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Confirmed and Death Cases of COVID-19: Which is Informative in Explaining the Returns and Volatilities of Saudi Stock Market Indices?

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In this paper, we examine the impact of COVID-19 surprises on the volatilities of the Saudi industry sector indices during the period from August 01, 2019 until November 30, 2020. We use a sample composed of 20 Saudi industry sector indices listed in the Saudi Financial Stock Market. To calculate the surprising component of COVID-19 shocks in Saudi Arabia and in USA, we utilize the Kuttner's (2001) methodology. We use GARCH (1.1) model to estimate the volatilities of the Saudi stock market indices. We conclude that the high return levels of the daily returns of Saudi industry sector indices are detected during the end of the 1st quarter to the 2nd quarter of 2020 which is paralleled with the elevated-level spread of the COVID-19 epidemic in the worldwide mostly in USA and in Saudi Arabia. We confirm that the returns of the Saudi stock market index and of the Saudi industry sector indices are influenced by the COVID-19 confirmed and death cases surprises in USA and by the COVID-19 confirmed cases in Saudi Arabia. Our conclusions prove that the spread of the virus in USA and in Saudi Arabia negatively influences the volatilities of the Saudi financial stock market indices.

Key words: *COVID-19; return; volatilities; stock market indices; surprises*

JEL Classification: D53, O16, G12, G23

1. Introduction

For many, the COVID-19 crisis is the worst economic crisis since the Great Depression of 1929. It thus caused the world stock markets to lose nearly 30% in the space of a month (between February 20 and March 23, 2020). If, as often, the financial markets initially chose to ignore the effects of the pandemic, they then panicked widely when Europe became its epicenter. During this episode of panic, in just a few days, many stocks gave up the gains they had made for several years.

For example, on March 13 and in the space of just a few weeks, the Bel20 reached 2,732 points, the lowest point since the start of 2014. The S & P500, the benchmark index for the American stock market, experienced the most volatile March and the fastest correction in its history. A study by AXA Investment Managers shows us the evolution of the stock market in the months preceding and following an economic and financial crisis. The repetition of patterns over the crises of the past fifty years is of particular interest to this study. Figure 1 allows us to draw several conclusions:

- We have experienced many crises, on average one every ten years. On the stock market, the result of each crisis is an average bear market of 36% with low points oscillating between -25% to -50%. Volatility is very important both before, during and even after these crisis episodes.

- Despite heavy falls, each of the crises analyzed led to significantly larger increases. On average, the observed increase is 156% from the low point. The bull market that follows each crisis episode, on the other hand, takes considerably longer than the initial bear market.

- In comparison with the other major global crises, the current pandemic will have had a much more sudden effect both in terms of the initial shock and in the level of the recovery which is in the process of succeeding it.

Historically, the stock market has bottomed out long before the worst economic data hits, like unemployment figures, for example. This market anticipation also prevails for the most significant increases. In March 2020, the explosion in the number of coronavirus cases in Europe took a heavy toll on the markets as evidenced by the historic fall in stocks, oil, and bond yields. A few months later, in early June 2020, when the World Health Organization (WHO) announces that the COVID-19 pandemic is worsening around the world, several reference stock exchanges then begin their umpteenth week of recovery.

The S&P 500, the flagship US index is now back to its early 2020 level. In Europe, although the situation is more mixed, the Stoxx600 index has already recovered half of its losses linked to the coronavirus. It is mainly the incentives put in place by central bankers and governments

that have revived stock markets all over the world. Given the past experience and current stimulus measures, it is reasonable to assume that the economy (and therefore the stock market) could recover further as the situation normalizes. While history will teach us some lessons, we should always keep in mind that every situation is different. Never in modern history have we found ourselves in a similar situation. The reaction of financial markets could therefore also differ. However, it is very clear that the availability of tests, the development of a vaccine, its deployment as well as the recovery of important economic indicators will weigh very heavily on the direction that the stock markets will take in the months to come.

Short- to medium-term volatility is usually the price to pay to profit from a post-crisis rebound. Ensuring a sufficiently long investment horizon (to cash in on short-term corrections) and diversifying your investments (to compensate for the more heavily impacted asset declines), turns out to be the winning strategy in all circumstances. This is all the truer during a crisis episode. While times of volatility in the stock market can be confusing, stepping in and out to avoid intermediate drops (and / or profit taking) could be a miscalculation. When the markets are turbulent, waiting and doing nothing can often be the best option. Numerous analyzes show that the majority of market outperformance is achieved only in the space of a few excellent trading sessions.

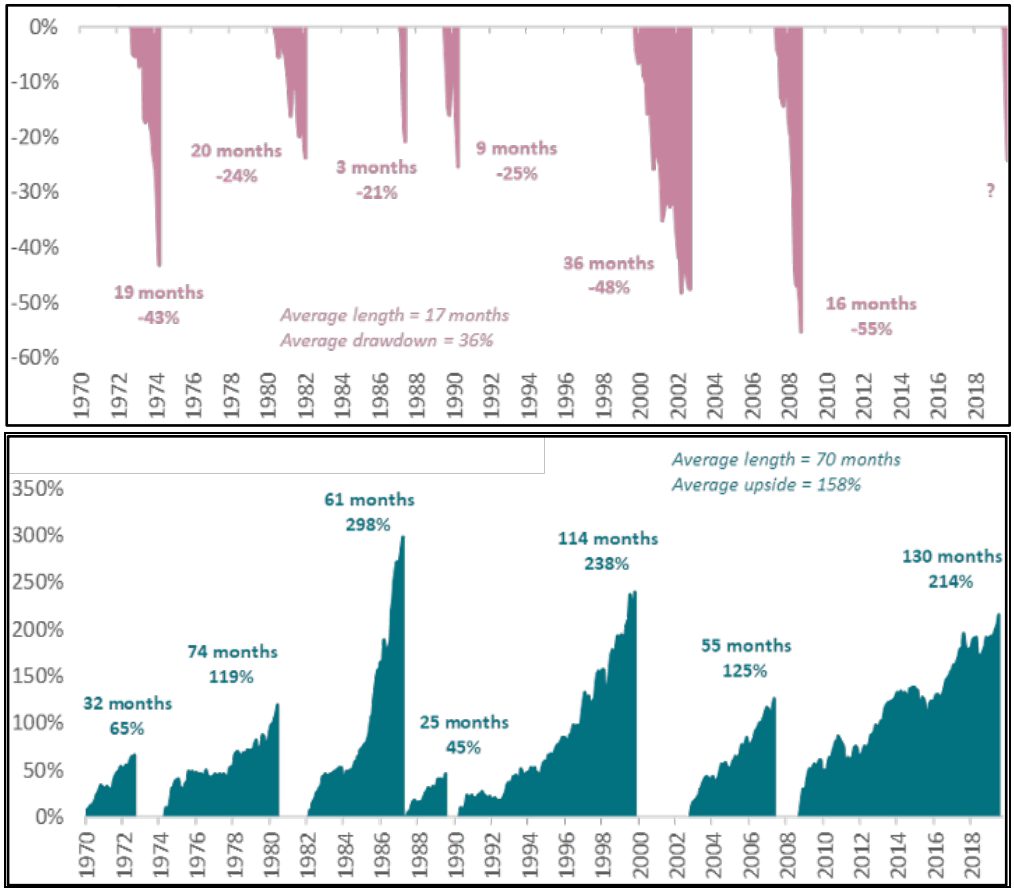

Figure 1. Evolution of international stock market indices
Sources: AXA IM, MSCI, Bloomberg et AXA IM Research (2021).

In this context, the objective of our study is to measure the impact of covid-19 on the dynamics of the Saudi "Tadawul" stock market throughout the period of study from August 01, 2019 to November 30, 2020. We employ a sample composed of 20 Saudi industry sector indices listed in the Saudi Financial Stock Market "Tadawul". To assess the unexpected element of COVID-19 surprises in Saudi Arabia (SA) and in USA, we employ the Kuttner's (2001) approach. We use GARCH (1.1) model as an appropriate econometric approach to estimate the volatilities of the Saudi stock market indices.

From our results, we conclude that the high return levels of the daily returns of Saudi industry sector indices are detected during the end of the 1st quarter to the 2nd quarter of 2020 which is paralleled with the elevated-level spread of the COVID-19 epidemic in the worldwide mostly in the USA and in the Saudi Arabia. Additionally, we confirm that the returns of the Saudi stock market index and of the Saudi industry sector indices are influenced by the COVID-19 confirmed cases and death cases surprises in the United States (the most affected country in the world) and by the COVID-19 confirmed cases in Saudi Arabia. Besides, the COVID-19 death cases (DCSA) surprises in Saudi Arabia does not have a significant impact on the Saudi stock market index and the Saudi industry sector indices. Our findings demonstrate that COVID-19 shocks affect the Saudi industry sector indices during the period of study employed in this paper. The propagate of the coronavirus in the United States and in the Saudi Arabia negatively affects the volatilities of the returns of the financial stock market indices in Saudi Arabia.
The rest of our paper is structured as follow: in section 2, we present a literature review for some important studies that examine the impact of COVID-19 on the financial stock markets. Section 3 presents the econometric methodology used in our study. Section 4 describes the data employed in this paper. Section 5 presents the empirical findings of our investigation. Finally, section 6 concludes and exposes some policy implications of our paper.

2. Literature review

The progressing COVID-19 pandemic has hauled down the economy at the worldwide and nation levels since the start of 2020. Alongside the flare-up and the increment in the COVID-19 cases over the long haul, the by and large financial climate and monetary action get discouraged. Monetary business sectors are additionally hit hard so that securities exchange crashes were seen in Asia, Europe, and North America, see Corbet et al. (2020) and Zhang et al. (2020). Clearly the adjustment in the disease cases flags the possible direction of the economy and exacting administrative intercessions of government, like isolate and lockdown. Accordingly, the monetary market ought to react to startling changes in COVID-19 cases.

For instance, Ashraf (2020) discovers securities exchanges responded contrarily to the development in COVID-19 cases dependent on-board information. Then again, COVID-19 likewise carries a ton of vulnerabilities to the economy. Baker et al. (2020) track down that about portion of the extended yield in withdrawal in 2020 is identified with the COVID-

initiated monetary vulnerability. Particularly, the vulnerability about the COVID-19 cases itself could be a sign too to the monetary market and its participators about the improvement of the pandemic. It follows that how the monetary market responds to the flood in the disease cases, and its vulnerability needs an examination. One may contemplate whether the monetary market stresses more over the ascent in COVID-19 cases or the vulnerability about the pandemic.

Indeed, even in its pre-pandemic stage, COVID-19 has seriously influenced the genuine economy, with a negative effect on exchange, the travel industry, and transport industry, creating neighborhood food deficiencies (Albulescu, 2020). Furthermore, within the sight of securities exchanges cost bubbles, the COVID-19 effect on the monetary framework could not be overlooked. Moreover, a few early papers center around the COVID-19 impacts on securities exchanges returns (Ashraf, 2020; Zhang et al., 2020), while just couple of papers underline the COVID-19 effect on monetary instability (Albulescu, 2020; Bakas and Triantafyllou, 2020; Zaremba et al., 2020). We add to this new strand of the writing and we explore the impact of true declarations regarding the COVID-19 new instances of disease, and casualty proportion, on the United States (US) monetary business sectors' instability.

The monetary instability has various sources, identified with financial conditions, institutional issues, or market vulnerability (Hartwell, 2018). Macroeconomic declarations additionally influence the monetary instability. In this line, Onan et al. (2014) track down that great and awful declarations unevenly sway the monetary instability, though the greater part of ongoing investigations center around the job of Economic Policy Uncertainty (EPU) in impacting the monetary unpredictability (Antonakakis et al., 2013; Chen and Chiang, 2020; Kalyvas et al., 2019; Li et al., 2020; Mei et al., 2018; Su et al., 2019; Tiwari et al., 2019; Yen and Cheng, 2020; Zhenghui and Junhao, 2019). For instance, Karnizova and Li (2014) anticipate the US downturn utilizing the cooperation among EPU and securities exchange unpredictability, though Zhu et al. (2019) explore what a dread file means for the US securities exchange instability.

Not the same as these examinations, we research the effect of Covid pandemic vulnerability (related with the new contamination cases and the casualty proportion revealed at worldwide level and in the US), on the monetary business sectors' unpredictability. Without a doubt, Zaremba et al. (2020) explore the effect of COVID-19 on the securities exchange instability at worldwide level with an emphasis on the impact of administrative mediations, while Bakas and Triantafyllou (2020) dissect the effect of the worldwide pandemic on product costs' unpredictability. None of these papers examine, nonetheless, the impacts of the WHO official declarations with respect to the proliferation of the clean emergency.

Hence, we expand upon Albulescu (2020) and we broaden this examination severally. In the first place, we utilize day by day information and we center around the time of the pandemic period of the emergency, beginning with March 11, 2020. Second, not the same as Albulescu (2020) who centers around the pre-pandemic case and the authority figures detailed in China,

we consider the new disease case declarations and the casualty proportion revealed at worldwide level and in the US. At last, in accordance with Ji et al. (2019), we utilize the S&P 500 acknowledged instability (RV) as an intermediary for the US monetary business sectors' unpredictability. Contrasted and different measurements of monetary instability, RV is by all accounts more useful about the unpredictability level (Andersen et al., 2003).

3. Methodology

The Volatility is a significant theory and model for finance and economic mainly in portfolio management and optimization, risk measure and management and stock market indices pricing. While financial dataset contains leptokurtosis (skewness), volatility clustering (kurtosis), long-term memory, volatility frown and leverage impacts, they are inadequate to explicate a numerous of essential characteristics commonplace to relate financial dataset by linear and non-linear models and estimations. That is, because the hypothesis of homoscedasticity is not suitable when utilizing financial dataset. To estimate return and volatility, Engle (1982) established ARCH specification (Autoregressive Conditional Heteroscedastic model) which is additional stretched by Bollerslev (1986) to GARCH (Generalized Autoregressive Conditional Heteroscedastic) model.

The Autoregressive Conditional Heteroscedastic model (ARCH) models are founded on the variance of the error term at moment t depends on the predictable values of the squared error terms in preceding time intervals. The ARCH model is identified as:

$$y_t = u_t \quad (1)$$

$$u_t \sim N(0, \sigma_t^2) \quad (2)$$

$$\sigma_t^2 = \alpha_0 + \sum_{t=1}^{q} \alpha_i u_{t-i}^2 \quad (3)$$

This specification is described to as ARCH(q), where q implies to the request of the lagged squared price returns contained in the Autoregressive Conditional Heteroscedastic model (p). If we employ ARCH(1) specification it be converted into:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 \quad (4)$$

While σ_t^2 is an estimate conditional variance, and it's an amount should continuously be exactly positive; a negative value of the variance at every viewpoint in moment would be irrelevant. Then to guarantee that the estimate conditional variance is exactly positive coefficient in the estimate equation must be $\alpha_0 > 0$ and $\alpha_1 \geq 0$. If that condition were not assured, achievements of several of σ_t^2 might be negative sign.

Generalized Autoregressive Conditional Heteroscedastic (GARCH) specification Bollerslev (1986) and Taylor (1986) suggest the Generalized Autoregressive Conditional Heteroscedastic(p,q) random procedure. The procedure allocates the conditional variance of each indicator to be determined upon preceding lags; in the beginning lag of the squared residual from the mean equal and give announcements regarding the volatility from the preceding phase which is as following:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 \qquad (5)$$

All estimate coefficients in variance estimation should be positive and $(\alpha + \beta)$ is anticipated to be fewer than one although it is close up to 1. If the total of the parameters corresponds to 1 it is labeled an Integrated Generalized Autoregressive Conditional Heteroscedastic (IGARCH) model.

Additionally, in this paper we contribute to the financial and economic literature by incorporating an exogenous component in the GARCH(1,1) specification which calculate the COVID-19 surprise in Saudi Arabia (SA) and in USA. Consequently, the expected equal of the GARCH(1,1) model is offered as follow:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 + \gamma_t S_t \qquad (6)$$

Where, S_t indicates the unanticipated COVID-19 surprise declarations at day t. Following Kuttner (2001), in this study we assess the surprise element as the scaled version of variation in the one-day COVID-19 confirmed and death cases at an occurrence period (*d* known as a pronouncement of COVID-19 confirmed and death cases in Saudi Arabia and in USA). Obviously, the surprise factor for each COVID-19 confirmed and death cases adjustment in Saudi Arabia and USA is offered by the following equivalent:

$$S = \frac{D}{D-d}(f_d - f_{d-1}) \qquad (7)$$

Where, f_d implies the total of COVID-19 confirmed and death cases on the ending of the announcement time (day) *d,* f_{d-1} characterizes the total of COVID-19 confirmed and death cases on the ending of the announcement time (day) (*d-1*) and *D* reveals the total of days in the month.

4. Data

4.1. Saudi stock market indices

In this part, we introduce the database employed in our research which contain of daily data (time series) of returns and volatilities of Saudi industry sector indices (20 sectors) which are presented in Table 1. In the perspective to examine the impact of the total of COVID-19 confirmed and death cases pronouncements, we focus on the unanticipated and surprise elements in the COVID-19 confirmed and death cases change in Saudi Arabia and in USA. Our dataset sample includes the period from August 01, 2019 to November 30, 2020. The database used in this paper is achieved from two dataset resources such as, https://markets.businessinsider.com/currencies and https://data.europa.eu/euodp/en/home. The choose of total COVID-19 confirmed and death cases change in Saudi Arabia and in USA is supported by two issues; (i) we study the impact of COVID-19 surprise on Saudi stock market (ii) and USA is the greatest affected country by COVID-19 epidemic.

Table 1. List of Saudi industry sector indices

No.	Code	Index name
1	TAS	Tadawul All Share
2	TI	Tadawul Insurance
3	TB	Tadawul Banks
4	TCG	Tadawul Capital Goods
5	TCPS	Tadawul Commercial & Professional Services
6	TCD	Tadawul Consumer Durables
7	TCS	Tadawul Consumer Services
8	TDF	Tadawul Diversified Financials
9	TE	Tadawul Energy
10	TFSR	Tadawul Food & Staples Retailing
11	TFB	Tadawul Food and Beverages
12	THES	Tadawul Healthcare Equipment & Services
13	TM	Tadawul Materials
14	Tmed	Tadawul Media
15	TPBLS	Tadawul Pharma, Biotech & Life Science
16	TREM	Tadawul Real Estate Management
17	TREIT	Tadawul REIT
18	TR	Tadawul Retailing
19	TTS	Tadawul Telecom services
20	TT	Tadawul Transportation
21	TU	Tadawul Utilities

Source: Own elaboration

Furthermore, we acknowledge that the whole stock price indices of Saudi industry sector indices are transformed into logarithm formation. Then, we utilize the logarithmic return such as calculated by $r_t = \ln\left(p_t / p_{t-1}\right)$, with P_t indicates the Saudi industry sector price index at the day t and P_{t-1} indicates the Saudi industry sector price index at the day t-1.

In Table 2, we present the most important descriptive statistics relative to the daily returns and volatility of Tadawul index (Saudi stock market index). The most crucial statistics which are offered in this table are the three coefficients: skewness, kurtosis and Jarque-Bera. The linear time series models are incapable to clarify a total of essential elements which are volatility clustering or pooling, leptokurtosis and leverage impacts mainly occur in the financial database. The volatility clustering or pooling, leptokurtosis and leverage impacts are propensity for financial portfolio asset returns. The positive skewness coefficient implies that the distribution of the returns has a lengthy right tail, and the negative skewness coefficient indicates that the distribution of the returns has a lengthy left tail. Also, the estimated kurtosis coefficient of the normal distribution is for the threshold of 1. Then, if the kurtosis coefficient surpasses the threshold of 1, so, the distribution is topped (leptokurtic) related to the normal distribution; if the kurtosis coefficient is fewer than the threshold of 1, then the distribution is fixed (platykurtic) relative to the normal. To test the normality, the Jarque-Bera test is utilized which has null assumption of the normal distribution and it is dispersed as with 2 levels of freedom. According to the table 2 the Saudi stock market index present a negative skewness coefficient and elevated positive estimated kurtosis coefficient. These two coefficients imply that the distributions of the Saudi stock market index present a lengthy left tail and leptokurtic. The Jarque-Bera coefficient indicate the rejection the null assumption of the normal distribution at the threshold of significance of 1%.

Table 2. Return and volatility of Tadawul index

	Return	Volatility
Mean	3.42E-05	81.51082
Median	0.000472	79.35592
Maximum	0.029669	162.8493
Minimum	-0.037717	7.139392
Std. Dev.	0.006056	45.54249
Skewness	-1.742386	0.124675
Kurtosis	14.86214	1.755320
Jarque-Bera	2108.113***	22.22396***
Probability	0.000000	0.000015
Observations	331	331

Note: This table presents summary statistics of daily returns and volatilities for Tadawul index. The data period is from August 01, 2019 to November 30, 2020. Statistical significance at the 1% is denoted by ***.

Source: Own elaboration

The daily returns for the Tadawul index (Saudi stock market index) are presented in Figure 2. This figure demonstrate that the high return values are observed during the first quarter of 2020 from January to March which is coincided with the high propagation of the COVID-19 pandemic in the world. The most important conclusion is that COVID-19 have an impact on the returns and the volatility of the Saudi stock market index.

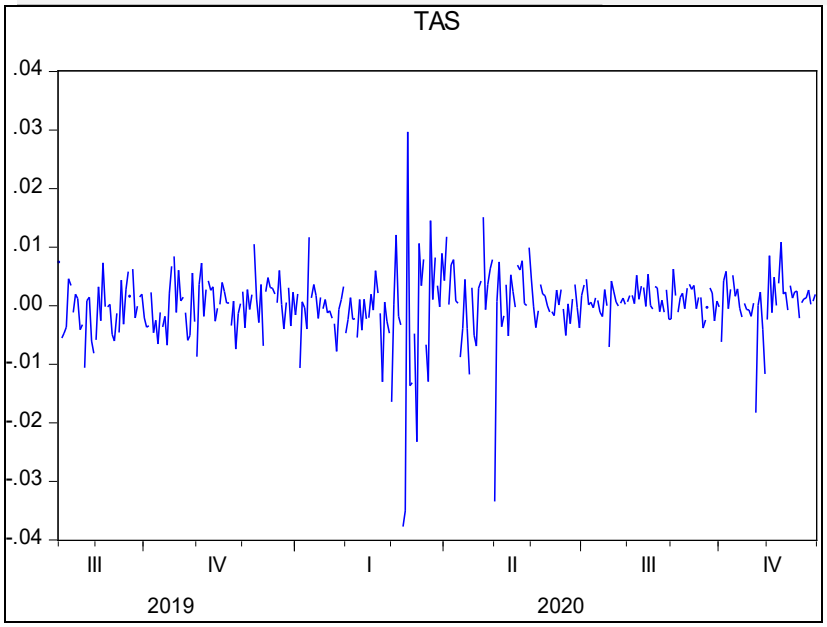

Figure 2. The evolution of the return of Saudi stock market index "Tadawul"

In Table 3, we offer the most important descriptive statistics relative to the daily returns of Saudi industry sector indices (20 sectors). The most crucial statistics which are presented in this table are the three coefficients: skewness, kurtosis and Jarque-Bera. Based on the table 3 the returns of Saudi industry sector indices present a negative and important skewness statistics and a higher and positive estimated kurtosis statistics. These two statistics suggest that the distributions of the returns of Saudi industry sector indices produce an extensive left tail and leptokurtic. The Jarque-Bera statistics imply the refusal the null assumption of the normal distribution at the threshold level of 1%. Also, in mean, the high daily returns of Saudi industry sector indices are for Tadawul Food & Staples Retailing sector (0.000700) followed respectively by Tadawul Pharma, Biotech & Life Science sector (0.000646) and Tadawul Capital Goods sector (0.000618). These sectors offer the best consumed services and goods during the COVID-19 pandemic propagation mainly in the period of confinement in the Saudi Arabia and especially based on the precautionary measures and procedures adopted by the regulatory authorities. The elevated consumption of the services and goods gives by these three sectors justifies their high returns. See Table 3 at the end of this article.

The daily returns for the daily returns of Saudi industry sector indices (20 sectors) are summarized in Figure 3 and Figure 4 during the period of study from August 01, 2019 until November 30, 2020. These figures demonstrate that the high return levels of the daily returns of Saudi industry sector indices are observed throughout the end of the first quarter to the second quarter of 2020 from February to June which is corresponded with the high-level propagation of the COVID-19 epidemic in the worldwide mainly in the Saudi Arabia. The most significant remark is that the spread of the COVID-19 pandemic presents an influence on the daily returns and the volatility of the Saudi industry sector indices (20 sectors). See Figures 3 and 4 at the end of this article.

In Table 4, we summarize the most important descriptive statistics relative to the volatility of the daily returns of Saudi industry sector indices (20 sectors). The main important statistics which are shown in this table are the three coefficients: skewness, kurtosis and Jarque-Bera. Based on the table 3 the returns of Saudi industry sector indices present a positive and important skewness statistics and a higher and positive estimated kurtosis statistics. These two statistics suggest that the distributions of the volatility of the daily returns of Saudi industry sector indices produce a lengthy right tail and platykurtic. The Jarque-Bera statistics imply the refusal the null assumption of the normal distribution at the threshold level of 1%. Also, in mean the volatility of the daily returns of Saudi industry sector indices are convergent in value which can explain the homogeneity of the financial stock market in Saudi Arabia. See Table 4 at the end of this article.

Furthermore, to studies concerning the dataset stationarity, the level of time series used in this paper are similarly characterized. The Augmented Dickey-Fuller (ADF) tests obviously eliminate the null assumption of the existence of the unit root at the 1% threshold of significance for each Saudi industry sector indices returns. The Table 5 recaps the Augmented Dickey-Fuller test findings.

Table 5. ADF test results

	Without trend		**With trend**	
Variable	ADF stat	p	ADF stat	**p**
TAS	-34.6531***	0.0000	-35.9952***	0.0000
TI	-28.3615***	0.0000	-33.2873***	0.0000
TB	-29.3465***	0.0000	-30.0024***	0.0000
TCG	-38.6649***	0.0000	-29.3357***	0.0000
TCPS	-28.6615***	0.0000	-29.3658***	0.0000
TCD	-37.8879***	0.0000	-28.0173***	0.0000
TCS	-29.1964***	0.0000	-27.3859***	0.0000
TDF	-36.5873***	0.0000	-28.7369***	0.0000
TE	-35.7534***	0.0000	-29.3581***	0.0000
TFSR	-38.6973***	0.0000	-29.2587***	0.0000
TFB	-29.1257***	0.0000	-34.2546***	0.0000
THES	-31.8002***	0.0000	-35.9537***	0.0000
TM	-36.0019***	0.0000	-34.0685***	0.0000
Tmed	-39.6590***	0.0000	-36.1895***	0.0000
TPBLS	-33.6554***	0.0000	-35.5658***	0.0000
TREM	-31.5008***	0.0000	-31.3025***	0.0000
TREIT	-30.8378***	0.0000	-30.9512***	0.0000
TR	-30.9027***	0.0000	-29.9570***	0.0000
TTS	-29.5635***	0.0000	-28.1618***	0.0000
TT	-37.2589***	0.0000	-29.6138***	0.0000
TU	-30.9832***	0.0000	-35.9531***	0.0000
Note: *** denotes significant at the 1% level.				

Source: Own elaboration

4.2. COVID-19 surprise

Table 6 recapitulates the descriptive analysis established on a specific data of the COVID-19 confirmed cases and death cases announcements in Saudi Arabia and USA during the period from August 01, 2019 until November 30, 2020. Then, in mean values of the high variations of the COVID-19 confirmed cases and death cases surprises is for the USA respectively 0.001051 and 0.012290. This outcome suggests that the COVID-19 confirmed cases and death cases surprises in USA is very significant and considerable than confirmed cases and death cases surprises in Saudi Arabia.

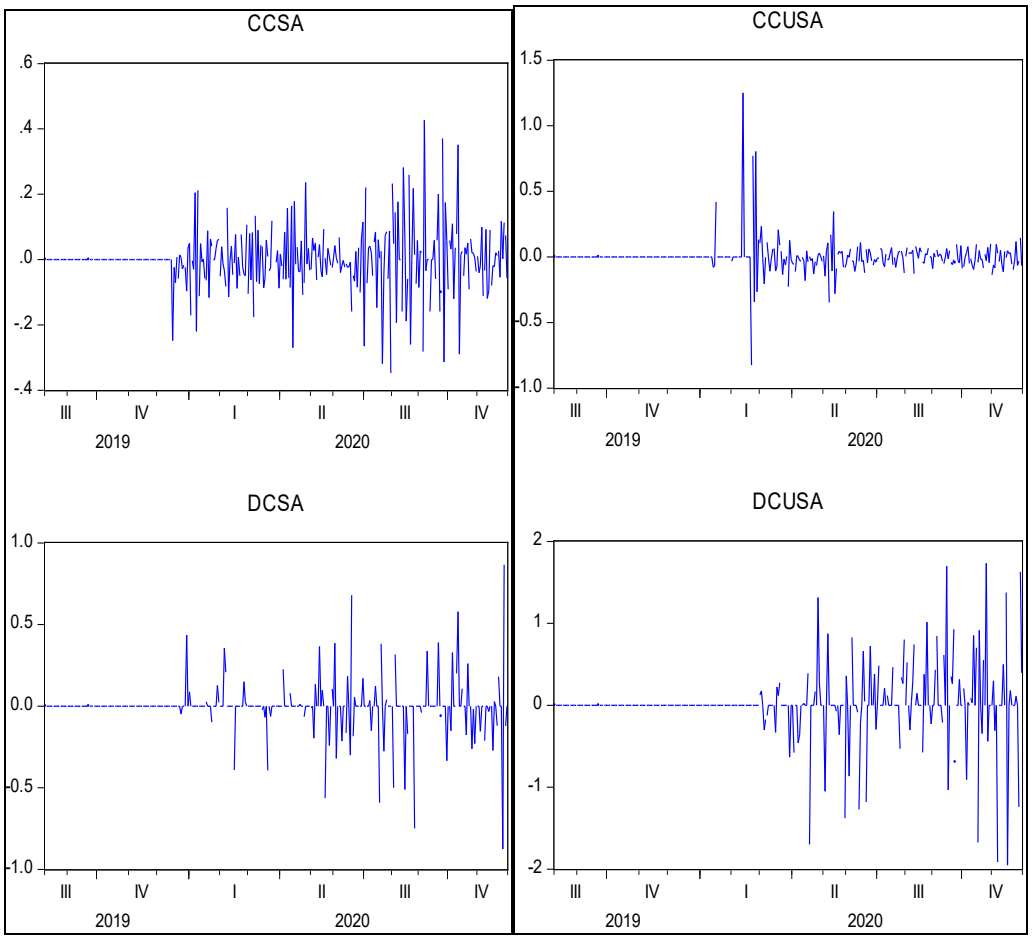

Figure 5. The evolution of the COVID-19 surprises

The Figure 5 presents the daily progression of the COVID-19 confirmed cases and death cases shocks in Saudi Arabia and in USA throughout the period of study from August 01, 2019 until November 30, 2020. Based on this figure, we find that the COVID-19 confirmed cases and death cases surprises in USA is further volatile than the COVID-19 confirmed cases and death cases surprises in Saudi Arabia. For the USA, the biggest volatility is for the COVID-19 confirmed cases shocks and for Saudi Arabia is for the biggest volatility is for the COVID-19 death cases shocks. However, the highest level of the volatility of COVID-19 confirmed and

death cases shocks in USA is justified by the propagation of the virus. The USA is the most affected by the COVID-19 during the pandemic period.

Table 6. Descriptive statistics of COVID-19 surprises

	CCSA	CCUSA	DCSA	DCUSA
Mean	-0.000630	0.001051	-0.003839	0.012290
Median	0.000000	0.000000	0.000000	0.000000
Maximum	0.426229	1.250725	0.865409	1.734341
Minimum	-0.347378	-0.824727	-0.875061	-1.950323
Std. Dev.	0.093253	0.124733	0.146192	0.393081
Skewness	0.161192	3.682705	-0.325809	-0.578957
Kurtosis	7.319413	47.68226	16.29910	12.45913
Jarque-Bera	257.1856***	28112.42***	2430.359***	1244.935***
Probability	0.000000	0.000000	0.000000	0.000000
Observations	331	331	331	331

Note: This table presents summary statistics of daily COVID-19 surprises in Saudi Arabia and in USA. The data period is from August 01, 2019 to November 30, 2020. Statistical significance at the 1% is denoted by ***.

Source: Own elaboration

Table 7 recapitulates the usually important statistical characteristics for the unconditional correlation matrix among the COVID-19 surprises and the Saudi stock market index (Tadawul). From this table, we give an evidence that the Saudi stock market index is correlated negatively to the COVID-19 confirmed cases shocks in USA and positively to COVID-19 death cases shocks in USA. However, the Saudi stock market index is correlated positively to the COVID-19 confirmed cases shocks in Saudi Arabia and negatively to COVID-19 death cases shocks in Saudi Arabia. This conclusion validates the spillover influences of the COVID-19 surprises on the Saudi stock market index.

Table 7. Unconditional correlation between COVID-19 surprises and Saudi stock market index

	CCSA	**DCSA**	**CCUSA**	**DCUSA**	**TAS**
CCSA	1	0.0677	0.1098	-0.0281	0.0227
DCSA	0.0677	1	-0.0210	-0.0840	-0.0609
CCUSA	0.1098	-0.0210	1	0.0193	-0.0141
DCUSA	-0.0281	-0.0840	0.0193	1	0.6255
TAS	0.0227	-0.0609	-0.0141	0.6255	1

Source: Own elaboration

Table 8 summarizes the most essential statistical attributes for the unconditional correlation matrix among the COVID-19 surprises and the Saudi industry sector indices. From this table, we provide a proof that the Saudi industry sector indices are commonly correlated negatively to the COVID-19 confirmed cases and death cases in the Saudi Arabia and in the USA during the period of study used in this paper.

Table 8. Unconditional correlation between COVID-19 surprises and Saudi industry sector indices

	TB	TCD	TCG	TCPS	TCS	TDF	TE	TFB	TFSR	THES
CCSA	0,017	0,023	0,024	-0,036	0,010	0,016	0,026	0,045	0,000	-0,053
DCSA	-0,066	-0,102	-0,071	-0,062	-0,107	-0,089	-0,048	-0,053	-0,044	-0,006
CCUSA	0,010	0,016	-0,027	-0,044	-0,033	-0,039	-0,038	-0,029	-0,057	-0,024
DCUSA	-0,001	0,089	0,057	0,029	0,054	0,069	-0,027	-0,035	-0,018	0,014
	TI	**TM**	**TMED**	**TPBLS**	**TR**	**TREIT**	**TREM**	**TT**	**TTS**	**TU**
CCSA	0,026	0,030	0,026	0,055	0,034	0,041	0,039	0,003	-0,026	0,028
DCSA	-0,093	-0,035	-0,043	0,040	-0,041	-0,107	-0,062	-0,042	-0,059	0,007
CCUSA	-0,002	-0,024	0,013	0,015	-0,001	0,008	-0,007	-0,054	-0,061	-0,022
DCUSA	-0,002	-0,021	0,029	0,116	-0,010	-0,060	0,031	0,050	0,030	0,100

Source: Own elaboration

5. Empirical results

Then, we use the ARCH-LM test. If the estimated value of the ARCH-LM test statistic is superior to the critical value obtained from the distribution of the used time series, then the null assumption is refused. Besides, we test all used models for the ARCH impact by the ARCH-LM Test. The Table 9 shows ARCH-LM test findings. This Table demonstrates that all used models have ARCH influence on their residual terms. Consequently, we can model the residual terms by the GARCH specifications.

Table 9. ARCH Test Results

Dependent Variable of model	ARCH(1)LM Stat	p
TAS	105.332***	0.0000
TI	332.592***	0.0000
TB	180.853***	0.0000
TCG	356.100***	0.0000
TCPS	209.394***	0.0000
TCD	221.619***	0.0000
TCS	256.381***	0.0000
TDF	119.384***	0.0000
TE	91.356***	0.0000
TFSR	168.209***	0.0000
TFB	150.630***	0.0000
THES	193.208***	0.0000
TM	180.623***	0.0000
Tmed	131.059***	0.0000
TPBLS	159.490***	0.0000
TREM	263.803***	0.0000
TREIT	334.659***	0.0000
TR	362.937***	0.0000
TTS	379.201***	0.0000
TT	391.259***	0.0000
TU	293.546***	0.0000

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

Source: Own elaboration

Although ARCH (α) and GARCH (β) and estimated coefficients are statistically important and significant in all GARCH specifications for returns of the Saudi stock market index and the Saudi industry sector indices. Table 10 recaps the estimated coefficients of GARCH Models in the case of the Saudi stock market index and in the presence of the by the COVID-19 surprises caused by the COVID-19 confirmed cases (CCUSA) and death cases (DCUSA) surprises in USA and the COVID-19 confirmed cases (CCSA) and death cases (DCSA) surprises in Saudi Arabia. Tables 11, 12, 13, and 14 summarize the estimated coefficients of GARCH Models in the case of the Saudi stock market index and in the presence of the by the COVID-19 surprises caused by the COVID-19 confirmed cases and death cases surprises in USA and the COVID-19 confirmed cases and death cases surprises in Saudi Arabia.

Table 10. Estimated Coefficients of GARCH Models in the case of the Saudi stock market index

	CCSA		DCSA		CCUSA		DCUSA	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p
α_0	0.0004	0.0000	0.0004	0.0000	0.0003	0.0000	0.0005	0.0000
α_0	$2*10^{-7}$	0.0000	$1*10^{-6}$	0.0000	$1*10^{-6}$	0.0000	$1*10^{-6}$	0.0000
α	0.0953	0.0000	0.0845	0.0000	0.0758	0.0000	0.0865	0.0000
β	0.9001	0.0000	0.9102	0.0000	0.9125	0.0000	0.9035	0.0000
θ	**0.8795**	**0.0000**	**-0.564**	**0.0000**	**-0.875**	**0.0000**	**0.8456**	**0.0000**
AIC	-5.6582		-5.8756		-5.8456		-5.9731	
SIC	-5.6487		-5.8617		-5.8394		-5.9670	
DW-stat	1.8413		1.8745		1.8652		1.9657	
ARCHLM test	8.8695***		8.8764***		8.8123***		8.7854***	
Obs.	331							

Notes: This table summarizes estimated coefficients from GARCH models in the case of COVID-19 surprises. To empirically test this model, we employ daily volatility series of returns for Saudi stock market index "Tadawul". The data period is from August 01, 2019 to November 30, 2020. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively.

Source: Own elaboration

For GARCH (1,1) specifications, all estimated coefficients are positive. Nevertheless, $(\alpha + \beta)$ is not excluding than 1 that involves the GARCH models take for the returns of the Saudi stock market index and the Saudi industry sector indices throughout the period of study from August 01, 2019 until November 30, 2020. Then, we validate an imperative potential explanation which validates that such persistence gets along with the phenomena of financialization of Saudi financial stock market indices and the COVID-19 health crisis, such as the Saudi industry sector indices and the COVID-19 surprises (Creti et al., 2013; Chebbi and Derbali, 2015; Chebbi and Derbali, 2016a, 2016b; Derbali and Jouini, 2019; Derbali and Bouzgarrou, 2020; Derbali et al., 2020a; Derbali et al., 2020b).

Based on the results of estimated models, the sum of the coefficient of α and β less than 1 and the volatility shocks issued by the COVID-19 surprises are quite persistent. Also, the magnitude of the estimated coefficient β is particularly elevated for all Saudi industry sector indices demonstrating a lengthy memorial in the variance equation. Furthermore, the lagged conditional variance estimated in our study is considerable and significantly positive and fewer than 1 suggesting that the influence of previous information issued from the COVID-19 surprises on the volatility is important and significant.

Additionally, the estimate of (α) is lesser than the estimate of (β) in mutually instances that is to demonstrate a negative surprise do not have a bigger influence on the conditional volatility than the positive surprises of the similar significance. Also, it appears that the Saudi stock market index returns are negatively associated with the changes in the volatility indicate that the volatility have a tendency to increase after a bad announcement and drop after a good announcement.

Based on the results presented in the Tables 11, 12, 13, and 14, (See tables at end of article) we demonstrate that the returns of the Saudi stock market index and the Saudi industry sector indices are affected by the COVID-19 confirmed cases (CCUSA) and death cases (DCUSA) surprises in USA and the COVID-19 confirmed cases (CCSA). However, the COVID-19 death cases (DCSA) surprises in Saudi Arabia does not have a significant impact on the Saudi stock market index and the Saudi industry sector indices. Our findings confirm that COVID-19 surprises affect the Saudi industry sector indices during the period of study used in this paper.

6. Conclusion

Numerous significant improvements have been offered in use to improve the expected outcomes relative to the impact of the surprises on the returns and volatility of financial stock markets. Then, we find the existence of the monetary policy shocks in the assessed returns and volatility concepts, the political uncertainties shocks, and the health catastrophe shocks (particularly in the case of the COVID-19 outbreak). These shocks in the volatility illustrations can be influenced by the country-complete governmental surprises, the economic and financial procedures, the national and international political procedures, the economic and financial influences (e.g., the subprimes crisis of 2007, the European sovereign-debt recession of 2010, the Arab Spring in the 2011, the Federal Open Market Committee monetary strategy, the European Central Bank monetary strategy, and recently the COVID-19 epidemic).

In this paper, we provide a significant perspective to the predictive capacity of confirmed and death cases of COVID-19 surprises in Saudi Arabia (SA) and in USA and creation statements for the returns and the volatilities of the Saudi stock market indices during the period of study from August 01, 2019 until November 30, 2020. We employ a sample composed of 20 Saudi industry sector indices listed in the Saudi Financial Stock Market "Tadawul". To calculate

analytically the surprising component of the confirmed and death cases of COVID-19 shocks in SA and in USA, we employ the Kuttner's (2001) methodology, and we utilize the total of confirmed and death cases of COVID-19 shocks in SA and in USA to establish the surprise component. To do so, we employ GARCH (1.1) model as an appropriate econometric approach.

From our empirical findings, we remark that the elevated return points of the daily returns of Saudi industry sector indices are observed during the end of the first quarter to the second quarter of 2020 from February to June which is corresponded with the high-level propagation of the COVID-19 pandemic in the worldwide mainly in the USA and in the Saudi Arabia. Also, we validate that the returns of the Saudi stock market index and the Saudi industry sector indices are affected by the COVID-19 confirmed cases (CCUSA) and death cases (DCUSA) surprises in USA and the COVID-19 confirmed cases (CCSA). However, the COVID-19 death cases (DCSA) shocks in Saudi Arabia does not have a significant impact on the Saudi stock market index and the Saudi industry sector indices. Our conclusions prove that COVID-19 surprises influence the Saudi industry sector indices throughout the period of study utilized in this study. Finally, the effect of COVID-19 confirmed and death cases shocks on the Saudi stock market index and the Saudi industry sector indices. The spread of the virus in USA and in Saudi Arabia negatively influences the volatilities of the financial stock market indices in Saudi Arabia.

Our findings provide to the study in financial impacts of the pandemic by offering practical proof that the COVID-19 epidemic surprises have an important influence on the financial stock market indices in Saudi Arabia. This paper is an essential motivation for shareholders, officials, policymaking, portfolio risk executives and directors. From a policy-making perspective, our findings present a useful explanation of the volatility spillovers during the financial stock market indices in Saudi Arabia is an essential stage in establishing useful monetary policy procedures and healthy policies. From the perspective of portfolio risk directors and managers, our results are reliable with the recommendation of cross-market hedging.

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Table 3. Descriptive statistics of the return of Saudi industry sector indices

Index	TB	TCD	TCG	TCPS	TCS	TDF	TE	TFB	TFSR	THES
Mean	-9.31E-05	0.000535	0.000618	-7.97E-05	0.000277	0.000448	0.000274	0.000409	0.000700	0.000548
Median	0.000262	0.000888	0.001496	0.000210	0.000668	0.000784	0.000171	0.000593	0.000221	0.000655
Maximum	0.024402	0.032299	0.027511	0.033621	0.027752	0.030839	0.040108	0.037841	0.036471	0.034634
Minimum	-0.040646	-0.036105	-0.044178	-0.042552	-0.043236	-0.041330	-0.039789	-0.036351	-0.043143	-0.036019
Std. Dev.	0.006797	0.007744	0.008247	0.006879	0.008214	0.007871	0.005880	0.006741	0.008414	0.006984
Skewness	-1.666833	-1.076555	-2.039156	-1.616755	-1.769858	-1.190108	-0.337029	-0.759701	-0.033377	-0.309112
Kurtosis	12.30560	8.943801	12.16712	15.41002	11.45336	11.38132	16.67334	10.82274	8.528699	9.839316
Jarque-Bera	1347.550***	551.1792***	1388.390***	2268.237***	1158.347***	1046.952***	2584.759***	875.8245***	421.6245***	650.3936***
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Obs.	331	331	331	331	331	331	331	331	331	331
Index	TI	TM	TMED	TPBLS	TR	TREIT	TREM	TT	TTS	TU
Mean	0.000443	4.50E-05	-3.00E-07	0.000646	0.000194	0.000119	2.03E-05	0.000288	7.37E-05	0.000139
Median	0.000616	0.000623	-8.95E-06	0.000000	0.000597	0.000276	0.000388	0.000904	4.10E-05	7.66E-05
Maximum	0.029821	0.030575	0.041076	0.041393	0.033183	0.021089	0.034885	0.028597	0.032866	0.024992
Minimum	-0.038165	-0.040319	-0.045275	-0.044371	-0.032491	-0.021417	-0.042147	-0.045626	-0.027766	-0.033179
Std. Dev.	0.007068	0.007000	0.010995	0.009066	0.007148	0.004168	0.007407	0.008098	0.006113	0.007539
Skewness	-1.088307	-1.542646	-0.038046	-0.424816	-0.929110	-1.021685	-1.458134	-2.016312	-0.105456	-0.429666
Kurtosis	10.56031	12.71395	6.357931	10.21188	10.75064	11.14874	12.90514	13.01771	8.017566	6.510293
Jarque-Bera	853.6473***	1432.676***	155.5905***	727.2777***	876.1220***	973.3797***	1470.417***	1608.336***	347.8320***	180.1275***
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Obs.	331	331	331	331	331	331	331	331	331	331

Note: This table presents summary statistics of daily returns for 20 Saudi industry sector indices. The data period is from August 01, 2019 to November 30, 2020. Statistical significance at the 1% is denoted by ***.

Source: Own elaboration

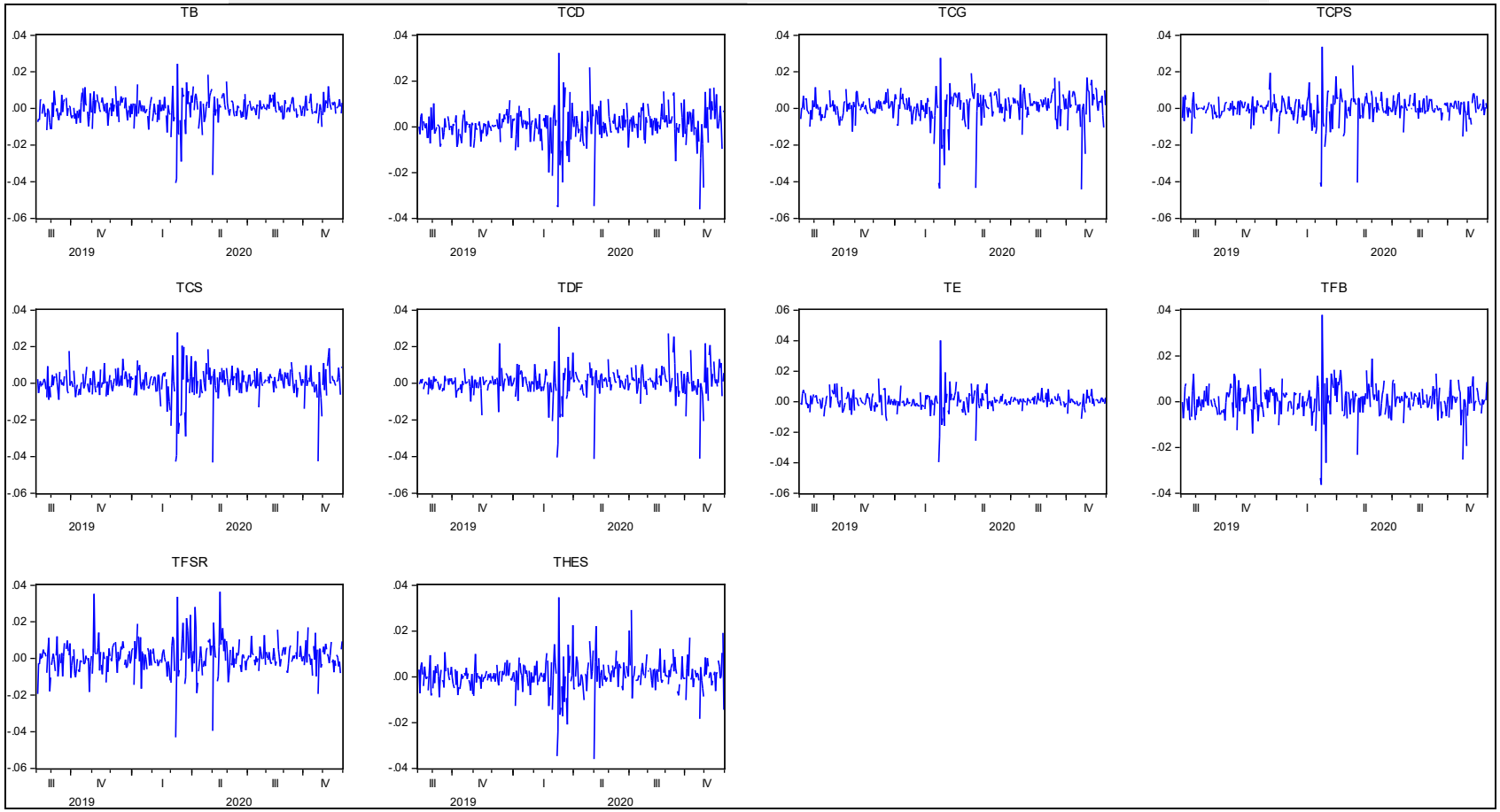

Figure 3. The evolution of the return of Saudi industry sector indices (TB, TCD, TCG, TCPS, TCS, TDF, TE, TFB, TFSR, and THES)

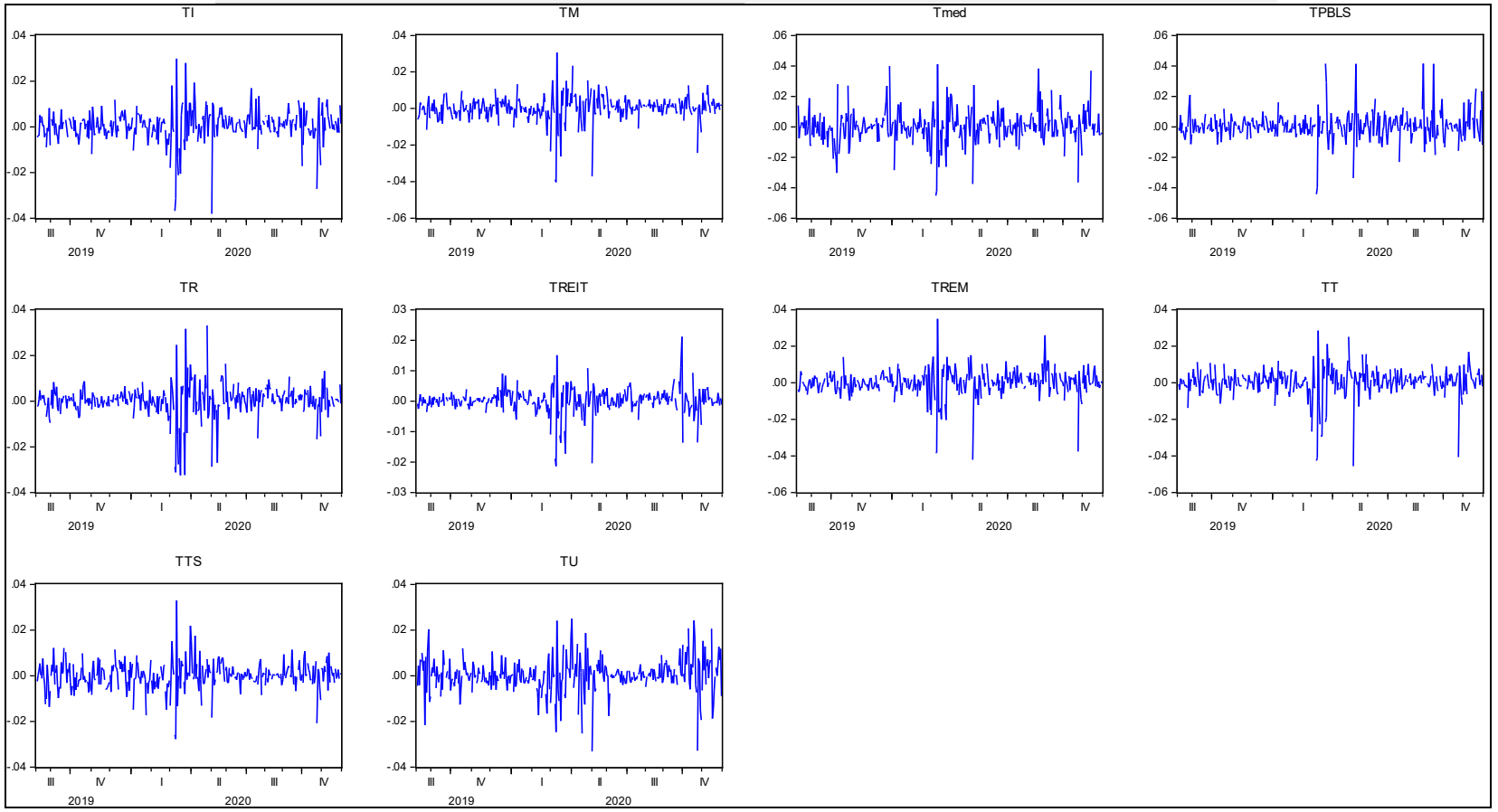

Figure 4. The evolution of the return of Saudi industry sector indices (TI, TM, TMED, TPBLS, TR, TREIT, TREM, TT, TTS, and TU)

Table 4. Descriptive statistics of the volatility of Saudi industry sector indices

	TB	TCD	TCG	TCPS	TCS	TDF	TE	TFB	TFSR	THES
Mean	81.51086	81.51068	81.51057	81.51089	81.51075	81.51072	81.51074	81.51063	81.51043	81.51063
Median	79.35648	79.35568	79.35774	79.35700	79.35730	79.35644	79.35522	79.35422	79.35360	79.35594
Maximum	162.8491	162.8475	162.8479	162.8498	162.8484	162.8480	162.8496	162.8494	162.8499	162.8493
Minimum	7.139769	7.138587	7.138581	7.138937	7.139015	7.138743	7.138245	7.139092	7.139599	7.138798
Std. Dev.	45.54251	45.54229	45.54234	45.54258	45.54258	45.54233	45.54271	45.54262	45.54246	45.54232
Skewness	0.124672	0.124678	0.124667	0.124675	0.124672	0.124675	0.124669	0.124690	0.124689	0.124682
Kurtosis	1.755312	1.755329	1.755321	1.755325	1.755326	1.755327	1.755328	1.755326	1.755317	1.755334
Jarque-Bera	22.22418***	22.22367***	22.22379***	22.22377***	22.22371***	22.22370***	22.22360***	22.22395***	22.22422***	22.22357***
Probability	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015
Obs.	331	331	331	331	331	331	331	331	331	331
	TI	**TM**	**TMED**	**TPBLS**	**TR**	**TREIT**	**TREM**	**TT**	**TTS**	**TU**
Mean	81.51065	81.51083	81.51089	81.51060	81.51077	81.51079	81.51088	81.51073	81.51084	81.51085
Median	79.35586	79.35592	79.35643	79.35486	79.35686	79.35562	79.35618	79.35731	79.35426	79.35507
Maximum	162.8492	162.8491	162.8489	162.8477	162.8497	162.8499	162.8496	162.8488	162.8495	162.8491
Minimum	7.138934	7.139285	7.138597	7.138772	7.138936	7.138912	7.138981	7.138869	7.139134	7.138147
Std. Dev.	45.54246	45.54245	45.54215	45.54246	45.54248	45.54262	45.54245	45.54257	45.54246	45.54242
Skewness	0.124680	0.124677	0.124678	0.124675	0.124674	0.124674	0.124675	0.124667	0.124681	0.124660
Kurtosis	1.755331	1.755323	1.755312	1.755317	1.755330	1.755319	1.755331	1.755326	1.755322	1.755316
Jarque-Bera	22.22363***	22.22385***	22.22425***	22.22405***	22.22360***	22.22397***	22.22355***	22.22362***	22.22397***	22.22387***
Probability	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015
Obs.	331	331	331	331	331	331	331	331	331	331

Note: This table presents summary statistics of daily volatilities for 20 Saudi industry sector indices. The data period is from August 01, 2019 to November 30, 2020. Statistical significance at the 1% is denoted by ***.

Source: Own elaboration

Table 11. Estimated Coefficients of GARCH Models in the case of CCSA

	TB		TCD		TCG		TCPS		TCS	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0005	0.0000	0.0005	0.0000	0.0004	0.0000	0.0003	0.0000	0.0005	0.0000
Variation equation										
α_0	$2*10^{-7}$	0.0000	$2*10^{-6}$	0.0000	$1*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$2*10^{-6}$	0.0000
α	0.1028	0.0000	0.1955	0.0000	0.0853	0.0000	0.0751	0.0000	0.1149	0.0000
β	0.8901	0.0000	0.7835	0.0000	0.9035	0.0000	0.9184	0.0000	0.8652	0.0000
θ	**0.6653**	**0.0000**	**0.8619**	**0.0000**	**0.9665**	**0.0000**	**-0.385**	**0.0000**	**0.5307**	**0.0000**
AIC	-5.9075		-5.5568		-5.9068		-5.2521		-5.4792	
SIC	-5.8991		-5.5421		-5.8963		-5.2463		-5.4657	
DW-stat	1.9869		1.9750		1.9936		1.8952		1.7955	
ARCHLM test	8.8313***		8.2258***		8.5172***		8.4753***		9.0014***	
Obs.	331									
	TDF		TE		TFB		TFSR		THES	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0001	0.0000	0.0005	0.0000	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000
Variation equation										
α_0	$1*10^{-6}$	0.0000	$1*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$2*10^{-6}$	0.0000
α	0.1082	0.0000	0.0256	0.0000	0.1524	0.0000	0.0591	0.0000	0.1152	0.0000
β	0.8653	0.0000	0.9425	0.0000	0.8325	0.0000	0.9256	0.0000	0.8622	0.0000
θ	**0.3846**	**0.0000**	**0.3266**	**0.0000**	**0.7364**	**0.0000**	**0.5325**	**0.0000**	**-1.857**	**0.0000**
AIC	-5.3352		-5.3256		-5.3368		-5.2543		-5.3256	
SIC	-5.3275		-5.3186		-5.3284		-5.2432		-5.3125	
DW-stat	1.7568		1.3652		1.8654		1.7956		1.8425	
ARCHLM test	8.4625***		8.7112***		8.8941***		8.9632***		8.9632***	
Obs.	331									
	TI		TM		TMED		TPBLS		TR	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0001	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0006	0.0000
Variation equation										
α_0	$3*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$1*10^{-6}$	0.0000	$1*10^{-6}$	0.0000	$2*10^{-6}$	0.0000
α	0.1250	0.0000	0.0957	0.0000	0.1255	0.0000	0.0581	0.0000	0.0873	0.0000
β	0.8652	0.0000	0.8927	0.0000	0.8512	0.0000	0.9233	0.0000	0.8915	0.0000
θ	**1.8012**	**0.0000**	**1.1147**	**0.0000**	**1.0785**	**0.0000**	**0.8137**	**0.0000**	**0.3562**	**0.0000**
AIC	-5.3621		-5.3258		-5.4785		-5.3251		-5.3253	
SIC	-5.3562		-5.3153		-5.4658		-5.3194		-5.3178	
DW-stat	1.8952		1.9652		1.8952		1.7582		1.8532	
ARCHLM test	8.1252***		8.1452***		8.9562***		8.4765***		8.9146***	
Obs.	331									
	TREIT		TREM		TT		TTS		TU	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0005	0.0000	0.0004	0.0000	0.0005	0.0000	0.0004	0.0000	0.0001	0.0000
Variation equation										
α_0	$2*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$2*10^{-6}$	0.0000
α	0.0752	0.0000	0.1081	0.0000	0.0658	0.0000	0.0822	0.0000	0.1185	0.0000
β	0.9002	0.0000	0.8755	0.0000	0.9273	0.0000	0.9074	0.0000	0.8752	0.0000

θ	**1.1802**	**0.0000**	**0.9950**	**0.0000**	**0.1492**	**0.0000**	**-1.107**	**0.0000**	**1.0752**	**0.0000**
AIC	-5.6325		-5.3251		-5.8546		-5.3745		-5.8542	
SIC	-5.6276		-5.3187		-5.8472		-5.3681		-5.8405	
DW-stat	1.9354		1.2575		1.3284		1.9653		1.5842	
ARCHLM test	8.9115***		8.8547***		8.4575***		8.3254***		8.3325***	
Obs.	331									

Notes: This table summarizes estimated coefficients from GARCH models in the case of COVID-19 surprises "CCSA". To empirically test this model, we employ daily volatility series of returns for 20 Saudi industry sector indices. The data period is from August 01, 2019 to November 30, 2020. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively.

Source: Own elaboration

Table 12. Estimated Coefficients of GARCH Models in the case of DCSA

	TB		TCD		TCG		TCPS		TCS	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000	0.0004	0.0000	0.0003	0.0000
Variation equation										
α_0	$1*10^{-6}$	0.0000	$1*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$5*10^{-6}$	0.0000	$5*10^{-6}$	0.0000
α	0.0562	0.0000	0.1023	0.0000	0.0452	0.0000	0.0225	0.0000	0.0856	0.0000
β	0.9354	0.0000	0.8824	0.0000	0.9470	0.0000	0.9623	0.0000	0.9001	0.0000
θ	**-1.562**	**0.2356**	**-1.546**	**0.9653**	**-1.824**	**0.5212**	**-0.465**	**0.7631**	**-0.045**	**0.8552**
AIC	-6.3352		-6.5846		-6.5245		-6.3584		-6.5486	
SIC	-6.3297		-6.5735		-6.5124		-6.3478		-6.5387	
DW-stat	1.6658		1.4857		1.6589		1.3553		1.3225	
ARCHLM test	8.6566***		8.7441***		8.3325***		8.4519***		8.0125***	
Obs.	331									
	TDF		TE		TFB		TFSR		THES	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0001	0.0000	0.0003	0.0000	0.0002	0.0000	0.0004	0.0000	0.0005	0.0000
Variation equation										
α_0	$2*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$3*10^{-6}$	0.0000
α	0.0751	0.0000	0.0650	0.0000	0.0822	0.0000	0.0914	0.0000	0.0738	0.0000
β	0.9073	0.0000	0.9280	0.0000	0.8971	0.0000	0.8825	0.0000	0.9185	0.0000
θ	**-1.812**	**0.9665**	**-0.754**	**0.5461**	**-0.012**	**0.8521**	**-0.663**	**0.7108**	**-1.652**	**0.1547**
AIC	-6.3545		-6.7954		-6.3584		-6.5469		-6.5845	
SIC	-6.3487		-6.7842		-6.3410		-6.5301		-6.5714	
DW-stat	1.6854		1.7586		1.9754		1.9012		1.9754	
ARCHLM test	8.0025***		9.1145***		8.7652***		8.4935***		8.7536***	
Obs.	331									
	TI		TM		TMED		TPBLS		TR	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0004	0.0000	0.0002	0.0000	0.0001	0.0000	0.0003	0.0000	0.0001	0.0000
Variation equation										
α_0	$7*10^{-6}$	0.0000	$5*10^{-6}$	0.0000	$8*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$4*10^{-6}$	0.0000
α	0.1005	0.0000	0.0761	0.0000	0.0461	0.0000	0.0812	0.0000	0.0617	0.0000
β	0.8825	0.0000	0.9056	0.0000	0.9480	0.0000	0.9021	0.0000	0.9246	0.0000
θ	**-0.351**	**0.5421**	**-0.380**	**0.5641**	**-0.754**	**0.4451**	**0.3571**	**0.9102**	**-0.117**	**0.3251**
AIC	-5.2451		-5.4851		-5.8951		-5.4851		-5.6831	

SIC	-5.2354		-5.4721		-5.8874		-5.4714		-5.6714	
DW-stat	1.9335		1.8654		1.6954		1.8547		1.9652	
ARCHLM test	8.1587***		8.1147***		8.2215***		8.3325***		8.2221***	
Obs.	331									
	TREIT		TREM		TT		TTS		TU	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0006	0.0000	0.0005	0.0000	0.0002	0.0000	0.0004	0.0000	0.0002	0.0000
Variation equation										
α_0	$3*10^{-6}$	0.0000	$4*10^{-6}$	0.0000	$6*10^{-6}$	0.0000	$7*10^{-6}$	0.0000	$2*10^{-6}$	0.0000
α	0.0682	0.0000	0.0755	0.0000	0.0485	0.0000	0.0652	0.0000	0.0745	0.0000
β	0.9275	0.0000	0.9132	0.0000	0.9357	0.0000	0.9175	0.0000	0.9180	0.0000
θ	**-0.853**	**0.1975**	**-0.744**	**0.3251**	**-0.451**	**0.9764**	**-1.124**	**0.5771**	**1.0121**	**0.4117**
AIC	-5.7584		-5.6985		-5.5487		-5.9856		-5.3254	
SIC	-5.7412		-5.6854		-5.5364		-5.9745		-5.3175	
DW-stat	1.8951		1.7845		1.7365		1.5645		1.9865	
ARCHLM test	8.0145***		9.2245***		9.7584***		9.2576***		8.0195***	
Obs.	331									

Notes: This table summarizes estimated coefficients from GARCH models in the case of COVID-19 surprises "DCSA". To empirically test this model, we employ daily volatility series of returns for 20 Saudi industry sector indices. The data period is from August 01, 2019 to November 30, 2020. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively.

Source: Own elaboration

Table 13. Estimated Coefficients of GARCH Models in the case of CCUSA

	TB		TCD		TCG		TCPS		TCS	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0007	0.0000	0.0002	0.0000	0.0001	0.0000	0.0008	0.0000	0.0008	0.0000
Variation equation										
α_0	$3*10^{-6}$	0.0000	$3*10^{-6}$	0.0000	$3*10^{-6}$	0.0000	$3*10^{-6}$	0.0000	$3*10^{-6}$	0.0000
α	0.0546	0.0000	0.0752	0.0000	0.0852	0.0000	0.0871	0.0000	0.1056	0.0000
β	0.9320	0.0000	0.0913	0.0000	0.9075	0.0000	0.9078	0.0000	0.8853	0.0000
θ	**0.6582**	**0.0000**	**0.7428**	**0.0000**	**-0.237**	**0.0000**	**-0.856**	**0.0000**	**-0.735**	**0.0000**
AIC	-5.6231		-5.3256		-5.3652		-5.8542		-5.6325	
SIC	-5.6187		-5.3191		-5.3525		-5.8471		-5.6214	
DW-stat	1.8552		1.5654		1.9745		1.9731		1.9653	
ARCHLM test	8.4785***		8.6745***		8.7456***		8.4736***		8.5468***	
Obs.	331									
	TDF		TE		TFB		TFSR		THES	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0005	0.0000	0.0004	0.0000	0.0006	0.0000	0.0007	0.0000	0.0006	0.0000
Variation equation										
α_0	$1*10^{-6}$	0.0000	$1*10^{-6}$	0.0000	$5*10^{-6}$	0.0000	$5*10^{-6}$	0.0000	$5*10^{-6}$	0.0000
α	0.0845	0.0000	0.0875	0.0000	0.0796	0.0000	0.0495	0.0000	0.0638	0.0000
β	0.9021	0.0000	0.9122	0.0000	0.9180	0.0000	0.9356	0.0000	0.9164	0.0000
θ	**-0.048**	**0.0000**	**-0.856**	**0.0000**	**-0.846**	**0.0000**	**-0.608**	**0.0000**	**-0.584**	**0.0000**
AIC	-5.6332		-5.7458		-5.7225		-5.6532		-5.7415	
SIC	-5.6314		-5.7325		-5.7166		-5.6415		-5.7322	
DW-stat	1.4568		1.8514		1.9571		1.9524		1.8375	

ARCHLM test	8.0014***		8.0147***		8.2457***		8.0711***		8.2554***	
Obs.	331									
	TI		TM		TMED		TPBLS		TR	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0006	0.0000	0.0001	0.0000	0.0001	0.0000	0.0004	0.0000	0.0003	0.0000
Variation equation										
α_0	$8*10^{-6}$	0.0000	$5*10^{-6}$	0.0000	$1*10^{-6}$	0.0000	$1*10^{-6}$	0.0000	$1*10^{-6}$	0.0000
α	0.0452	0.0000	0.0635	0.0000	0.0523	0.0000	0.0557	0.0000	0.0374	0.0000
β	0.9212	0.0000	0.9280	0.0000	0.9381	0.0000	0.9378	0.0000	0.9570	0.0000
θ	**-0.244**	**0.0000**	**-0.751**	**0.0000**	**0.105**	**0.0000**	**0.8465**	**0.0000**	**-0.854**	**0.0000**
AIC	-5.3662		-5.3265		-5.3265		-5.8451		-5.3665	
SIC	-5.3587		-5.3191		-5.3164		-5.8357		-5.3564	
DW-stat	1.8545		1.7641		1.8521		1.8564		1.9014	
ARCHLM test	8.0217***		9.2254***		9.2554***		9.0148***		9.7558***	
Obs.	331									
	TREIT		TREM		TT		TTS		TU	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0002	0.0000	0.0004	0.0000	0.0003	0.0000	0.0003	0.0000	0.0001	0.0000
Variation equation										
α_0	$2*10^{-6}$	0.0000	$3*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$3*10^{-6}$	0.0000	$2*10^{-6}$	0.0000
α	0.0821	0.0000	0.0837	0.0000	0.0866	0.0000	0.0733	0.0000	0.0532	0.0000
β	0.9075	0.0000	0.9034	0.0000	0.9075	0.0000	0.9175	0.0000	0.9352	0.0000
θ	**0.8546**	**0.0000**	**-0.271**	**0.0000**	**-0.507**	**0.0000**	**-0.639**	**0.0000**	**-0.636**	**0.0000**
AIC	-6.2256		-6.5548		-6.8456		-6.2542		-6.2548	
SIC	-6.2155		-6.5465		-6.8394		-6.2465		-6.2458	
DW-stat	1.9547		1.6985		1.8564		1.8951		1.6358	
ARCHLM test	8.8564***		8.6559***		8.4785***		8.0012***		8.2254***	
Obs.	331									

Notes: This table summarizes estimated coefficients from GARCH models in the case of COVID-19 surprises "CCUSA". To empirically test this model, we employ daily volatility series of returns for 20 Saudi industry sector indices. The data period is from August 01, 2019 to November 30, 2020. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively.

Source: Own elaboration

Table 14. Estimated Coefficients of GARCH Models in the case of DCUSA

	TB		TCD		TCG		TCPS		TCS	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0003	0.0000	0.0004	0.0000	0.0006	0.0000	0.0007	0.0000	0.0002	0.0000
Variation equation										
α_0	$7*10^{-6}$	0.0000	$5*10^{-6}$	0.0000	$8*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$4*10^{-6}$	0.0000
α	0.0581	0.0000	0.0871	0.0000	0.0491	0.0000	0.0852	0.0000	0.0658	0.0000
β	0.9232	0.0000	0.9010	0.0000	0.9357	0.0000	0.8949	0.0000	0.9300	0.0000
θ	**-0.562**	**0.0000**	**0.3854**	**0.0000**	**0.8562**	**0.0000**	**0.7421**	**0.0000**	**0.2139**	**0.0000**
AIC	-7.6356		-7.6532		-7.6586		-7.6584		-7.3584	
SIC	-7.6285		-7.6485		-7.6435		-7.6404		-7.3425	
DW-stat	1.5624		1.6895		1.8564		1.8546		1.9564	
ARCHLM test	8.1157***		8.0196***		8.5791***		8.9658***		8.7759***	

Obs.	331									
	TDF		TE		TFB		TFSR		THES	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0001	0.0000	0.0005	0.0000	0.0009	0.0000	0.0005	0.0000	0.0002	0.0000
Variation equation										
α_0	$7*10^{-6}$	0.0000	$5*10^{-6}$	0.0000	$8*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$4*10^{-6}$	0.0000
α	0.0852	0.0000	0.0923	0.0000	0.0638	0.0000	0.0584	0.0000	0.0715	0.0000
β	0.9027	0.0000	0.8937	0.0000	0.9276	0.0000	0.9375	0.0000	0.9076	0.0000
θ	**0.9654**	**0.0000**	**-0.701**	**0.0000**	**-0.402**	**0.0000**	**-0.640**	**0.0000**	**0.1275**	**0.0000**
AIC	-7.5584		-7.6653		-7.2584		-7.5642		-7.8519	
SIC	-7.5401		-7.6598		-7.2456		-7.5510		-7.8456	
DW-stat	1.9653		1.9856		1.9102		1.8564		1.5620	
ARCHLM test	8.1004***		8.6658***		8.9956***		8.5249***		8.6981***	
Obs.	331									
	TI		TM		TMED		TPBLS		TR	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0005	0.0000	0.0001	0.0000	0.0007	0.0000	0.0002	0.0000	0.0003	0.0000
Variation equation										
α_0	$7*10^{-6}$	0.0000	$5*10^{-6}$	0.0000	$8*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$4*10^{-6}$	0.0000
α	0.0304	0.0000	0.0587	0.0000	0.0672	0.0000	0.0985	0.0000	0.0752	0.0000
β	0.9052	0.0000	0.9354	0.0000	0.9012	0.0000	0.8867	0.0000	0.9011	0.0000
θ	**-0.739**	**0.0000**	**-0.846**	**0.0000**	**0.1694**	**0.0000**	**0.2381**	**0.0000**	**-0.359**	**0.0000**
AIC	-6.5641		-6.2661		-6.5642		-6.8546		-6.7546	
SIC	-6.5528		-6.2595		-6.5504		-6.8497		-6.7451	
DW-stat	1.5664		1.8564		1.8564		1.6952		1.5984	
ARCHLM test	9.2458***		9.3566***		9.2254***		9.4586****		9.4856***	
Obs.	331									
	TREIT		TREM		TT		TTS		TU	
	GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)		GARCH(1,1)	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Mean equation										
α_0	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000
Variation equation										
α_0	$7*10^{-6}$	0.0000	$5*10^{-6}$	0.0000	$8*10^{-6}$	0.0000	$2*10^{-6}$	0.0000	$4*10^{-6}$	0.0000
α	0.0574	0.0000	0.0635	0.0000	0.0485	0.0000	0.0685	0.0000	0.0741	0.0000
β	0.9351	0.0000	0.9275	0.0000	0.9275	0.0000	0.9125	0.0000	0.9105	0.0000
θ	**-0.982**	**0.0000**	**0.4081**	**0.0000**	**0.6318**	**0.0000**	**0.9047**	**0.0000**	**0.6325**	**0.0000**
AIC	-7.3365		-7.3652		-7.5481		-7.5648		-7.3256	
SIC	-7.3215		-7.3598		-7.5368		-7.5589		-7.3154	
DW-stat	1.8594		1.8466		1.8564		1.9430		1.9058	
ARCHLM test	8.2589***		9.5632***		9.4853***		9.1589***		8.1205***	
Obs.	331									

Notes: This table summarizes estimated coefficients from GARCH models in the case of COVID-19 surprises "DCUSA". To empirically test this model, we employ daily volatility series of returns for 20 Saudi industry sector indices. The data period is from August 01, 2019 to November 30, 2020. Statistical significance at the 1%, 5% and 10% levels is denoted by ***, ** and *, respectively.

Source: Own elaboration