral stock market prices. That is, they are presumed to move in opposite directions. It is also hypothesized that a decrease in NC may affect the long-term deviation of the sectoral stock market index differently than an increase in NC of the same magnitude.

Table1: Variable description

	Description	Source
NC	Independent variable represent the confirmed cases of covid-19	World Health Organization
ITR	international Travel control —ordinal variable with the following categories: 0—no measures; 1—Ban on all regions or total border closure	Oxford COVID-19 Government Response Tracker (Ox CGRT) database
OIL	Brent Spot Price for Crude Oil (Dollars per Barrel). The price of crude oil is a significant marker for the global economy. Brent Crude is the international benchmark for oil prices, accounting for around two-thirds of all oil prices.	Energy Information Administration
TASI	dependent variable	Investing.com
BANK	Banking index in Saudi Stock market including 12 firm	
Energy	Energy index in Saudi Stock market countian 6 firms	
Food	Production food index in Saudi Stock market countian 14 firm	
Healthcare	Healthcare index in Saudi Stock market countian 8 firms	
Telecomm	Telecommunication index in Saudi Stock market countian 4 firms.	
Insurance	Insurance index in Saudi Stock market countian 27 firms	
Medi& entertainment	Media and entertainment index in Saudi Stock market countian 3 firms	
Material	Essential material index in Saudi Stock market countian 43 firm	

Note: *All variables convert to the natural Log except NC, Oil, and ITR is a dummy variable.*

Consequently, θ_1 and θ_2 are not equal. Similarly, θ_3 and θ_4 This suggests a long-term relationship between declining oil prices and sectoral stock market prices. However, these are presumed to be positive, implying they will move in the same direction. Equation (1) demonstrates that NC (number of confirmed COVID-19 cases) and oil prices are nonlinear, as proven in the BDS section.

4. Estimated Results

In the estimation process, we typically follow a step-by-step approach. We begin by conducting a BDS to test the non-linearity of variabilities. Examine the unit root test to examine the stationarity of the variables by applying the PDF and PP tests and determining the structural break. After the unit root test, we proceed with the F-bound test to assess the presence of cointegration among the variables. Once cointegration is confirmed, we move on to estimating the NARDL model (Non-Autoregressive Distributed Lag model). Next, we evaluate the error correction model (ECM) alongside the NARDL model. Lastly, we perform Wald test diagnostics for the estimated models. These diagnostics involve assessing goodness of fit, model specification, and detecting any statistical issues or assumption violations.

4.1 Descriptive data

To provide a comprehensive overview of the data, we present descriptive statistics along with Figure 2 to visualize the data and its characteristics. Table 2 includes maximum and standard deviation values, which provide valuable information about the variability and range of the data. These statistics offer essential context for understanding the variables.

Table 2: Descriptive statistics of the variable

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness
TASI	8.86	8.89	8.98	8.69	0.07	-0.45
BANK	8.75	8.76	8.87	8.59	0.06	-0.18
OIL	32.42	36.88	45.90	12.17	9.72	-0.500
ENERGY	8.49	8.50	8.58	8.37	0.045	-0.49

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness
FOOD	8.47	8.51	8.62	8.21	0.11	-0.68
HEALTH	7.84	7.83	7.95	7.73	0.051	0.29
MATERIAL	8.38	8.39	8.58	8.11	0.12	-0.175
MEDIA	8.36	8.40	8.50	8.15	0.09	-0.55
NC	8.89	8.99	8.96	8.823	0.032	-0.40
TELECOM	1790.14	1595.00	4919.00	0.00	1327.23	0.40

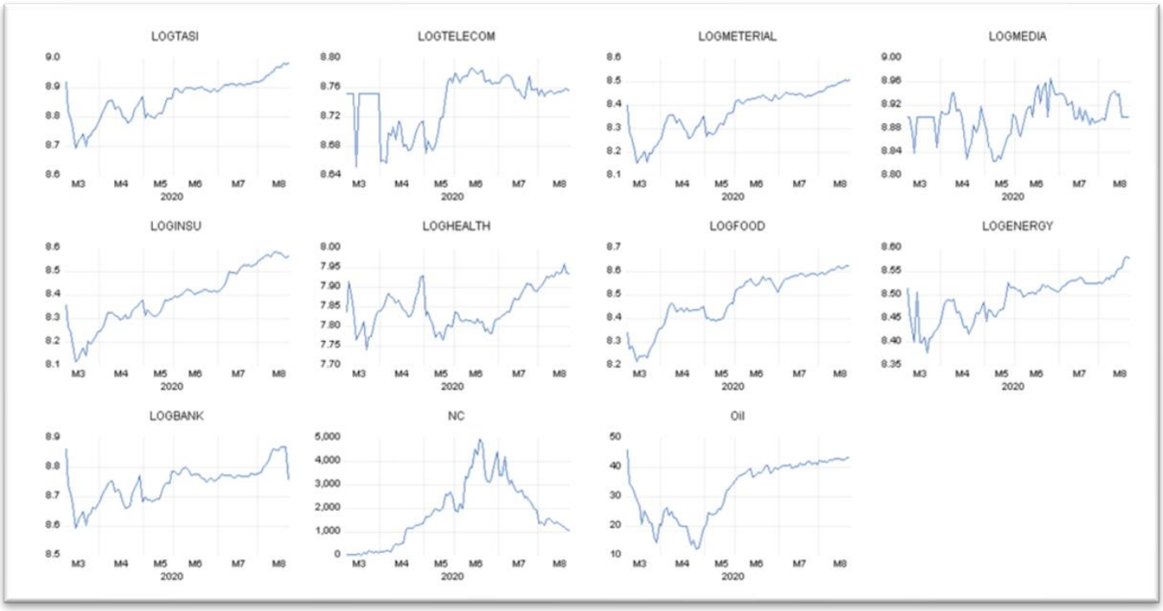

Figure 2: Displays the variables that were considered.

4.2 BDS test

The first thing to do in the empirical analysis of this study is testing the data for nonlinearity to determine the suitability of the models being employed. The study employs the BDS nonlinearity test by Brock et al. (1996) to ascertain the presence of nonlinear interdependence in the dataset. The BDS test is utilized to examine the residuals of the series. The occurrence of nonlinearity in the data occurs when the test statistic is greater than the critical value for the standard normal distribution at the significance levels. The BDS nonlinearity test utilizes the correlation integral of the time series as its foundation. The BDS test is performed using the following equation:

$$W_m(\varepsilon, T) = \frac{\sqrt{T[C_m(\varepsilon, T) - C_1(\varepsilon, T)^m]}}{\sigma_m(\varepsilon, T)}, \qquad (6)$$

$W_m(\varepsilon, T)$denotes the BDS test statistic$\sigma_m(\varepsilon, T)$ represents the standard deviation for $C_m(\varepsilon, T)$, and m refers to the embedding dimension, ε the maximum difference between pairs of data points, and T is the length of the time series. The BDS test is commonly used to detect nonlinearity in time series data, as it measures the degree of dependence between different points in the time series. By comparing the test statistic to critical values from the standard normal distribution at various significance levels, researchers can determine if there is evidence of nonlinearity in the data. observations that are taken in to account when calculating the correlation integral. The BDS procedure exhibits an asymptotic normal distribution, characterized by a mean of zero and a variance of one, denoted as N(0,1). The null hypothesis in the BDS nonlinearity test posits that the observed data follows an independently and identically distributed (iid) pattern. The null hypothesis regarding linearity is deemed invalid if the calculated test statistic surpasses the critical value at the customary significance level. The null hypothesis is rejected when there is evidence of nonlinear dependence in the data. Brock et al. (1996) offers a comprehensive exposition of the BDS framework, providing an in-depth account of its various components and intricacies. If the Boycott, Divestment, and Sanctions (BDS) test is applied.

Table 3: BDS test of independence

Dimension (m)	Tasi	bank	Energy	Material	Health care	Media	Food	Insurance	NC	Oil
2	0.157***	0.1422***	0.1484***	0.158**	0.145***	0.1320***	0.1759***	0.177***	0.1647***	0.1620***
3	0.259***	0.230***	0.239***	0.265***	0.2302***	0.205***	0.296***	0.298***	0.277***	0.273***
4	0.326***	0.283***	0.301***	0.334***	0.2781***	0.243***	0.375***	0.377***	0.3529***	0.350***
5	0.371***	0.319***	0.346**	0.375***	0.310***	0.263***	0.427***	0.4343***	0.398***	0.3962***
6	0.402***	0.348***	0.378***	0.407***	0.3282***	0.295***	0.462***	0.474***	0.4260***	0.422***

Note: **** representing the significant level at 1%.*

The output of the test in Table 3 shows that, it is in favor of the rejection of the null hypothesis, and it confirms the non-linear dependency of all the series at a 1% significant level.

4.3 The Unit Root test Result

Starting with the unit root test, the results of the unit root test ADF (Dickey & Fuller, 1979) and Phillips-Perron (PP) address the potential issue of biased results resulting from the ADF and PP tests in detecting structural breaks. We presented the findings of the Zivot-Andrews (ZA) test, which Zivot et al. (1992) proposed, in Table 4. The table shows the ADF and PP tests at the level and in the first difference. The majority of the 11 variables are stationary at the level except for a number of cases, Telecom, and the NC at the first difference. In order to ascertain the integration order of the variables, the outcomes of the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are presented in Table 4, indicating that the independent variables and four dependent variables exhibit non-stationarity in their level forms. We presented the findings of the Zivot-Andrews (ZA) test, which Zivot and Andrews (1992) proposed, to address the potential issue of biased results resulting from the ADF and PP tests in detecting structural breaks. The unit root testing method was developed by Zivot and Andrews in 1992. The proposed methodology demonstrates resilience in addressing concerns related to structural breaks within the dataset. Considering the existence of at least one structural break within the dataset, the models being examined are labeled as A, B, and C. Model A represents Zivot-Andrew’s approach, where the structural break is permitted to occur in the intercept. Model B represents Zivot-Andrew’s approach, where the structural break is allowed to occur in the trend. Model C represents the Zivot-Andrew’s approach, where the structural break is permitted to occur in both the intercept and the trend. In the present study, model C is employed. This model is designed to forecast test statistics based on the unconditional hypothesis of non-stationarity as opposed to the alternative hypothesis of stationarity. The series in question is assumed to have had a single break at an unidentified point in time. The analysis of unit roots is typically conducted prior to the analysis of cointegration. Sen (2003) suggested that model C is better than all the remaining models; therefore, this study will use it. For these purposes, we have chosen to apply the C model, which will be executed according to the following equation:

Model C:

$$Model\ C: \Delta y = \sigma + \hat{u} y_{t-1} + \beta t + \theta DT_t \gamma DU_t + \sum_{j=i}^{t} d_j \Delta y_{t-1} + \varepsilon_t \qquad (7)$$

$$DU_t = \begin{cases} 1 \ldots\ldots\ldots\ldots if\ t > TB \\ 0 \ldots\ldots..\ldots if\ t < TB \end{cases} \quad and \quad DU_t = \begin{cases} t - TB \ldots\ldots if\ t > TB \\ 0 \ldots\ldots.\ldots if\ t < TB \end{cases} \qquad (8)$$

DUt represents the mean shift of the dummy variable at a potential break date for the corresponding variable being employed.

The results obtained from the Zivot-Andrews unit root test indicate that the variables are commonly integrated at the level and the first difference, except Telecom and log bank have structural breaks at 6/04/2020, and 4/08/2020 respectively.

Table 4: Unit Root test

	ADF-Test an intercept and trend		**PP-Test an intercept and trend**		**ZA -Test an intercept and trend**	
	I(0)	I(1)	I(0)	I(1)	T statistic	Break point
LogTASI	-6.0315***	-10.0986***	-6.0195***	-10.23***	-4.06***	4/08/2020
LogEnergy	-2.938	-13.521***	-6.1347***	-13.79***	-7.33**	5/18/2020
Logtelecom	-3.376**	-12.48***	-3.367*	-13.10***	-13.13	6/04/2020
LogMeterial	-4.9759***	-10.0072***	-5.2456***	-10.11***	-11.88**	4/07/2020
LogInsurance	-5.5152***	-9.0562***	-5.6282***	-9.085***	-4.95***	5/04/2020
LogFood	-2.0377	-9.416***	-2.6476	-9.398***	-10.67**	9/04/2021
LogHealth	-2.497	-10.602***	-2.497	-10.602***	-5.093**	5/04/2020
LogBank	-5.966***	-8.488***	-6.024***	-8.46***	-8.99	4/08/2020
Logmedia	-3.553**	-11.144***	-4.4026***	-9.341***	-9.180**	5/12/2020
NC	-0.9184	-10.1295***	-0.8494	-10.132***	-6.453***	6/08/2020
Oil	-5.114***	-10.44**	-4.808***	-19.551***	-5.60**	5/14/2020

Note: *The null hypothesis that the series has a unit root. The break dates are determined by the critical values for the t-statistic at significance levels of 1%, 5%, and 10% are -5.57, -5.08, and -4.82, respectively, as recommended by the Zivot-Andrews (ZA) method. *, **, and *** indicate the level of significance level of statistic 10%, 5%, and 1%, respectively.*

According to the Saudy Press Agencey (2020, April 6), a 24-hour curfew was imposed on several cities in Saudi Arabia." the Saudi government has started the restrictive policies Starting Monday, April 6, curfews placed in the cities of Riyadh, Jeddah, Dammam, Tabuk, Dhahran, and Hafouf for 24 hours a day, and governorates will restrict entry and exit from certain areas until further notice. Residents can only leave for necessities like medical care and food supplies, and businesses operating within these areas are allowed. In addition, the study also identifies the specific days on which structural breaks occurred to address the structural break we add two dummy variables dummy1, and dummy2 in the model of bank and telecom. The verification of the stationarity of the variables enables us to proceed with the nonlinear cointegration analysis.

4.4 Bound test

To perform the bounds test, we compare the calculated F-statistic to critical values provided by Narayan .(2004), at a significance level of 5%. If the F-statistic is higher than the upper bound critical value, it suggests the presence of a long-run relationship between the variables. By applying this test, we can determine whether there is evidence of a long-run relationship among the variables. If the F-statistic exceeds the upper bound critical value, it provides support for the existence of a long-run relationship. The bounds test allows us to assess the presence or absence of a long-term relationship between the variables, assisting in further analysis and modeling decisions.

Table 5: Bound test result

			Critical Value at 5%		
Model	**Model specification**	**F- statistic**	**LP.**	**UP**	**Conclusion**
1	LogTASI; $(NC^{+}, NC^{-}, oil^{+}oil^{-})$	3.45	2.65	3.49	No Cointegration
2	LogEnergy $(NC^{+}, NC^{-}, oil^{+}oil^{-})$	5.41	2.39	3.38	Cointegration
3	Logtelecom $(NC^{+}, NC^{-}, oil^{+}oil^{-})$	4.45	2.39	3.38	No Cointegration
4	LogMeterial $(NC^{+}, NC^{-}, oil^{+}oil^{-})$	3.12	2.39	3.38	Cointegration
5	LogInsurance $(NC^{+}, NC^{-}, oil^{+}oil^{-})$	5.23	2.39	3.38	Cointegration
6	LogFood $(NC^{+}, NC^{-}, oil^{+}oil^{-})$	3.07	2.39	3.38	No Cointegration
7	LogHealth $(NC^{+}, NC^{-}, oil^{+}oil^{-})$	4.44	2.39	3.38	Cointegration
8	LogBank $(NC^{+}, NC^{-}, oil^{+}oil^{-})$	6.56	2.38	3.38	Cointegration
9	Logmedia $(NC^{+}, NC^{-}, oil^{+}oil^{-})$	3.27	2.38	3.38	No Cointegration

Notes*: Critical values at 5% significance level.*

The NARDL bound test result represents in table 7, it shows that 5 models have a cointegration; they are as follow: energy, telecom, insurance, health, and bank, Where the F-statistic is greater than the upper bound value at 5%, reject the null hypothesis of no cointegration and confirm the existence of symmetric cointegration.

4.5 NARDL Estimation

The estimation of the long-run and short-run asymmetry of the NARDL model is represented in Table 6. In the long run, as shown in panel A of the energy model, the positive value of NC (number of confirmed COVID-19 cases) has a statistically insignificant impact on the logenergy. For instance, an increase in the number of cases by 1 leads to a decline in the energy index by 0.000005%, which is a very small effect. The negative value, however, is not significant at 5%. In terms of oil, the positive value has a significant impact at the 5% level. Thus, if the price of oil rises by 1 dollar, this leads to a decrease in the energy index of 0.0016%. However, a decrease in the oil price (the negative value) is not statistically significant.

In contrast to the energy model, the insurance model shows that the negative value of the number of cases has a positive and significant impact on the insurance index at the 1% level, by 0.000004%. Moreover, the health model estimates an increase in the health index by 0.0000434 at the 5% level when the number of cases declines by one unit.In the banking model, increasing the number of cases significantly decreases the bank index in the long run by 0.000007 at the 5% level. Similarly, in the telecom industry, a decline in the number of cases by one unit leads to a decline in the telecom index by 0.000038% at a 5% significant level.

Regarding the oil price, both positive and negative values in the previous period increased the bank index. Specifically, when the oil price increased by one unit, it increased the bank sector by 0.001% at the 10% level. Interestingly, international travel restrictions have a significant positive impact on the insurance index at the 2% level.

Table 6: Non-Linear ARDL Estimation output

	Model (2,0,0,0,0,0)	Model (1,0,0,1,0,1)	Model (1,0,0,2,0,1)	Model (1,0,0,2,0,1)	Model (1,0,0,2,1,2)
	LogEnergy	**LogInsurance**	**LogHealth**	**LogBank**	**Logtelecom**
Independent Variable	Coeff	Coeff	Coeff	Coeff	Coeff
Constant	4.086***	1.494***	1.74***	1.612**	2.369***
A. Long-run output					
LogEner(1-)	-0.488***	-	-		
LogInsurance(-1)		-0.187***	-		
LogHealth (-1)			-0.230***		
LogBank(-1)				-0.19**	
Logtelecom					-0.27***
NC^{+}	-0.000005*	-.0000015	-0.0000018	- 0.00000719*	0.0000012
NC^{-}	-0.0000022	-0.00000434*	-0.0000064**	-0.0000022	0.0000038**
$\mathbf{Oil}^{+}$	0.00165***				
$\mathbf{Oil}^{+}$(-1)	-	0.000384	-0,00079	0.0012*	0.001379***
$\mathbf{Oil}^{-}$	-0.00060	-0.000377	-0.00086	-0.00083	
$\mathbf{Oil}^{-}(-\mathbf{1})$					0.0013**
ITR	0.008325				
ITR(-1)		0.0378*	0.032	0.072***	0.0361**
Dummy1	-0.0284***		--		
Dummy2				-0.030**	
B. Short-run output.					
ΔNC^{+}	-	-	-		
ΔNC^{-}	-	-	-		
ΔOil^{+}	-	0.00355***	0.0023	-0.000009	0.0032**
$\Delta Oil^{+}(-1)$	-	-	-0.00269	-0.0046**	-0.0044***
ΔOil^{-}	-	-	-		-0.0027
$\Delta logenergy(-1$	-0.206*	-	-		
D(ITR)	-	-0.020*	-0.0175	0.0490***	-0.037***
D(ITR)(-1)					0.072***
ECT_{t-1}	- 0.488523***	-0.187493***	-0.230275***	- 0.196435***	-0.272959***
C. Residual Diagnoses					
LM	0.79	o.8	o.93	0.13	0.966
REST	0.072	0.33	0.50	0.126	0.011
ARCH	0.322	0.109	0.614	0.011	0.349
CUSUM-test	Stable	Stable	Stable	Stable	Stable
CUSUMSQ-test	Stable	Stable	Stable	Stable	Stable
D. Wald test -statistic					
	10.02***	3.354**	3.458**	3.5**	2.2

Note: *The optimal lagged selection is Energy and Health model based on the Shwaz Information Criterion; while Insurance, Bank, Telecom model were based in Akaike Information Criterion; *, **, *** represents significant level at 1%, 5%, 10% respectively; and Dmmy1 andDummy2 refer to the structural break dummy variables identified from Zivot& Andrew analysis. LM is the serial correlation test, ARCH the heteroskedasticity test, REST test the model misspecification.*

The error correction coefficient is equal to -0.23, representing the adjustment speed at the 1% level. In the healthcare sector, where there is no significant impact, the international travel restriction has a significant positive impact on insurance, health, and telecom sectors. In the short run, the error correction adjustment for energy, insurance, banking, health, and telecom were as follows: -0.48, -0.187, -0.23, -0.19, -0.27 at the 1% level. This indicates the adjustment in the long run. Furthermore, the estimation, followed by the diagnostic tests in panel C, shows that the bank model suffers from heteroskedasticity, with a p-value of 0.011, rejecting the null hypothesis of homoskedasticity.

All models are free of serial correlation, meaning there is no problem of autocorrelation; they are correctly specified, thereby confirming the underlying assumptions. The Ramsey RESET test results confirmed that all models were appropriately specified, and the F-statistics and corresponding p-values ensured the model's prediction accuracy, except for the telecom model, where the p-value is significant.

In regard to the significance of the Wald test, an asymmetric relationship between the negative and the positive values of NC and oil with the stock index is confirmed in the energy, insurance, banking, and health models, excluding the telecom model. The results suggest a symmetric relationship in the telecom model. In summary, only the energy, insurance, and health models are free from diagnostic issues.

The CUSUM (Cumulative Sum) and CUSUMSQ (Cumulative Sum of Squares) tests, as recommended by Pesaran and Pesaran (1997), were then used to ascertain the stability of the models.

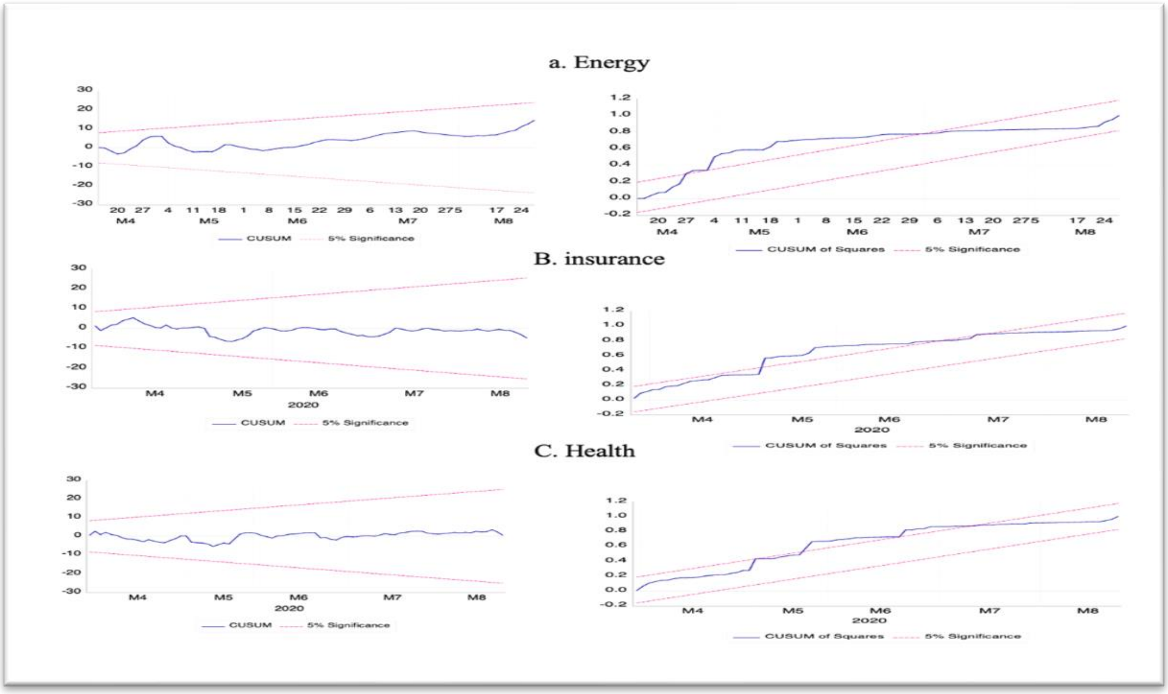

Figure 3: The Cumulative sum and Cumulative sum square for residual.

All three models-maintained stability throughout the duration of the study. Furthermore, the plots of CUSUM and CUSUMSQ (shown in Figures3) affirm the stability of each model.

4.6 Dynamic nonlinear Multiplier outcomes

In order to analyze the framework of the dynamic asymmetric adjustment, where stock indexes deviate from their initial long-run equilibriums and subsequently adjust to a new long-run equilibrium following shocks, we employ the dynamic multipliers suggested by Shin et al. (2014).

As illustrated in Figure 4, this framework demonstrates the cumulative effects of the dynamic nonlinear multiplier on the log-energy, log-insurance, and log-health indexes over a 90-day period. The outcomes are presented in relation to both positive and negative changes in the variables NC and Oil.

The figure depicts the response of indexes (log-energy, log-insurance, and log-health) to the positive and negative shocks in NC and Oil. The dotted black lines represent the adjustments of the dependent variables over time due to negative shocks, while the solid black lines illustrate the responses of the dependent variables to positive shocks in the independent variables, in this case, NC and Oil.

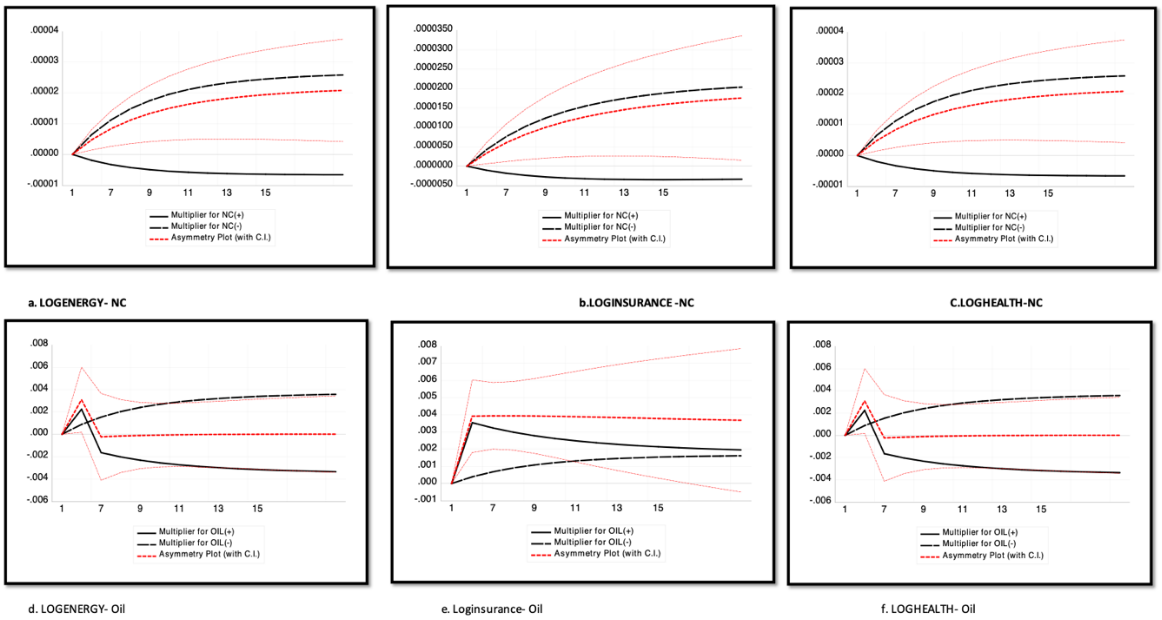

Figure 4: The Cumulative dynamic multipliers.

The dashed dark red line, also known as the asymmetric line, is located between the lower and upper boundaries of the 95% confidence interval, illustrating the differences between the dynamic multipliers of positive and negative shocks. It is crucial to note that if the zero line is contained within the boundary, it signifies an absence of asymmetry due to statistically insignificant result.

In accordance with the findings presented in Table 6 the graphs indicate that the initial impact of changes in NC exhibited a comparable magnitude for both negative and positive changes in log-insurance and log-health. However, for log-energy, the magnitude of the negative shocks in the long run were more pronounced, supporting the Wald test results in Table 6, which indicates an existing asymmetric relationship (see Figure 4 a, b, and c).

On the other hand, the adjustment of log-energy, log-insurance, and log-health to the positive and negative shocks in oil prices demonstrated in Figure 4 (d, e, f). These figures represent the asymmetrical relationship in the long run, where the positive shocks in all three models have a stronger impact than the negative ones.

5. Discussion and Conclusion

The primary objective of this paper is to examine the influence of the COVID-19 pandemic on the Saudi stock market, specifically by estimating the asymmetric effects of the number of cases and oil prices on Saudi stock market indices. Our analysis reveals that the positive shock of the number of cases negatively impacts the energy and bank sector, while a negative shock in the NC will increase the insurance, health, telecom sectors. Moreover, Positive shock in oil prices significantly increases energy sector. In contrast, the insurance sector sees an increase in indices with a decrease in new cases, but oil prices do not significantly affect this sector.

We attribute these disparities in findings to the variations in the estimation models employed by the different studies when investigating the impact of COVID-19 in Saudi stock market. Previous studies have employed relatively simple models that did not take into account the influence of oil prices, a crucial factor affecting the Saudi market. However, our analysis of asymmetric model considers the impact of oil prices on the stock market, recognizing its significance in the Saudi Arabian context.

Our study reveals that the health sector experiences a minor positive impact from the decline in new cases of COVID-19 .

With respect to travel policies, the paper covers their sensitivity to the stock market. The implementation of travel restrictions has proven to have a noticeable positive impact on the insurance, health, and telecom sectors, underscoring the significance of these policies in curbing the spread of the pandemic.

Findings from the estimated nonlinear ARDL model indicate the presence of a dynamic asymmetry relationship between the new confirmed cases of COVID-19 and the Saudi stock market index. These phenomena encompass short-term asymmetry, long-term asymmetry, and asymmetry in adjustment. The empirical estimation demonstrates significant long- and short-run effects of positive and negative shocks in the NC, oil, and the following industries: energy, insurance, and health.

Positive shocks in the NC have a stronger impact in the long run than negative shocks, even though the impact is significant but slightly small. This is because the government has been able to control the health pandemic effectively, as stated by CHIKRI et al. (2020), suggesting that countries with control over the pandemic will show a smaller impact on their financial markets compared to countries that lose control over the health pandemic. The government's effective management of the health pandemic has contributed to the resilience of the NC's financial market.

These findings underscore the importance of proactive measures in mitigating the negative effects of global health crises on economies. The results are consistent with those of Ullah (2023).

The study affirms the positive influence of government policies on the performance of stock market, a conclusion also reached by Zhang et al. (2020).

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