The impact of Covid-19 crisis on the efficiency of the US stock market

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Summary: This paper search the impact of COVID-19 on the efficiency of financial markets, Specifically, the impact of Covid -19 on the Standard and Poor's 500 (S&P500) index, using three efficiency indicators: Run test, Ljung-Box test, and Bartels test, We used daily data for return (S&P500) index, from 2-10-2019 to 30-06-2020,Divided into two periods, the pre-crisis period from 2-10-2019 to 10-3-2020, and the crisis period from 11-3-2020 to 30-6-2020, the results suggest that the return appeared to be more volatile during the (COVID-19)crisis period and the U.S stock market(s&p500) was efficient in weak form during pre-crisis COVID-19, and not efficient during crisis COVID-19 After the world organization announced that the Coronavirus is a global epidemic.

Keywords: Stock markets ; Efficiency markets ; Random walk ; COVID-19 ; S&P500; Run test.
Jel Classification Codes : G14 ; C59

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I- Introduction :

The stock market is a vehicle that provides investors with opportunities to trade in a variety of financial assets and receive returns on them. Investors consider the behavior of the stock market when making investment decisions. For the financial sector and economy at large, the stock market's capacity to allocate financial resources optimally, increase the level of financial development, and facilitate economic growth, depends on its behavior. Investors can perceive stock market behavior through its efficiency and volatility (Adeyeye, 2018, p. 374).

However, financial market returns are affected by major events, for example, disasters, political events, and Financial crises are like a financial crisis 1929,1987,2008. Stock market returns may also respond to pandemic diseases, for example, Severe Acute Respiratory Syndrome (SARS) outbreak, Ebola Virus Disease (EVD) outbreak, and Covid 19 (2019) (Al-Awadhi, 2020, p. 1).

In the current economic scenario, with the world facing unprecedented crisis investors are quickly changing their behavior, which can be reflected in their transactions. It is interesting to link crisis with investor's reaction at the time of crisis, in other words, to link crisis with the repercussion of investors 'trading behavior on financial markets at times of crisis by focusing on the repercussion of investors' reaction through buying and selling transactions at the time of "Financial and Coronavirus (Covid-19)Crisis (Allam, 2018, p. 2), the latter affect the financial efficiency of the stock market also.

The COVID-19 pandemic has strongly affected many persons, either for medical reasons or for the economic aftermath of the various prophylactic measures decided by governments, in particular lockdowns. The evolution of financial markets during the pandemic illustrates the economic impact of these measures. According to several empirical studies, financial markets have indeed been strongly disturbed during this period (We'll notice this in previous studies) (Ammy-Driss, A., 2007). In general, these studies focus on variations of several statistics, such as Normal distribution, mean, (Std) deviation, skewness, kurtosis, divergence of price return densities, etc. In this research paper we will focus on measuring the impact of the COVID-19 pandemic on market efficiency.

FAMA (1970) explained that a market in which all available information reflects is always called an efficient market, that is, when new information arrives in the market, prices correctly respond to that information. It is also assumed that investors work towards rational expectations about future safety returns. The expected returns represent equilibrium market conditions (Hiremath, 2014, p. 3).

In other words, if markets are efficient, price returns are not correlated with each other and investors are not able to statistically determine what is more profitable between selling and buying a financial asset. Even if this dogma is sometimes questionable in calm periods, we wonder if it can resist to a crisis. We also wonder if we can observe regional disparities, hypothetically related to the magnitude of the outbreak in these regions, and how fast financial markets recover (Ammy-Driss, 2020, p. 2).

The efficient market hypothesis yields a number of interesting and testable predictions about the behavior of financial asset prices and returns.

The main objective of this study is to investigate the difference between the impact of the financial crisis and the Covid 19 crisis on the efficiency of the USA stock markets(s&p500), It is an expression of the impact of a financial crisis and an epidemic crisis, and we formally test if the stock markets have become more inefficient in light of the coronavirus crisis. Proponents of behavioral finance argue that in times of panic or irrational exuberance, asset prices deviate from their fundamental values and this leads to violation of the efficient market hypothesis. The weak form of the efficient market hypothesis states that a market is efficient if prices cannot be predicted using historical price-related information. For this purpose, we use the Run test, Ljung-Box test, and Bartels test in order to measure efficiency, this was done using returns of the USA stock market(s&p500), and covers the period from 2 October 2019 to 30 June 2020.

So, this paper attempts to address the following question: **Has the Covid19 crisis affected the efficiency of the US market (s&p500 index)?** Andweask the following sub-questions :

1. Does the return of the American stock market(s&p500) follow a random walk-in the period of the Covid19 crisis?

2. Does the US stock market(s&p500) efficient at the weak form in the period of the Covid19crisis?
3. Did the Coronavirus affect the efficiency of the US stock market(s&p500)?

The hypothesis of the study:

1. The return of the American stock market(s&p500) follows a random walk.
2. The US stock market (s&p500) efficient at the weak form.
3. COVID-19 affects the efficiency of the US stock market(s&p500).

I.1. Literature Review

Little work exists on the impact of COVID-19 on stock market efficiency, presumably because the crisis is still ongoing. However, some studies have already reported stylized facts about the developments in financial markets after the COVID-19 crisis. We discuss some of them here.

(Lalwani, 2020, pp. 40-44): The researchers examined if the stock markets have become more inefficient in light of the coronavirus crisis. They are collected the data on 12 industry sorted value-weighted portfolios from the Kenneth French's data library. The time spans from 1st October 2019 to 31st March 2020, using several statistical tests, Ljung-Box, Runs-test, Bartels and RankAuto, Variance Ratio and Hurst R/S. The researchers concluded that the predictability of stock prices has increased for stocks in some industries, namely Telecom, Manufacturing, Business Equipment, Finance, and Shops (wholesale and retail). Thus, the results show that the COVID-19 crisis has led to increased inefficiency in stock markets.

(Ammy-Driss, 2020, pp. 1-22): Examined the impact of COVID-19 on financial markets. They are focused on the evolution of the market efficiency, using two efficiency indicators: the Hurst exponent and the memory parameter of a fractional Lévy-stable motion. The researchers relied on the application of ten (10) stock indices of various regions: USA (S&P 500, S&P 100), Europe (EURO STOXX 50, Euronext 100, DAX, CAC 40), Asia (Nikkei, KOSPI, SSE 180), and Australia (S&P/ASX 200). During the period 1st May 2015 and the 29th June2020.and their results showed that the stock markets become efficient during the COVID-19 crisis the efficiency is clearly rejected in the case of the S&P index. The researchers observed that the occurrence of an inefficiency period almost at the beginning of the crisis, even thoughtless noticeable for the Chinese and the Australian indices.

(Apergis, 2020, pp. 1-9): The researchers studied the effect of Covid-19 on stock market returns and their volatility over the period 22 January 2020 through 30 April 2020 in China using daily data, the start date of 22 January 2020 reflects the date when the first Covid-19 case was officially announced in China. Using The GARCH (generalized autoregressive conditional heteroskedasticity) model proposed by Bollerslev (1986) is a popular framework among the scientific community to model risk and its forecasting in a time series, in this study the analysis considers the GARCHX model that builds upon the GARCH framework, The GARCHX model allows to include information on certain additional important controls that are allowed to impact the mean of stock returns, the researchers concluded that the Covid-19 pandemic shock drives the Chinese market ‘crazy’, although the Chinese Covid-19 experience was not among the worst cases in an international context. However, the reflection of death cases provided an informative ‘opportunity’ for market participants to learn something about investors ‘psychology and human behavior, and news on this pandemic event is richer and diffuses much more rapidly across market environments. Therefore, the stock market impact of the Covid-19 pandemic is highly likely to trigger daily stock market jumps and high stock market volatility.

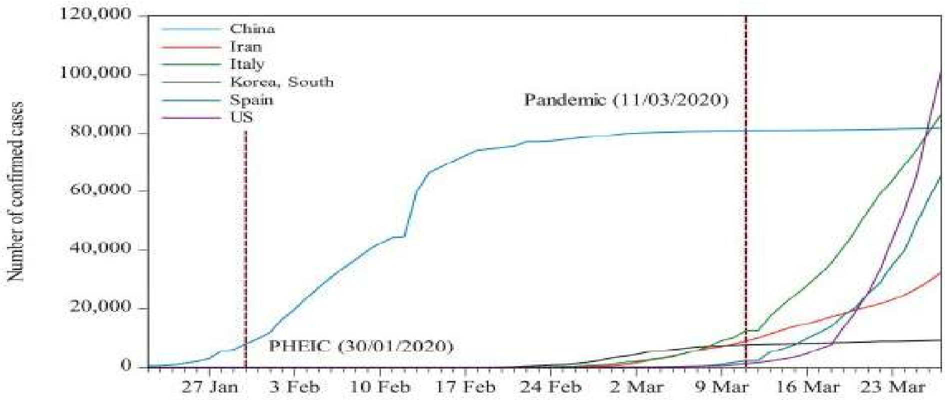
(Al-Awadhi, 2020, pp. 1-4)**:** the researchers studied the effect of a more recent pandemic disease on stock market outcomes, specifically the effect of the COVID-19 contagious infectious disease on the Chinese stock market, the researchers relied on the application of the data of companies included in the Hang Seng Index and Shanghai Stock Exchange Composite Index over the period from January 10 to March 16, 2020, the researchers applied panel testing to examine the relative performances of stocks in relation to COVID-19, while controlling for firm-specific characteristics, the researchers concluded that this pandemic disease interacts negatively with stock market returns. Specifically, stock returns are significantly negatively related to both the daily growth in total confirmed cases and the daily growth in total cases of death caused by COVID-19.

There is a difference in the method of studying the effect of Covid 19 on the efficiency and performance of the stock market, but all previous studies unanimously agreed that there is a negative impact on the performance of the stock market and the COVID-19 crisis has led to increased inefficiency in stock markets.

I. 2. The epidemiological situation of the United States of America (Covid 19):

On 11 March 2020, the World Health Organization (WHO) officially declared the coronavirus (COVID-19) outbreak to be a global pandemic (Zhang, 2020, p. 2).

Figure(1)**:** Confirmed cases in major affected countries



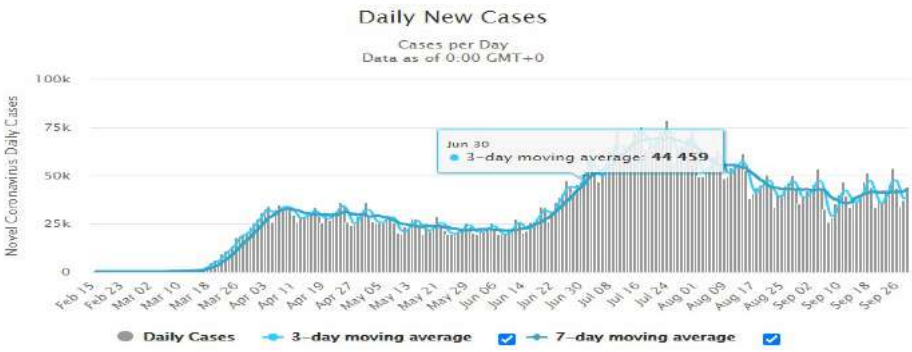
The source : Zhang, D., Hu, M., & Ji, Q. (2020). Financial markets under the global pandemic of COVID-19. Finance Research Letters, 101528.P.3

It is clear through the curve (Figure 1) that the spread of the Coronavirus in the United States of America began late compared to China, but it quickly spread in March, exceeding the number of cases in China in late March, where the United States of America experienced a terrible spread of Coronavirus that exceeded all imaginations, as shown by the curves below, (Figure.2), (Figure.3), (Figure.4).

Figure(2)**:** Total Coronavirus Cases in USA

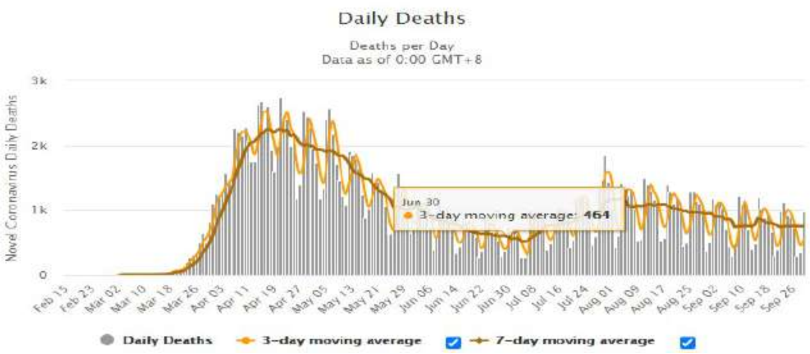
The source: https://www.worldometers.info/coronavirus

Figure(3)**:** Daily New Cases corona virus in USA



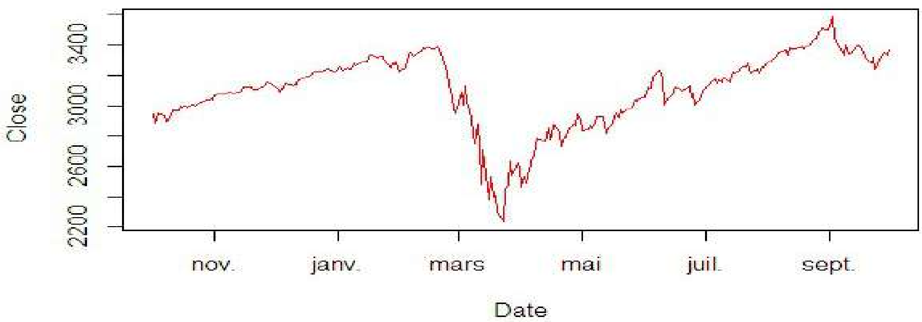
The Source :https://www.worldometers.info/coronavirus

Figure(4):Total Coronavirus Deaths in USA



The Source :https://www.worldometers.info/coronavirus

Figure(5):The development of the US stock market(s&p500) before and during the Corona crisis



The source:Authors Depending of R package

It is clear through the (Fig.5) that the s&p500 index has witnessed a decrease in the period of the high incidence of Coronavirus, especially when the World Health Organization announced in

March that Corona is a global epidemic, this negatively affected the performance of the American stock market.

I. 3. The efficiency of the stock market

In this article, it is understood that the price formation of an asset lies in the efficient market hypothesis (EMH), which provides a normal return.

In Fama (1970), it is assumed that asset prices reflect all available information. In turn, a market that always fully reflects available information is named as 'efficient' (Batista, 2018, p. 407).The efficient market theory is still an important part of modern finance. Its empirical evidence is ambiguous, but the concept itself is sound (Degutis, 2014, p. 8).

To test and define efficiency, one must first begin with a model that governs the behavior of prices and incorporates available information. According to Fama (1970), the most reasonable such model is one which is based on the presupposition that the expected price of a financial time t+1 is a function of information and price at time t, namely:

$$\tilde{p}_{j,t+1}/\Phi_t = [1 + E(\tilde{r}_{j,t+1}|\Phi_t)] * p_{j,t}$$

where $\tilde{p}_{j,t+1}$ is the price of asset *j* at time *t+1*, $p_{j,t}$ is the price of asset *j* at time *t*, Φ_t is a general set of attainable information, $\tilde{r}j,t+1$ is the return of asset at time *t+1* and the tildes are meant to specify that r and p are random variables (Lönnquist, 2019, p. 6).

Considering the information reflected in market prices, market efficiency is usually broken down into three levels. Weak, semi-strong, and strong forms of market efficiency are distinguished. In weakly efficient stock markets, the current stock price reflects all information related to the stock price changes in the past.

Such information includes data on previous prices, trading volume, etc. Based on the above-mentioned information, it becomes then impossible to make an excess profit in the stock market. Thus, if the market is weakly, efficient, the technical analysis yields no excess return. In semi-strongly efficient markets, current stock prices reflect not only information about historical prices but also all current publicly available information, e. g., announcements of acquisitions, dividend pay-outs, changes in accounting policy, etc. Finally, in strongly efficient markets, the current stock prices reflect all possible information which does not necessarily have to be public (Degutis, 2014, p. 8).

I. 4. Random walk:

The random walk hypothesis simply states that at a given point in time, the size and direction of the next price change is random concerning the knowledge available then (Sharma, 2009, p. 137).

The simple random walk model is written:

$$P_t = P_{t-1} + \epsilon_t \,, \quad \epsilon_t \sim i,i,d(0,\sigma^2)$$

P_t: is the price at t, P_{t-1}: is the price at $t-1$,

ϵ_t: the shock of new information

The random walk hypothesis (RWH) allows us to approach the theory of efficiency from another angle. Indeed, if the random walk hypothesis is not validated, the future price is therefore predictable and thus contradicts the random walk hypothesis (RWH) (Pham, 2012, p. 10).

A weak efficient market can be regarded as a random model, because the historical price changes are reflected in the current price. So, this is an argument to test for randomness in the markets (Jula, 2017, p. 879).

II– Methods and Materials:

II– 1. Data:

We study the effect of Covid-19crisis inefficiency of the stock market returns, the data in this study consists of historical prices of stocks listed on the USA stock index S&P500, over the period02October 2020 through31July 2020, represented by 211daily observations, Data were obtained from yahoo finance site and include the close price of S&P500index, The sample (02 October 2019–10 March 2020), the crisis period (11 March 2020-30June 2020), The beginning of the crisis period has been determined from the date on which the World Health Organization declared on March 11, 2020, that the Coronavirus is a global pandemic, the returns used in this study is defined by the following :

$$R_{jt} = lny_{jt} - lny_{jt-1}$$

Where$lny_{jt}$is the logarithmic close price of index S&P500$j$at time t and R_{jt} is the logarithmic return of close price of index S&P500$j$at time.

the behavior of stock market returns was examined under the pre-crisis and crisis, Table(1) presents the preliminary analyses (descriptive statistics and residual diagnostics).

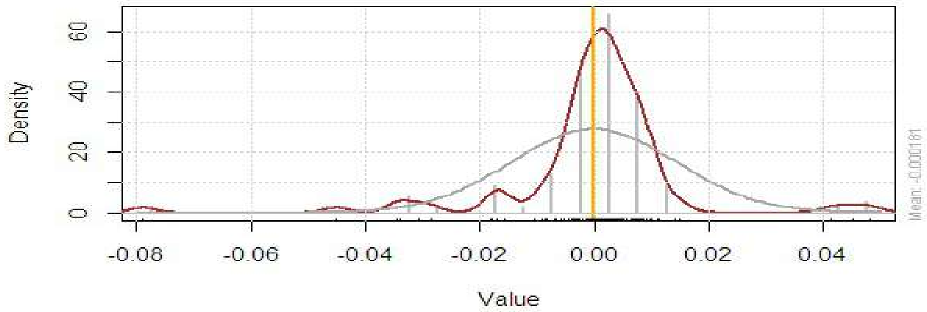
Table (1) : Preliminary statistical analysis of S&P500 index

Statistic	Pre-crisis	Crisis
Mean	-0.0001812	0.000935
Median	0.0013197	0.004269
Maximum	0.0482151	0.089683
Minimum	-0.0790104	-0.127652
Std. Dev	0.01447018	0.03332907
Skewness	-1.340989	-0.628761
Kurtosis	12.71894	6.321256
Jarque-Bera	465.9 p-value < 2.2e-1	40.989 p-value = 1.257e-09
Observations	110	78

The source: Authors Depending of R.4.0.2 package

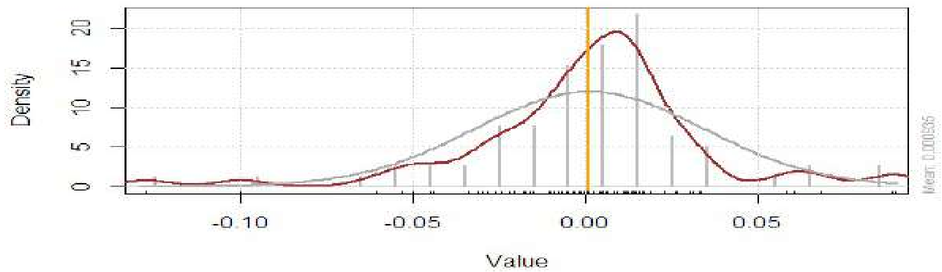
It is observed from Table(1) that there is a greater margin between the maximum and minimum values of return index series in the crisis period, and this implies that there was a larger variance in return during this period comparing the pre-crisis periods, which recorded the highest standard deviation statistic(Std=0.03332), thus suggesting that return appeared to be more volatile during the Coronavirus (COVID-19)crisis, The volatility has seen an over 2-fold increase, These statistical indicators give us a first look that there is an impact of the Corona crisis on the stock market. We also notice from Table 1 that the Skewness coefficient for both periods is negative, and this means that the distribution is twisted to the left, and from it, the distribution of the index returns series S&P500 in both periods is asymmetric, and this indicates investor interest in returns. The asymmetry of the distribution is caused by the heterogeneity of the conditional variance of errors, which expresses severe fluctuations in returns, as shown in Figure 1 and 2.We also note that the Kurtosis coefficient is greater than three (3) in the period before and during the crisis, so the distribution is of type Leptokurtic, This means that the distribution clusters more around the mean as compared to the normal distribution. Table 1 also indicates that the statistic of Jarque-Bera is completely greater than the tabular value of the χ^2 distribution in both periods at a significant level 0.05, In the pre-crisis period(JB=465.9>$\chi^2_{0.05}$=5.99), In the crisis period(JB=40.989>$\chi^2_{0.05}$=5.99). And from it, the return S&P500 index chain is not a normal distribution, not before or after the Covid 19 crisis. To confirm the previous results, we estimate the density function, as it gives more accurate information, as shown in the two figures below, (Figure.6), (Figure.7).

Figure(6):The density function and the normal distribution function of return S&P500 index before the Covid-19 crisis



The source: Authors Depending of R4.0.2 package

Figure(7):The density function and the normal distribution function Of return S&P500 index in the Covid-19 crisis period



The source: Authors Depending of R package

Through the two curves, we note that there is no match between the estimated density function and the normal distribution function, which suggests that the yield distribution is abnormal in the two study periods.

In this paper, we are mostly interested in determining whether the financial market of the USA (S&P500) is efficient before and after a coronavirus crisis. For this purpose, we have introduced indicators Runs test, Ljung – Box test and rank von Neumann ratio test (Bartels test)**,** These tests is well known and widely used to prove the random walk model because it ignores the properties of distribution, which in turn indicates efficiency at the weak from.

II– 2 Methodology

To measure the impact of the Covid 19 crisis on the efficiency of the US stock market, we used the following nonparametric tests, which are tests that measure the lack of independence and randomness of financial markets, which have been used by many previous studies, past and present.

II.2.1.Runs test:

The run test is another non-parametric test approach to test and detect statistical dependencies (randomness), which may not be detected by the parametric Auto-correlation test. The test is well known and widely used to prove the random walk model. The null hypothesis of the test is that the observed series is random. The numbers of runs are computed as a sequence of price changes of the same sign (such as ++, – –, 0 0). When the expected number of runs is significantly different from the observed number of runs it implies that the null hypothesis of the randomness of the daily return series is rejected. The run test converts the total number of runs into a Z statistic. For large samples, the Z statistics give the probability of the difference between the actual and expected number of runs. The Z value is greater than or equal to ±1.96; reject the null hypothesis at a 5 percent level of significance.

The question of whether a sequence of observed numbers (i.e., the individual company's daily share price series or daily share price index series) is a random sequence can be studied by the number of runs observed in the series. The number of runs is computed as a sequence of the price change of the same sign. The actual number of runs is compared with the expected number of runs, irrespective of the sign (Mobarek, 2008, p. 28).

II.2.2: Ljung – Box test

Named after Greta Ljung and George Box, finds out if there is any significant autocorrelation in a time series. We should expect the autocorrelation when the financial series has momentum or a mean-reversion. The test starts with the Ljung – Box statistic:

$$Q = (n + 2)\sum_{k=1}^{h} \frac{\hat{\rho}_k^2}{n-k} \text{ where}$$

*N*is the dimension of the series, $\hat{\rho}_k^2$ is the autocorrelation of the series at K lag, h is the number of lags. Under the null hypothesis, the statistics follow a chi-squared distribution(Jula, 2017, p. 1721).

II.2.3: rank von Neumann ratio test (Bartels test)

The rank von Neumann ratio test (Bartels (1982), will be used to assess the randomness of log price differences. The rank version of von Neumann's ratio test procedure can be summarized as follows. Let be the rank of the observation in a sequence of T; then the rank version of von Neumann's ratio (RVN) is defined by(Panas, 1990, p. 1721).

$$RVN = \frac{\sum_{i=1}^{T-1}(R_i - R_{i+1})^2}{\sum_{i=1}^{T}(R_i - \bar{R})^2} \text{ where}$$

R_i=rank (X_i), i=1,...,n .It is known that (RVN−2)/σ is asymptotically standard normal, where σ^2=[4(n−2) (5n^2−2n−9)]/[5n(n+1)$(n-1)^2$].

III- Results and discussion :

Table(2) reports the results Runs test for daily returns s&p500 index that:

- For the pre-COVID-19 crisis period of our sample are randomly distributed, the p-values show that we should accept the randomness hypothesis(H0) at the 1% confidence level (0.0489>0.01), This is a quantitative indication that the U.S. stock market is efficient during this period (pre-covid19 crisis).

- For the COVID-19 crisis period our sample are not randomly distributed, the p-values show that we should reject the randomness hypothesis(H0) at the 1% confidence level (0.010≈0.01), This is a quantitative indication that the U.S. stock market is not efficient during this period (covid19 crisis).

Table (2): Results of Runs test (daily market returns series S&P500)

	Standard Normal	P-Value	N
Pre-Crisis period 10-2019 to 10-3-2020	1.1531	0.0489	105
Crisis period 11/3/2020-30/6/2020	2.551	0.01074	55

The source: Authors depending of R package
Note: indicate statistical significance at 1% confidence level.

Table(3) shows the results Ljung-Box test for daily returns s&p500 index that:
- For the period pre-covid19 crisis of our sample are randomly distributed, the p-values show that we should accept the randomness hypothesis(H0) at the 1% confidence level (0.05605>0.01), This is a quantitative indication that the U.S. stock market is efficient during this period (pre-covid19 crisis).
- For the period covid19 crisis our sample are not randomly distributed, the p-values show that we should reject the randomness hypothesis(H0) at the 1% confidence level (0.00038<0.01), This is a quantitative indication that the U.S. stock market is not efficient during this period (covid19 crisis).

Table(3): Results of Ljung-Boxtest (daily market returns series S&P500)

	Squared	df	P-Value	N
Pre-Crisis period 10-2019 to 10-3-2020	3.6507	1	0.05605	105
Crisis period 11/3/2020-30/6/2020	12.601	1	0.0003854	55

The source: Authors depending of R package
Note: indicate statistical significance at 1% confidence level.

Table (4) reports the results of Bartels test for daily returns s&p500 index that:

- For the period pre-covid19 crisis of our sample are randomly distributed, the p-values show that we should accept the randomness hypothesis(H0) at the 1% confidence level (0.6359>0.01), This is a quantitative indication that the U.S. stock market is efficient during this period (pre-covid19 crisis).

- For the period covid19 crisis our sample are not randomly distributed, the p-values show that we should reject the randomness hypothesis (H0) at the 1% confidence level (0.010<0.01), This is a quantitative indication that the U.S. stock market is not efficient during this period (covid19 crisis).

Table (04): Results of Bartels test(daily market returns series S&P500)

	Standardized bartels statistic	RVN Ratio	P-Value
Pre-Crisis period 10-2019to 10-3-2020	0.47349	2.0903	0.6359
Crisis period 11/3/2020-30/6/2020	8.5693	2.5818	0.01019

The source: Authors Depending of R package
Note: indicate statistical significance at 1% confidence level.

IV- Conclusion:

This paper tries to present simply the behavior and efficiency of the US stock market during the COVID-19 outbreak period and pre-crisis the COVID-19, the indicator on which we should focus is the standard deviation, it has seen an over 2-fold increase from 0.0144 to 0.333, thus suggesting that returns appeared to be more volatile during the (COVID-19) crisis period. This extreme volatility in revenues was a result of bad information coming to the market, with the World Health Organization declaring Coronavirus a global epidemic on March 11th, 2020, the market seems to incorporate the news.

We also came up with this study that the U.S stock market(s&p500) was efficient during pre-crisis COVID-19, and not efficient during crisis COVID-19, we used the runs-test, Ljung-Box test, and Bartels test which accepts the random walk hypothesis in the pre-crisis period and rejects the random walk hypothesis in the crisis period, Where these tests provide statistical evidence that the U.S. stock market during the COVID19 pandemic was not efficient.

Finally, we should highlight the impact of American stimuli (the $2 trillion stimulus pack) on the efficiency of the US market.

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