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The Influence of Coronavirus (COVID-19) Pandemic Outbreak on the Share Market Syariah Index Employing Benford's Law Forensic Tool

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ABSTRACT

The novel of coronavirus was first detected in December 2019 in Wuhan province, China and has turned into a pandemic rapidly. The coronavirus pandemic is progressively pervasive and becomes a prominent economic challenge in modern history. Beyond the instantaneous tragedies of death, the implicit effect through fear is taking hold on a serious number of investors and consequently has had a dramatic impact on stock market indices globally. Thus, the aim of the study is to analyze the distribution of the daily close price in Islamic market index throughout the pandemic outbreak using Benford's Law as a diagnostic forensic tool spanning from January 02, 2020 until December 30, 2020. Study utilized daily data from Dow Jones Islamic Market International Titan 100 index, FTSE Bursa Malaysia Emas Shariah index and Jakarta Islamic index. Study analyzed the distribution of the first significant leading digits and assessed conformity to Benford's Law with Mad Absolute Deviation, Distance and Kolmogorov-Smirnov conformity test. The analysis conducted is two-fold, the year of 2020 taken as one complete observation and sliced into monthly observation to capture the full dynamic distribution movement behavior. Findings of this study found that Benford's Law conformity values are bigger than the tabulated critical values for all Islamic market indices.

Keywords: Benford's Law, First Digit, Conformity Test, Islamic market index, coronavirus

INTRODUCTION

The phenomena of Benford's Law are the observation of significant leading digit frequencies in data which distributed ununiformly as it would be expected for example, a registered number in mathematical tables, raw data or combination real-life data (Benford, 1938). In further, Hill (1995) has stated that the Benford's Law portrays significant leading digit proportions in various data field pursue a very specific logarithmic distribution. To date, classical Benford's Law by Frank Benford is well known as First Digit Phenomenon and can be represented in Equation (1) (Benford, 1938):

$$P\left(D_1 = \left\{d_1\right\}\right) = \log_{10}\left(1 + d_1^{-1}\right) \tag{1}$$

For easier understanding, the first significant leading digit is the most extreme left value in a single data. Example 1 has provided to demonstrate how to sort for the first significant leading digit

Example 1

$$D_n = d_1 = \sqrt{2} \quad = \quad 1.414... \quad = \quad 1$$
$$D_n = d_1 = \pi^{-1} \quad = \quad 0.3183... \quad = \quad 3$$
$$D_n = d_1 = e^{\pi} \quad = \quad 23.14... \quad = \quad 2$$

The First Digit Phenomenon has attracted Hill (1995) to derived a Generalized Benford's Law. Through Definition (1), Generalized Benford's Law can be represented in Equation (2) Hill (1995).

Definition 1.

For every non-zero real value x, the first significant leading digit of x, denoted by $D_1(x)$ is the unique integer $j \in \{1, 2, ..., 9\}$ satisfying $10^k j \le |x| \le 10^k (j+1)$ for some necessarily unique amount of positive integer $k \in \square$. For convenience, the first digit being 444444 contains $k = 5$ for every $k \in \square$ which are $P(D_n = d_1 = 4, D_n = d_2 = 4, D_n = d_3 = 4, D_n = d_4 = 4, D_n = d_5 = 4)$.

$$P\left(D_1 = d_{1,...} D_k = d_k\right) = \log\left[1 + \left(\frac{1}{\sum_{i=1}^{k} d_i \times 10^{k-i}}\right)\right] \tag{2}$$

For all positive integers k and all $d_1 \in \{1, 2, ..., 9\}$.

Explicitly, Equation (2) has been derived from Definition (1) from Hill (1995) which generally describe the phenomenon of Equation (1). Hence, Hill (1995) has demonstrated that Equation (2) representing Generalized Benford's Law is an observation of more thorough structure than classical Benford Law representing through Equation (1). Hence, study has adapted General Significant Digit of Benford's Law by Hill (1995) and Table 1 is provided representing the expected proportion of significant leading digit derived from Equation (2). Besides that, Figure (1) is provided to illustrate the distribution of expected proportion of significant leading digit frequencies representing General Significant Digit of Benford's Law movement behavior.

Table 1: The Expected Proportions of General Significant Digit of Benford's Law

d	$P(D_1)$
1	0.3010
2	0.1761
3	0.1249
4	0.9690
5	0.7920
6	0.0669
7	0.0580
8	0.5120
9	0.0458

Source: (Nigrini, 2012)

d : First significant leading digit. $d = \{1, 2, ..., 9\}$

$P(D_1)$: The expected proportions of d

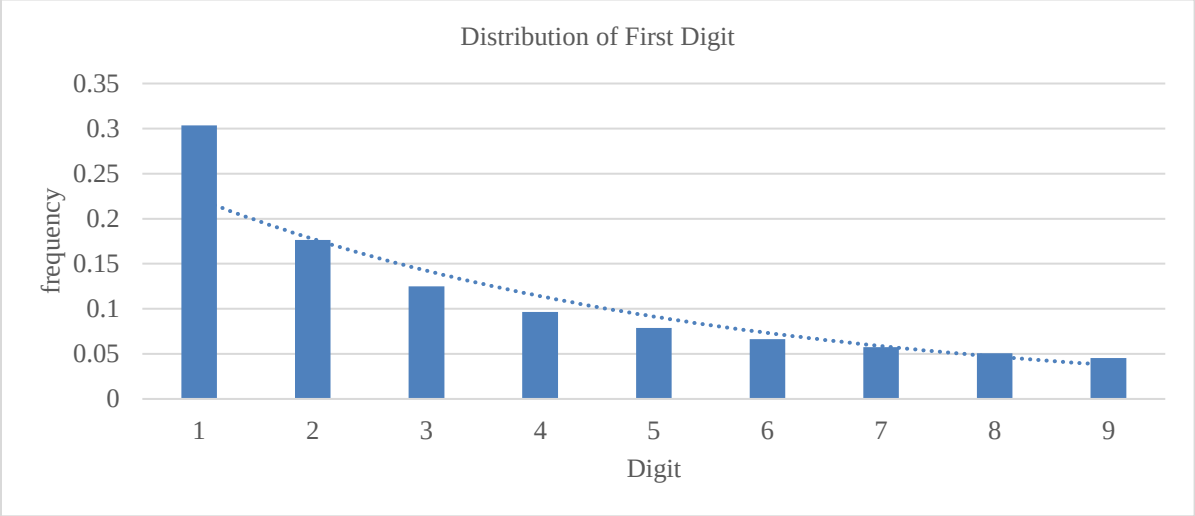

Figure 1: The First Digit Frequency Logarithmic Distribution

Benford's Law is vastly utilized to test the trustworthiness and reliability of natural occurring data in various areas. Benford's Law practically happened to be employed as a forensic mathematical tool to analyze and continuously assess for data speculation and fabrication in datasets (Nigrini, 2012). Moreover, Benford's Law is regularly distinguished as a legitimate mathematical approach to encounter fabricated in financial data, tax dodging and speculation in the stock market prices (Nigrini, 2012). Recently, Benford Law has been used on the novel of coronavirus (COVID-19) pandemic to assess the reported number of confirmed cases and death. Previous research conducted by Coeurjolly (2020), Idrovo and Manrique-Hernández (2020), Koch and Okumura (2020), Lee et al., (2020), Miranda (2020) and Wei and Vellwock (2020) have found that there is no evidence of data manipulation is seen on the reported number of confirmed cases and death throughout pandemic COVID-19 outbreak. However, Ghafari et al., (2020) has utilized Benford's Law and found the possibility of data manipulation of COVID-19's confirmed cases and the reported deaths in Iran. Likewise, Kapoor et al. (2020) has conducted Benford's Law study to show that authoritarian government has appeared to manipulate COVID-19 data. Last but not least, Isea (2020) has applied classical Benford's Law and analyzed the registered cases infected with the COVID-19. At the end of study, the result has showed that Belgium, Chile, Denmark, Italy, Netherland, Portugal and United Kingdom are suspicious countries to manipulate data.

Hence, present research on ongoing COVID-19 using Benford's Law has shown some mixed result especially in the reported confirmed cases. This is crucial observation because the mixed result will contribute to mix signal to various entities especially among investors around the world. Baker et al. (2020) has stated that inconsistencies resulting from classical Benford's Law have brought a great economic damage such as recent stock market behavior since stock market prices representing a visible reflection of the expected damage caused by COVID-19 pandemic.

Next, Sherif (2020) has claimed that the Islamic financial stock market is understudied in time of COVID-19 pandemic. In details, Sherif (2020) has stated that even though faith-based investment is increasingly getting attention from around the world but scholastic exploration to scrutinize the performance of the faith-based investment such as shariah ethical stock market index is still minimal and yet insufficient in time of COVID-19 pandemic era. Sherif (2020) has stressfully certain that investor awareness to the COVID-19 pandemic outburst is vital and conclusively contribute to a new empirical investigation. Simply put, Sherif (2020) has questioned does religious philosophy affect investor behavior in Islamic market throughout the unprecedented event of COVID-19 outburst. This is because Sherif (2020) has voiced out that over the past several decades, Islamic commerce and shariah investment has endorsed extraordinary and surprisingly wide-ranging development and miraculous improvement. Therefore, it is natural that question arises whether the Islamic market indices follow Benford Law distribution during COVID-19 duration. Hence, the goal of study is to analyze the distribution of the Islamic index market throughout the pandemic outbreak by employing General Benford's Law as a forensic mathematical tool.

LITERATURE REVIEW

COVID-19 is undeniable sudden and new pandemic disease to appear and has shock the entire world. According to World Health Organization (WHO), a pneumonia of unknown cause has been detected in China, specifically in Wuhan province on 31 December 2019 (World Health Organization, 2019). The disease outburst was announced as a Public Health Emergency of International Concern on 30 January 2020 and consequently, (World Health Organization, 2019) has affirmed COVID-19 as a new fast spreading virus on 11 February 2020 (World Health Organization, 2019).

Furthermore, Koch and Okumura (2020) had investigated trust in Chinese-reported data on COVID-19 contagious disease cases. Koch and Okumura (2020) had strongly believed that the study is important and significant for policymakers. Media and politicians around the globe have cast doubt on Chinese- reported data. Thus, Koch and Okumura (2020) had used Benford's Law method as statistical fraud detection technique had analyzed the distribution of the first significant leading digit proportion of the reported data and had conformed with chi-square and Kuiper's conformity test. At the end of analysis, Koch and Okumura (2020) had found that Chinese-reported data distribution had matched with Benford's Law distribution. Thus, Koch and Okumura (2020) had found no evidences at data manipulation and thus, had suggested that policymakers should trust the Chinese data and formulate policy accordingly. Furthermore, Koch and Okumura (2020) had strongly suggested Chinese data on post-quarantine and social distancing be an indicator to guide policies in other countries.

Next, Idrovo and Manrique-Hernández (2020) had utilized Benford's Law to analyze data from World Health Organization's to assess the character and aspect in the Chinese epidemiological scrutiny structure in time of COVID-19. Idrovo and Manrique-Hernández (2020) had believed that Benford's Law is a convenient tool to assess data distribution and able to suggest quality of data. Idrovo and Manrique-Hernández (2020) had analyzed the first significant leading digit of observed proportion and had compared with the Benford's Law. Then, chi-square conformity test had been used for conformity test. At the end of analysis, Idrovo and Manrique-Hernández (2020) had

suggested that China had an acceptable aspect in its epidemiological scrutiny structure. Idrovo and Manrique-Hernández (2020) had claimed that the result is important because a well-planned epidemiological scrutiny structure is fundamental for epidemic administration.

In addition, Coeurjolly (2020) had carried out a study on the total value of registered COVID-19 cases and deaths reported by Chinese government. In line with Koch and Okamura (2020), Coeurjolly (2020) had found that doubt was raised about the number of confirmed cases. Coeurjolly (2020) had examined data available from China at the city and provincial levels and had compared the result with Canadian provincial data, U.S data and French regional data using Benford's law to detect frauds. In details, Coeurjolly (2020) had analyzed distribution of the first-two digit representing the first and second significant leading digit proportion frequencies and then, Coeurjolly (2020) had make comparison with classical Benford's law expected frequencies distribution. Then, Coeurjolly (2020) had applied the Chi-square conformity test for conformance with Benford's Law. Coeurjolly (2020) had considered the cumulative and daily numbers of confirmed cases and death. Coeurjolly (2020) had found no evidence of data manipulation for all these countries. Hence, Coeurjolly (2020) had failed to reject the hypothesis that these data expected to be deviated from theoretical Benford's Law.

Besides that, Ghafari et al., (2020) had adopted Benford's Law to examine the possibility of data manipulation regarding COVID-19 confirmed cases in Iran. Iran is a second country that had been affected after China. The confirmed registered cases in Iran had growth exponentially but Ghafari et al., (2020) had noticed that the numbers did not follow the expected global pattern. However, Ghafari et al., (2020) had found no evidence on the data manipulation to support such a claim. However, Ghafari et al., (2020) only compared distribution of the first significant leading digit distribution with Benford's Law distribution visually. There is no conformity test had been conducted by Ghafari et al., (2020).

In addition, Miranda (2020) had examined the distribution of the reported COVID-19 confirmed cases data distribution conforms to Benford's Law distribution. Miranda (2020) had compared the first significant leading digit and had applied the Kolmogorov-Smirnov conformity test. At the end of analysis, Miranda (2020) had found that there is no significant difference between the first significant digit of COVID-19 data distribution to Benford's Law distribution. Thus, Miranda (2020) had concluded that the reported COVID-19 data sets did conform to the Benford's Law distribution.

Next, Balashov et al. (2020) had used Benford's Law to test if the countries had manipulated the reported COVID-19 pandemic data. Balashov et al. (2020) had assumption that the countries with weaker democracies, weaker economic and healthcare system have lower data accuracy as indicated by Benford's Law distribution. Balashov et al. (2020) had analyzed distribution of the first and second significant leading digit using chi-square and Kuiper's conformity test. At the end of investigation, Balashov et al. (2020) had found that the democratic countries with the higher GDP per capita, higher healthcare expenditure and better universal healthcare coverage are less likely to deviate from the Benford's Law distribution and vice versa.

Conjointly, Lee et al. (2020) had conducted a study to build an association between Benford's Law using confirmed COVID-19's cases data with the epidemic growth mathematical model. Lee et al. (2020) had observed that the current hustle is intend to "flatten the curve" forasmuch as the transmission of COVID-19 has seized on the pandemic scope. The unprecedented COVID-19 event contributed to the lack of convincing regulation and supervision from local authority

interference, hence, the curve could be steeped and the confirmed registered COVID-19 cases had thriving aggressively Lee et al. (2020). In further observation, Lee et al. (2020) has explained that the level of proliferation had happened since the number of confirmed cases in many countries had closely follows an exponential trend. Therefore, Lee et al. (2020) had argued that when a number is taken from exponential distribution caused by confirmed COVID-19 cases data, the sample automatically conveyed to obey Benford's Law. By using chi-square conformity test, had found that epidemic growth intervention is prone to fascinated with Benford's Law considering epidemic growths obey an exponential family distribution by natural. Hence, Lee et al. (2020) had concluded that Benford' Law is applicable to be embedded in epidemic growth model in time of COVID-19 outbreak period.

Moving on, Isea (2020) had analyzed the registered cases of infected COVID-19 patients using Benford's Law. Isea (2020) believed that the Benford's Law is convenient and easily adapted tool to represent digital forensic analysis technique. For conformity test on Benford's Law distribution, Isea (2020) had calculated the P-values of pearson Chi-square and mantissa arc test on the first significant leading digit. At the end of study, result had showed that Italy, Portugal, Netherland, United Kingdom, Denmark, Belgium and Chile were suspicious countries for data manipulation.

Likewise, Kapoor et al. (2020) had conducted a Benford's Law study to prove that the authoritarian government had responsible to fabricated COVID-19 data. As such, Kapoor et al. (2020) had grouped affected countries into 4 regimes which are authoritarians, hybrid, flawed democracy and full democracy. Next, Kapoor et al. (2020) had collected COVID-19 confirmed cases and the number of deaths from John Hopkin University until June, 2020. Kapoor et al. (2020) has computed on the first significant leading digit of daily cases and deaths frequencies using Benford's Law. At the end of analysis, Kapoor et al. (2020) had found that the reported confirmed COVID-19's deaths cases data declared by authoritarian governments did not follow with Benford's Law distribution by using chi-square conformity test. Kapoor et al. (2020) had expressed that the authoritarian government had seemed to manipulate COVID-19 data by virtue of the impact on economic policies and political outcomes due to COVID-19 pandemic.

DATA AND METHODOLOGY

Study has focuses to analyze the first significant leading digit in Islamic market indices during COVID-19 pandemic outbreak spanning from 02 January 2020 until 30 December 2020. The study analyzes daily close prices of Dow Jones Islamic Market International Titan 100 index (DJII), FTSE Bursa Malaysia Emas Shariah index (EMAS) and Jakarta Islamic index (JII). The study tests the null hypothesis that the Islamic market indices follow Benford's Law distribution. In this study, Mad Absolute Deviation, Distance and the Kolmogorov-Smirnov conformity test is used to conform with Benford's Law at significance level $\alpha = 0.05$.

To conduct an analysis on the first significant leading digit distribution, the following steps are taken.

1. Sorting out the first extreme left value of daily closing price index market representing the first significant leading digit (f_o).
2. Calculate the theoretical probability distribution function of the first significant leading digit $\left(P_d\right)$ by using Equation (9).

3. Calculate the expected first significant leading digit proportion frequencies (f_e) using the Equation (3).
4.

$$f_e = f_O \times P_d \tag{3}$$

5. Apply Mad Absolute Deviation (MAD), Distance and Kolmogorov-Smirnov conformity test.
6. Compare step (4) with the theoretical critical value at alpha = 0.05.
7. Make a decision to reject null hypothesis or study have to fail to reject and conclude the analyzed data for the first significant leading digit.

MAD is conformity test that neglect the variable N representing the total amount of observation value in dataset for conformance with Benford's Law. The MAD conformity test framework is represented in Equation (4) (Larsen, 2017).

$$|M| = \frac{\sum_{i=1}^{K} |A - E|}{K}, \tag{4}$$

where variable A stand for the actual proportion, E represents the expected proportion and K denotes the number of significant leading digits. There are three parts to the MAD. The deviation in the numerator uses the difference between the actual and expected proportion frequencies for each first and second significant leading digit. The numerator as can be seen in Equation (4) represent the absolute deviations from summation of the significant leading digits. Meanwhile, the denominator represents the total number of significant leading digit which is 9 for the first significant leading digit. The greater the MAD value, the bigger the discrepancy between the actual and expected proportions and vice versa. Table 3 represent the range of MAD critical values for the first and second significant leading digit (Nigrini, 2012). In the nutshell, reject null hypothesis if MAD values is above nonconformity range.

Table 2: Critical Values and Conclusions for MAD Values

Range	Conclusion
0.000 to 0.006	Close conformity
0.006 to 0.012	Acceptable conformity
0.012 to 0.015	Marginally acceptable conformity
Above 0.015	Nonconformity

Source: (Nigrini, 2012)

Next, the first significant leading digit distribution has been assessed by using the Distance conformity test which has been proposed by (Morrow, 2009). The Distance conformity test is given through Equation (5) (Morrow, 2009).

$$m^*_N \equiv \sqrt{N}. \max_{d \in \{1,\ldots,9\}} \left| \mathrm{P}\left(f_0\right) - P\left(f_e\right) \right| \tag{5}$$

The rejection region for the Distance conformity test is provided in Table 3. Study rejects null hypothesis if the Distance conformity value is bigger than the critical value at significance level $\alpha = 0.05$ (Morrow, 2009).

Table 3: Critical Values for Maximum and Distance Conformity Test

Conformity Test	$\alpha = 0.05$
Distance	1.330

Source: (Morrow, 2009)

Last but not least, the first significant leading digit distribution has been assessed by Kolmogorov-Smirnov conformity test (K-S). K-S is another all-digit-at-once conformity test besides MAD conformity test. The K-S conformity test is centre with regards to the cumulative density function (CDF) on the observed and expected significant leading digit proportion frequencies. The K-S test uses the largest of the absolute CDF values of differences between observed and expected significant leading digit proportion frequencies. The largest of absolute values is called supremum in statistical terms. The K-S conformity test can be represented by Equation (6) (Mohd & Bee, 2011).

$$K - S = \sup_x \left| F^* \left(x \right) - F_n \left(x \right) \right| \tag{6}$$

where 'sup' symbolizes supremum, which means the greatest. Referring to Equation (6), $F^* \left(x \right)$ is the observed proportion frequencies that occurred in data and $F_n \left(x \right)$ is the expected proportion frequencies derived from theoretical value using Equation (1). For the decision rule, the formula for the critical value is shown in Equation (7) (Nigrini, 2012). At the final analysis, study have to reject the null hypothesis if the calculated K-S value is bigger than the tabulated critical value.

$$C = \frac{1.36}{\sqrt{N}} \tag{7}$$

where 1.36 denotes constant of significance level at 5% and N denotes total records of significant leading digit frequencies.

RESULT

Table 6 until Table 8 summarized empirical finding using Generalized Benford's Law proposed by Hill (1995) for DJII, EMAS and JII with MAD, Distance and K-S conformity test respectively. For easier references throughout empirical analysis, the Table 5 provides of all mathematical notation involved with definition.

Table 5: Mathematical Notation with Definition

Notation	Definition
$D_n = d_n$	Significant leading digit
$f_o(D_1)$	Frequency of the first significant leading digit sorted out from data (observation value)
$f_e(D_1)$	Frequency of the expected first significant leading digit (theoretical value)
$P_{f_0}(D_1)$	Probability of the observed first significant leading digit
$P_{f_e}(D_1)$	Probability of the expected theoretical first significant leading digit
$\lvert M \rvert$	Mad Absolute Deviation Conformity Test
d^*_N	Distance Conformity Test
K-S	Kolmogorov-Smirnov Conformity Test

Table 6: Empirical Analysis of DJII

$D_n = d_n$	$f_o(D_1)$	$f_e(D_1)$	$P_{f_0}(D_1)$	$P_{f_e}(D_1)$	$\lvert M \rvert$	d^*_N	K-S
1	0	75.860	0	0.301	75.860	0.091	-75.860
2	0	44.375	0	0.176	44.375	0.031	-44.375
3	5	31.485	0.020	0.125	26.485	0.011	-26.485
4	60	24.421	0.238	0.097	35.579	0.020	35.579
5	137	19.953	0.544	0.079	117.047	0.216	117.047
6	50	16.871	0.198	0.067	33.129	0.017	33.129
7	0	14.613	0	0.058	14.613	0.003	-14.613
8	0	12.890	0	0.051	12.890	0.003	-12.890
9	0	11.532	0	0.046	11.532	0.002	-11.532
Total	252	252	1	1	41.279	9.960	117.047

Table 6 summarizes the empirical finding analysis of DJII employing Benford's Law. As can be observed through Table 6, the total value of daily observation is 252 and proportions of occurrences is being provided empirically $P_{f_0}(D_1)$ and theoretically $P_{f_e}(D_1)$. For conformance with Benford's Law proportion, the final value of all conformity test which are MAD and Distance is being compared with tabulated critical value. Meanwhile, Equation (7) is used to check conformance to Benford's Law for the K-S conformity test. Study has found that final value of MAD and Distance conformity test are bigger than tabulated critical value at significance level alpha = 0.05. For the K-S conformity test, empirical analysis value (117.047) is massively deviated from calculated theoretical critical value which is 0.085672. Hence, the null hypothesis is rejected. Study concludes that the distribution of first significant leading digit in DJII's daily close prices do not follow with theoretical expected of Benford's Law distribution throughout the COVID-19 pandemic outbreak in 2020. Based on empirical Benford's Law analysis, this study proposes pervasive influences such as panic mode from investors and psychological intervention from local government does exist in daily prices of DJII throughout COVID-19 pandemic outbreak.

Table 7: Empirical Analysis of EMAS

$D_n = d_n$	$f_o(D_1)$	$f_e(D_1)$	$P_{f_0}(D_1)$	$P_{f_e}(D_1)$	$\lvert M \rvert$	d^*_N	K-S
1	236	0.952	0.303	75.257	160.743	0.420	235.048
2	0	0	0.177	43.781	43.781	0.031	0
3	0	0	0.125	30.956	30.956	0.016	0
4	0	0	0.097	23.950	23.950	0.009	0
5	0	0	0.079	19.529	19.529	0.006	0
6	0	0	0.066	16.484	16.484	0.004	0
7	0	0	0.057	14.258	14.258	0.003	0
8	0	0	0.051	12.561	12.561	0.003	0
9	12	0.048	0.045	11.224	0.776	0.000	11.952
Total	248	1	1	248	35.893	11.054	235.048

Table 7 summarizes empirical finding analysis of EMAS employing Benford's Law. As can be observed through Table 7, total value of daily observation is 248 and proportions of occurrences is being provided empirically $P_{f_0}(D_1)$ and theoretically $P_{f_e}(D_1)$. For conformance with Benford's Law proportion, the final value of all conformity test which are MAD and Distance is being compared with tabulated critical value. Meanwhile, Equation (7) is used to check conformance to Benford's Law for the K-S conformity test. Study has found that final value of MAD and Distance conformity test are bigger than tabulated critical value at significance level alpha = 0.05. For the K-S conformity test, empirical analysis value (235.048) is massively deviated from calculated theoretical critical value which is 0.08636. Hence, the null hypothesis is rejected. Study concludes that the distribution of the first significant leading digit in EMAS's daily close prices do not follow with theoretical expected of Benford's Law distribution throughout COVID-19 pandemic outbreak in 2020. Based on empirical Benford's Law analysis, this study proposes pervasive influences such as panic mode from investors and psychological intervention from local government does exist in daily prices of EMAS throughout COVID-19 pandemic outbreak.

Table 8: Empirical Analysis of JII

$D_n = d_n$	$f_o(D_1)$	$f_e(D_1)$	$P_{f_0}(D_1)$	$P_{f_e}(D_1)$	$\lvert M \rvert$	d^*_N	K-S
1	0	0	0.303	73.133	73.133	0.092	0
2	0	0	0.177	42.546	42.546	0.031	0
3	1	0.004	0.125	30.082	29.082	0.015	0.996
4	23	0.095	0.097	23.274	0.274	0.000	22.905
5	152	0.631	0.079	18.978	133.022	0.305	151.369
6	65	0.270	0.066	16.018	48.982	0.041	64.730
7	0	0	0.057	13.856	13.856	0.003	0
8	0	0	0.051	12.206	12.206	0.003	0
9	0	0	0.045	10.907	10.907	0.002	0
Total	241	1	1	241	40.445	10.886	151.369

Table 8 summarizes empirical finding analysis of JII employing Benford's Law. As can be observed through Table 8, total value of daily observation is 241 and proportions of occurrences is being provided empirically $P_{f_0}(D_1)$ and theoretically $P_{f_e}(D_1)$. For conformance with Benford's Law proportion, the final value of all conformity test which are MAD and Distance is being compared with tabulated critical value. Meanwhile, Equation (7) is used to check conformance to Benford's Law for the K-S conformity test. Study has found that final value of MAD and Distance conformity test are bigger than tabulated critical value at significance level alpha = 0.05. For the K-S conformity test, empirical analysis value (151.369) is massively deviated from calculated theoretical critical value which is 0.087605. Hence, the null hypothesis is rejected. Study concludes that the distribution of the first significant leading digit in JII's daily close prices do not follow with theoretical expected of Benford's Law distribution throughout COVID-19 pandemic outbreak in 2020. Based on empirical Benford's Law analysis, this study proposes pervasive influences such as panic mode from investors and psychological intervention from local government does exist in daily prices of JII throughout COVID-19 pandemic outbreak.

Moving forward, Figure 2 and Figure 3 representing MAD and Distance conformity test against tabulated critical region for DJI1, EMAS and JII respectively to capture the full distribution movement and the width of data deviation from tabulated critical region during COVID-19 pandemic era in 2020.

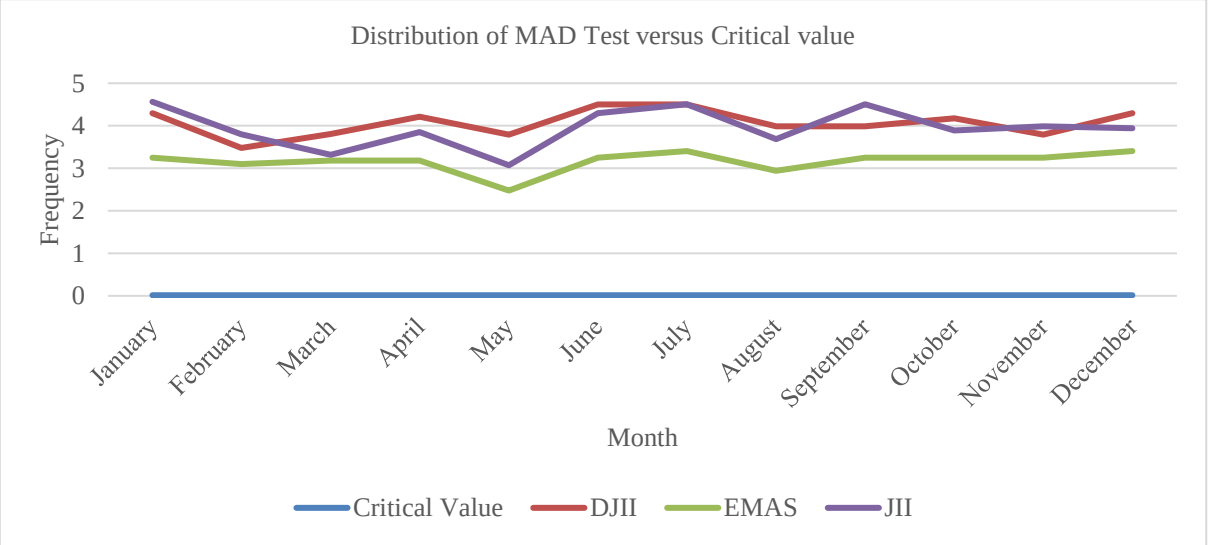

Figure 2: MAD Distribution for DJII, EMAS and JII

Based on Figure 2, one observes that DJII, EMAS and JII has deviate massively and shows turbulence movement behaviour compare to tabulated critical value throughout COVID-19 pandemic outbreak in 2020. Moreover, there are several microscopic differences between DJII and JII since ongoing COVID-19 in 2020. such as from January to March and June until December. EMAS demonstrates the smallest deviation from tabulated critical region. Nevertheless, study observes that data irregularities does exist for all market index since all market index deviate aggressively from critical value.

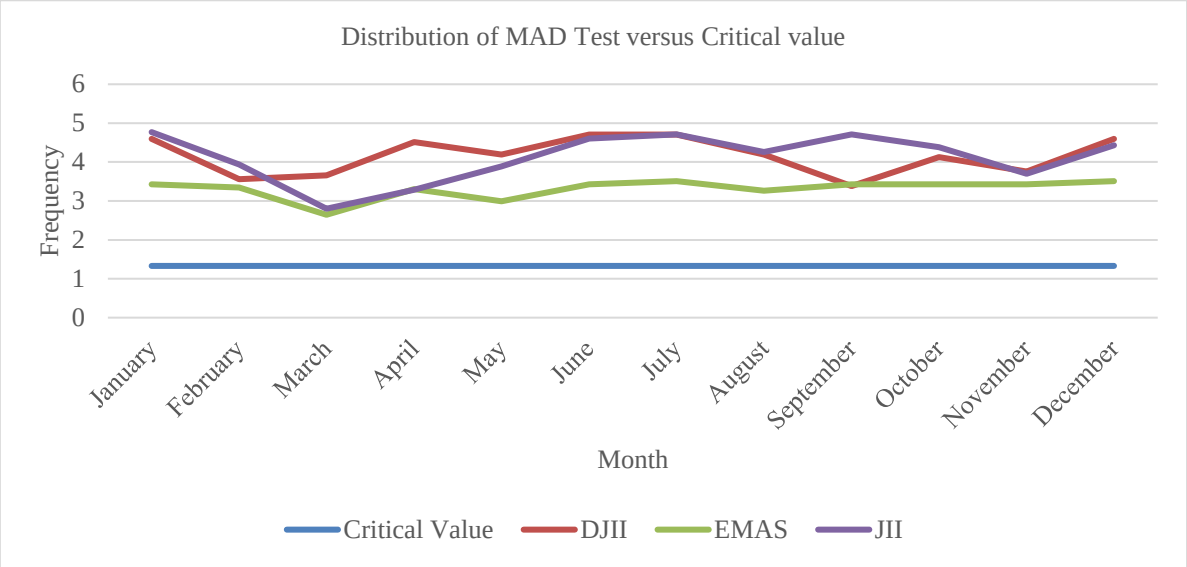

Figure 3: Distance Distribution for DJII, EMAS and JII

Based on Figure 3, one observes that DJII, EMAS and JII has deviate massively and shows turbulence movement behaviour compare to tabulated critical value throughout COVID-19 pandemic outbreak in 2020. Moreover, there are several microscopic differences between all Islamic market indices since ongoing COVID-19 in 2020. such as in February, March and November. Besides that, there are several microscopic differences between DJII and JII starting from May until August and October until December. However, EMAS demonstrates the smallest deviation from tabulated critical region. Nevertheless, study observes that data irregularities does exist for all market index since all market index deviate aggressively from critical value.

DISCUSSION

The initial notion is to expect Shariah compliant market index to follow Benford's Law. However, empirical result shows that Islamic market indices has deviated aggressively from Benford's Law expected distribution during COVID-19 pandemic. Null hypothesis is to expect Islamic financial market to follow Benford's Law because to examine whether Shariah compliant market index is able to provide a safe-haven investment for inventors when sudden unprecedented event such as COVID-19 outbreak. The root could stem from greater faith and trust in each other among investors in the midst of panic mode and uncertainty about the future. Thus, various investors significantly depend on the common religious faith that binds them together and create "group behavior". However, Benford's Law empirically proves otherwise. In congruence with Sherif (2020), study has proposed that faith-based investment philosophies are insufficient to convince and maintain the investors who choose to invest in Islamic market in the middle of pandemic COVID-19 outbreak.

Empirical finding in this study has supported the previous research conducted by Shu (2010) who has observed that the financial market behavior has been affected powerfully by investor's mood. Here, Shu (2010) has portrayed that the investor's mood has significantly play a powerful

role. In general, Shu (2010) has studied that the instability in the investors mood precisely affect stock market prices for steadiness in assets and predetermined return. Shu (2010) has suggested that the responses of investors have been greatly influenced by current broadcasting media. As such, the higher the volumes of reading materials regarding to the unprecedented events, the greater the volumes of withdrawals Shu (2010). Therefore, study strongly believes that investor's mood during COVID-19 pandemic has affect distribution of daily prices of stock index market. In short, all calculated values have showed a large deviation from critical values at all conformity test. Comparable with Shu (2010), study has agreed that economies around the globe have been allied and associated due to proliferation in financial market. Moreover, progressive in economies performance across the world has expanded, thus the interdependence between global financial market instrument around the world has been increasing in recent years. Especially at the time of COVID-19 outbreak, study has believed interdependence has increased among the global stock market and may have an impact on global investor's decision on asset allocation. Besides that, interdependence among the global financial market also may have an impact on economy as well as economic policies to ensure economic stability (Liu et al., 2020).

CONCLUSION

Benford's Law has unquestionable pertinent implication for active investors, local policymakers and local financial governor in the market turmoil era specifically since ongoing COVID-19 pandemic to date. Focusing on efficient assessment on financial asset, the role of Benford's Law as mathematical forensic tool should have been given a high consideration in the election process of assets by market players especially in the Islamic financial asset. Knowledge of association between Benford's Law and investor's behaviour in Islamic financial market is able to help various investors succeeding of accomplishing intelligent, logical and efficient financial decisions throughout ongoing COVID-19 pandemic era. Besides that, Benford's Law study is able to facilitate high driven governor to bring back competency in the Islamic financial instrument in such a challenging time.

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REFERENCES

Baker, S. R., Bloom, N., Davis, S. J., Kost, K., Sammon, M., & Viratyosin, T. (2020). The Unprecedented Stock Market Reaction to COVID-19. The Review of Asset Pricing Studies, 0(0), 1–17. https://doi.org/10.1093/rapstu/raaa008

Balashov, V. S., Yan, Y., & Zhu, X. (2020). Are Less Developed Countries More Likely to Manipulate Data During Pandemics? Evidence from Newcomb-Benford Law. SSRN Electronic Journal, 1(201), 1–34. https://doi.org/10.2139/ssrn.3662462

Benford, F. (1938). THE LAW OF ANOMALOUS NUMBERS. American Philosophical Society, 78(4), 551–572. http://www.jstor.org/stable/984802.

Coeurjolly, J.-F. (2020). Digit analysis for Covid-19 reported data. *ArXiv Preprint ArXiv:2005.05009*, 1–22

Ghafari, M., Hejazi, B., Karshenas, A., Dascalu, S., Kadvidar, A., Khosravi, M. A., Abbasalipour, M., Heydari, M., Zeinali, S., Ferretti, L., Ledda, A., & Katzourakis, A. (2020). Ongoing outbreak of COVID-19 in Iran: Challenges and signs of concern with under-reporting of prevalence and deaths. MedRxiv. https://doi.org/10.1101/2020.04.18.20070904

Hill, T. P. (1995). A Statistical Derivation of the Sidnificant-Digit Law. Statististical Science, 10(4), 354–368.

Idrovo, A. J., & Manrique-Hernández, E. F. (2020). Data Quality of Chinese Surveillance of COVID-19: Objective Analysis Based on WHO's Situation Reports. Asia-Pacific Journal of Public Health, December 2019, 10–12. https://doi.org/10.1177/1010539520927265

Isea, R. (2020). How Valid are the Reported Cases of People Infected with Covid-19 in the World? International Journal of Coronaviruses, 1(2), 53–56. https://doi.org/10.14302/issn.2692

Koch, & Okumura. (2020). Benford 's Law and COVID-19 Reporting ∗ Chinese Reporting on the Coronavirus. Economics Letters, 196(109573), 1–16. https://doi.org/10.1016/j.econlet.2020.109573

Larsen, J. E. (2017). Benford's Law and Earnings Management Detection: The Case of REITs. Journal of Forensic & Investigative Accounting, 9(2), 779–790. http://web.nacva.com/JFIA/Issues/JFIA-2017-No2-4.pdf

Lee, K. B., Han, S., & Jeong, Y. (2020). COVID-19, flattening the curve, and Benford's law. Physica A: Statistical Mechanics and Its Applications, 559, 125090. https://doi.org/10.1016/j.physa.2020.125090

Liu, H., Manzoor, A., Wang, C., Zhang, L., & Manzoor, Z. (2020). The COVID-19 outbreak and affected countries stock markets response. International Journal of Environmental Research and Public Health, 17(8), 1–19. https://doi.org/10.3390/ijerph17082800

Miranda. A. T. (2020). World's Distribution of Covid-19 Cases and The Benford's Law. An International Multidisciplinary Double-Blind Peer-Reviewed Research Journal, II(Iv), 26–28. capecomorinjournal.org.in

Mohd Razali, N., & Bee Wah, Y. (2011). Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. Journal of Statistical Modeling and Analytics, 2(1), 21–33. http://instatmy.org.my/downloads/e-jurnal 2/3.pdf%0Ahttps://www.nrc.gov/docs/ML1714/ML17143A100.pdf

Morrow, J. (2009). Benford's law, families of distributions and a test basis. Centre For Economic Performance, CEP Discus (1291), 1–26.

Nigrini, M. J. (2012). Benford's Law Application for Forensic Accounting, Auditing, and Fraud Dectection. In J. T. Wells (Ed.), John Wley & Sons, Inc. John Wley & Sons, Inc. https://www.wiley.com/enmy/Benford's+Law: +Applications+for+Forensic+Accounting, +Auditing, +and+Fraud+Detection-p-9781118152850

Organization, W. H. (2020). No Title. Https://Www.Who.Int/Health-Topics/Coronavirus#tab=tab_1. https://www.who.int/malaysia/emergencies/coronavirus-disease-(covid-19)-in-malaysia

Sherif, M. (2020). The impact of Coronavirus (COVID-19) outbreak on faith-based investments: An original analysis. Journal of Behavioral and Experimental Finance, 28(100403), 1–19. https://doi.org/10.1016/j.jbef.2020.100403

Shu, H. C. (2010). Investor mood and financial markets. Journal of Economic Behavior and Organization, 76(2), 267–282. https://doi.org/10.1016/j.jebo.2010.06.004

Wei, A., & Vellwock, A. E. (2020). Is COVID-19 data reliable? A statistical analysis with Benford's Law Is COVID-19 data reliable? A statistical analysis with Benford ' s Law Anran Wei , Andre