Are African Stock Markets Efficient? A Comparative Analysis Between Six African Markets, the UK, Japan and the USA in the Period of the Pandemic

Rui Dias
CEFAGE – Centro de Estudos e Formação Avançada, em Gestão e Economia, Universidade de Évora, Portugal
rui.dias@esce.ips.pt

João M. Pereira
Universidade Aberta, Portugal
jmpereira@uab.pt

Luísa Cagica Carvalho
CEFAGE – Centro de Estudos e Formação Avançada, em Gestão e Economia, Universidade de Évora, Portugal
luisa.c.carvalho@esce.ips.pt

Abstract

The aim of this study is to test and compare the efficient market hypothesis, in its weak form, on the stock markets of Botswana, Egypt, Kenya, Morocco, Nigeria, South Africa, Japan, the UK and the USA from 2 September 2019 to 2 September 2020. This study is based on the following research question: has the global pandemic (COVID-19) reduced the efficiency – in its weak form – of African financial markets compared to the mature markets of the UK, Japan and the USA? The results sustain the evidence that the random walk hypothesis is not supported by the financial markets analysed in the period of the global pandemic. The variance ratio values are lower than the unit, which implies that the returns are self-correlated over time. A reversion to the average is also observed, with no differences identified between mature and emerging financial markets. In corroboration, the Detrended Fluctuation Analysis (DFA) exponents show that the financial markets present signs of (in)efficiency in its weak form, thus showing persistence in the yields. This therefore implies the existence of long memories validating the results of the variance using the Wright's Rank and Signs Test (2000), which prove the rejection of the random walk hypothesis.

Keywords: African stock markets, efficient market hypothesis, mean reversion, random walk

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Introduction

The COVID-19 pandemic has negatively affected global trade as well as social and cultural life, including tourism, trade in goods, production, and sectors such as transport. Therefore, rating agencies such as Moody's and Standard & Poors reduced China's growth forecast for 2020. In line with all these adverse effects, it seems inevitable that stock markets, economic growth and exchange rates have also been affected equally (Liu, Manzoor, Wang, Zhang and Manzoor, 2020). Interest in African Stock markets from international investors has been increasing and attracting significant private investment. There are currently over twenty-nine (29) stock exchanges in Africa with significant disparities in market size, number of companies listed, volume of transactions and access to information. These institutional limitations, together with the existence of information asymmetry, agency problems, regulatory constraints and the presence of weak financial institutions, have implications for the efficient market hypothesis (EMH) in these regional stock exchanges (Hawaldar, Rohith, & Pinto, 2020; Lawal, Nwanji, Adama, & Otekunrin, 2017; Lawal, Somoye, & Babajide, 2017; Tweneboah, Owusu, & Oseifuah, 2019).

Thus, the aim of this study is to test the hypothesis of an efficient market, in its weak form, in the stock markets of Botswana, Egypt, Japan, Kenya, Morocco, Nigeria, South Africa, the UK and the USA from 2 September 2019 to 2 September 2020, in order to cover the year most affected by the global pandemic. This test is conducted based on the following research question: Has the global COVID-19 pandemic reduced the efficiency, in its weak form, of African financial markets? The results suggest very pronounced structural breaks, the existence of reversion to the mean, and the rejection of the informational efficiency hypothesis in its weak form. In corroboration, the DFA exponents show that the financial markets present signs of (in)efficiency in its weak form, thus showing persistence in the yields. This, therefore, implies the existence of long memories validating the results of the variance using the Wright's Rank and Sign Test (2000), which prove the rejection of the random walk hypothesis. These results also suggest that prices do not fully reflect the available information and that price changes are not independent and identically distributed (i.i.d.) in all markets. The high sensitivity of prices to the arrival of new information is said to have been due to the climate of pessimism and uncertainty experienced by investors during the period of the global pandemic.

This study is justified because there are still some gaps in the literature relating to the efficient market hypothesis (HME) in African stock exchanges. For instance, hybrid evidence is inconclusive in empirical studies on Africa. The authors Smith, Jefferis and Ryoo (2002), Simons and Laryea (2006), Obayagbona and Igbinosa (2015), Whisky (2015), Ogbulu (2016), Lawal, Somoye and Babajide (2017), Fusthane and M (2017), and Ajekwe, Ibiamke and Haruna (2017) demonstrated that African markets display signs of marked levels of (in)efficiency in its weak form, substantiating that returns are predictable based on historical prices. In addition, the authors Kelikume (2016), Abakah, Alagidede, Mensah and Ohene-Asare (2018), and Hawaldar, Rohith and Pinto (2020) showed that African markets are efficient in their form and verified the fact that stock prices fully reflect all the information available in the market, and investors cannot obtain anomalous returns with the same level of risk. Therefore, this research is justified by the need to mitigate existing empirical divergences on the African stock market. Moreover, as these stock exchanges develop in the presence of imperfect information, investors, regulators and other participants demand transparency about the efficiency or inefficiency of these stock markets to avoid sharp structural breaks, which can cause significant losses to domestic and international investors.

In terms of structure, this test is organised into five sections. In addition to the current introduction, section 2 is a Literature Review on the random walk hypothesis in African financial markets, section 3 describes the methodology, and section 4 contains the data and results. Finally, section 5 contains the general conclusions of the work.

Literature Review

The subject of the efficient market hypothesis (HME) denotes that the current price of assets reflects all the available information at a given moment, and the price adjusts quickly as new and unexpected information reaches the market. The hypothesis of reversion to the average, also called negative series correlation, has been interpreted as an efficient correction mechanism in developed markets and a speculative bubble sign in emerging financial markets (Summers, 1986; Fama & French, 1988).

The EMH assumes the absence of asymmetric information in trading activities in a traditional stock market. The EHM has been tested extensively in developed markets with mixed results. The same has happened in relation to African financial markets due to the presence of asymmetric information and institutional constraints. Validating the African economy's assumptions has continued to be of great interest to investors and academics, given the prominence of the African economy in global economic growth (Kelikume, 2016).

Smith, Jefferis and Ryoo (2002), and Simons and Laryea (2006) analysed market efficiency in its weak form in African markets. Smith, Jefferis and Ryoo (2002) tested the random walk hypothesis on the stock markets of South Africa, Egypt, Kenya, Morocco, Nigeria, Zimbabwe, Botswana and Mauritius. The authors show that the random walk hypothesis is rejected in seven of these markets due to the autocorrelation of the yields. For the South African market, the stock index follows the random walk hypothesis.

Simons and Laryea (2006) examined four African stock markets – Ghana, Mauritius, Egypt and South Africa. Based on the results of the parametric and non-parametric tests, the authors show that the South African stock market is efficient in its weak form. At the same time, Ghana, Mauritius and Egypt are inefficient.

Additionally, Tiwari and Kyophilavong (2014), Obayagbona and Igbinosa (2015), Whisky (2015), Ogbulu (2016), and Kelikume (2016) tested whether African markets are predictable. Tiwari and Kyophilavong (2014) examined the hypothesis of random walk in the BRICS stock indices. The authors demonstrated that these markets show inefficiency in its weak form, except for the Russian stock index. Obayagbona and Igbinosa (2015) show dependence on the series of returns and, therefore, non-randomness, demonstrating that the Nigerian market shows signs of (in)efficiency in its weak form. Whisky (2015) examined the behavior of four sectors in Nigeria, suggesting that the series of returns does not support randomness, except in the agricultural sector, which implies inefficiency in its weak form in this African market. Ogbulu (2016) shows that the Nigerian Stock Exchange (NSE) is (in)efficient in its weak form for the daily, weekly, monthly and quarterly time scales. Kelikume (2016) studied the Nigerian stock market from 1985 to 2015, showing that it follows a random walk behaviour, thus verifying signs of efficiency. In other words, stock prices fully reflect all the information available in the market, and investors cannot obtain abnormal returns with the same level of risk.

In terms of the risk, Lawal, Somoye and Babajide (2017), Fusthane and M (2017), Ajekwe, Ibiamke and Haruna (2017), Abakah, Alagidede, Mensah and Ohene-Asare (2018), and Hawaldar, Rohith and Pinto (2020) tested the hypothesis of arbitration, namely the possibility of investors obtaining abnormal returns without incurring additional risk. Lawal, Somoye and Babajide (2017) studied the validity of the random walk hypothesis in the seven largest African markets. The authors argue that the EHM is rejected in its weak form, implying that African markets are inefficient and that the implementation of adjusted trading strategies may provide trading by arbitration. Fusthane and M (2017) examined the Johannesburg Stock Exchange, pointing out that this market shows signs of inefficiency in its weak form. Along the same lines, Ajekwe, Ibiamke and Haruna (2017) established that the Nigerian stock market is efficient in its weak form. The implication of these results demonstrates that investors cannot have anomalous returns with the same level of risk. Abakah, Alagidede, Mensah and Ohene-Asare (2018) re-examined efficiency in its weak form, in the stock markets of South Africa, Nigeria, Egypt, Ghana and Mauritius. The authors point out that South African, Nigerian and Egyptian stock market indices follow the random walk hypothesis (RWH) and are efficient in their weak form. In contrast, the markets of Ghana and Mauritius are inefficient. Hawaldar, Rohith and Pinto (2020) examined the predictability of eight African stock markets. The authors determined that investors cannot obtain anomalous returns based on historical prices, proving that these markets are efficient in their weak form.

In summary, the aim of this paper is to provide information to investors and regulators in African financial markets, where individual and institutional investors seek to efficiently diversify their portfolios in a period of uncertainty and lack of confidence arising from the global COVID-19 pandemic.

Methodology

The stock market index prices of Botswana, Egypt, Kenya, Morocco, Nigeria, South Africa, Japan, the UK and the USA were analysed from 2 September 2019 to 2 September 2020. The quotations are daily and were obtained from the DataStream platform in local currency to mitigate exchange rate distortions.

This sample period was chosen as a result of a study by Nsoesie, Rader, Barnoon, Goodwin and Brownstein (2020). According to these authors from Harvard Medical School, evidence has emerged that the first outbreak of the virus occurred in the city of Wuhan, China, in the period before December 2019. The study was based on the observation of an increase in vehicles in the car parks of main hospitals and the high number of searches of Chinese search engines (Baidu) related to symptoms of the virus in late summer 2019.

The preference for these African financial markets is explained by their unstable, rapidly developing economies linked by cultural heritage and other similar economic conditions. Additionally, following the 2008 financial crisis in international emerging markets and those of Africa, these markets became an important investment destination. The choice of financial markets in Japan, the UK and the USA is due to the relevance of these markets in a global context. They are also very relevant indices of the regions in which Asia, Europe and America are part.

This research was developed over several stages. In the first stage, descriptive statistics and the Jarque and Bera (1980) adherence test was used to verify that the data follow a normal distribution. Graphs were produced of the markets, in levels and yields, to estimate the evolution of the markets under analysis. Additionally, the stability of residues was examined. To verify the breaks in structure, the Clemente et al. test was used (1998). To test the market efficiency in its weak form, a non-parametric test developed by Wright (2000) was used because this test is more resilient to time series that do not exhibit normality and are relatively consistent when they show series correlation. The aforementioned author's methodology consists of two tests: the position test (Ranks) for homoscedastic series, and the Signs test for heteroscedastic series.

The position test (Ranks) of the variance is supported in the ordering of the yield series.

For clarity, $r(r_t)$ is considered the profitability position, r_t, between r_1 , r_2, …, r_T:

$$r'_{1t} = \frac{\left(r(r_t) - \frac{T+1}{2}\right)}{\sqrt{\frac{\frac{(T-1)(T+2)}{2}}{12}}} \quad (1)$$

$$r'_{2t} = \Phi^{-1}\left(\frac{r(r_t)}{T+1}\right) \quad (2)$$

Where Φ^{-1} refers to the cumulative reverse standardised normal distribution, r'_{2t} is a standardised linear transformation of the yield position, and r'_{2t}a standardised reverse normal transformation.

$$R_1(q) = \left(\frac{\frac{1}{Tq}\sum_{t=q+1}^{T}(r'_{1t} + r'_{1t-1} + \cdots + r'_{1t-q})^2}{\frac{1}{T}\sum_{t=q+1}^{T}(r'_{1t})^2} \right) \times \left(\frac{2(2q-1)(q-1)}{3qT} \right)^{-1/2} \quad (3)$$

$$R_2(q) = \left(\frac{\frac{1}{Tq}\sum_{t=q+1}^{T}(r'_{2t} + r'_{2t-1} + \cdots + r'_{2t-q})^2}{\frac{1}{T}\sum_{t=q+1}^{T}(r'_{2t})^2} \right) \times \left(\frac{2(2q-1)(q-1)}{3qT} \right)^{-1/2} \quad (4)$$

The rejection of the RWH of yields is generated by a simulation process, in which the values of the r'_{1t} and r'_{2t} statistics are replaced by the r'^{*}_{1t} and r'^{*}_{2t} simulated value Using bootstrap estimates, which result in successive random generation of data, in order to simulate the statistical properties of the true sample distribution, the exact distribution of $R_1(q)$ and $R_2(q)$ can be approximated to a given confidence level.

Wright's methodology (2000) proposes a second test, called the signal variance ratio, which considers the signal yield, r_t, to calculate the signal ratio, being the same heteroscedastic. Thus, the following test statistic can be used:

$$S_1(q) = \left(\frac{\frac{1}{Tq}\sum_{t=q+1}^{T}(S_t + S_{t-1} + \cdots + S_{t-q})^2}{\frac{1}{T}\sum_{t=q+1}^{T}(S_t)^2} \right) \times \left(\frac{2(2q-1)(q-1)}{3qT} \right)^{-1/2} \quad (5)$$

where

$$S_t = 2\upsilon(r_t, 0)$$

$$\upsilon(x_t, p) = \begin{Bmatrix} 0,5 & se\ x_t > p \\ -0,5 & se\ x_t \leq p \end{Bmatrix} \quad (6)$$

The distribution of $S_1(q)$ can be approximated by $S_1^*(q)$ through bootstrap techniques, as in the case of the ratio of variance by rankings. $S_1^*(q)$ is obtained from the $\{S_t^*\}_{t=1}^{T}$ sequence, as each of its elements registers a value of 1 or -1, with the same probability.

Detrended Fluctuation Analysis (DFA) was used in order to validate the results. DFA is an analysis method that examines time dependency in non-stationary data series. By assuming that time series are non-stationary, this technique avoids spurious results when the analysis focuses on long-term data series relationships (Bashir, Yu, Hussain and Zebende, 2016; Guedes, Ferreira, Dionísio and Zebende, 2019).

A DFA is based on the following interpretation:

Table 1. Detrended Fluctuation Analysis (DFA)

Exponent	Type of signal
$\alpha_{DFA} < 0.5$	long-range anti-persistent
$\alpha_{DFA} \simeq 0.5$	uncorrelated, white noise
$\alpha_{DFA} > 0.5$	long-range persistent

Source: Authors

Results

In terms of the main results, it is important to highlight the results illustrated in Figure 1, which depict the evolution, in return, of the nine financial markets. The graphical analysis of the indices indicates that they show very similar behaviour patterns during the sample period. These patterns were strongly marked by the occurrence of the global COVID-19 pandemic. In contrast, the graphical analysis also verifies the existence of a bear market period between February, March and April 2020, which is characterised by a sharp drop in the index resulting from the evolution of the global COVID-19 pandemic.

Table 2 shows the main descriptive statistics of the financial markets under analysis, and allows us to ascertain that Botswana, Egypt, Japan, Kenya, Morocco, Nigeria, South

Africa and the UK stock market returns present negative daily averages, with the exception of the Japanese and US markets, which show positive daily averages. The US market exhibits the most pronounced standard deviation (0.020652). Additionally, the authors of this paper verified that all the markets present negative asymmetries, while the short ones have values above 3, which contradicts the hypothesis that the data follow a normal distribution (asymmetry = 0, kurtosis = 3). In corroboration, the adherence test of Jarque-Bera provides evidence that the data series do not follow normal distributions.

Since the time series are estimated, it is necessary to examine the stationary nature of the data series of the nine markets. The Levin, Lin and Chu (2002) test postulate that the null hypothesis has unitary roots, showing the stationary nature of the time series. However, the Hadri test (2000) postulates the stationarity in the null hypothesis. As can be see, there is rejection, which demonstrates that the data series is not stationary and that the time series may not be stable. As a result of this evidence, the Clemente et al. (1998) test is to be conducted to analyse the stationarity with breaks in structure.

Figure 2 shows the stability tests performed on stock market residuals, assessing the existence of disturbances in variance. Additionally, when examining the graphs and the 95% probability limits, a violation of the limits of the probability can be verified, thus the time series shows unstable behaviour.

Figure 3 illustrates the unit root test results, with structure breaks, by Clemente et al. (1998), showing the existence of structural breaks in March 2020, except for the Botswana Stock Exchange, which was expected given the evolution of the global COVID-19 pandemic. These findings are corroborated by the authors Sansa (2020), He, Liu, Wang and Yu (2020), who showed structural breaks in the financial markets resulting from the global pandemic.

Table 5 shows the results of the non-parametric version of Wright's variance test (2000), which includes the Rank and Signs variance tests. In both cases, the statistics were calculated for lags of 2, 4, 8 and 16 days. Considering the results of the Wright's Rank and Signs variance test (2000), the RWH is rejected in all stock market indices. Therefore, the results sustain the conclusion that the analysed financial markets do not support the RWH during this period of the global pandemic. The values of the variance ratios are lower than the unit, which implies that returns are autocorrelated over time, and there is a reversion to the mean. No differences were identified between mature and emerging financial markets. Under these conditions, markets tend to overreact to information – whether good or bad news – eventually adjusting in the following days. The high sensitivity of prices to the arrival of new information was due to the climate of pessimism and uncertainty experienced by investors during the sample period studied. Additionally, the hypothesis of informational efficiency of the financial markets may be questioned. These results are corroborated by the studies of the authors Aggarwal (2018), and Sadat and Hasan (2019), as well as partially by those of Ngene, Tah and Darrat (2017), Abakah, Alagidede, Mensah and Ohene-Asare (2018), and Malafeyev et al. (2019).

Table 6 shows that the results of the DFA exponents are demonstrated, showing that the financial markets display signs of (in)efficiency in its weak form. The persistence in the yields is then substantiated, i.e. the existence of long memories, thus validating the results of the Wright's Rank and Signs variance test (2000), which shows the rejection of the RWH. These findings demonstrate that prices do not fully reflect the available information and that changes in prices are not i.i.d. in all markets. This situation has implications for investors, since some returns can be expected, thus creating opportunities for arbitrage and abnormal returns instead of the assumptions of random walk and information efficiency.

Table 6. DFA exponent for return. The values of the linear adjustments for αDFA always had $R^2 > 0.99$

Index	DFA exponent (Covid-19)
Botswana	0.61 ≈ 0.0214
Egypt	0.63 ≈ 0.0079
Japan	0.65 ≈ 0.0019
Kenya	0.60 ≈ 0.0073
Morocco	0.62 ≈ 0.0081
Nigeria	0.77 ≈ 0.0190
South Africa	0.64 ≈ 0.0015
UK	0.64 ≈ 0.0029
US	0.59 ≈ 0.0175

Note: The hypotheses are H_0: $\alpha = 0.5$ and H_1: $\alpha \neq 0.5$
Source: Authors

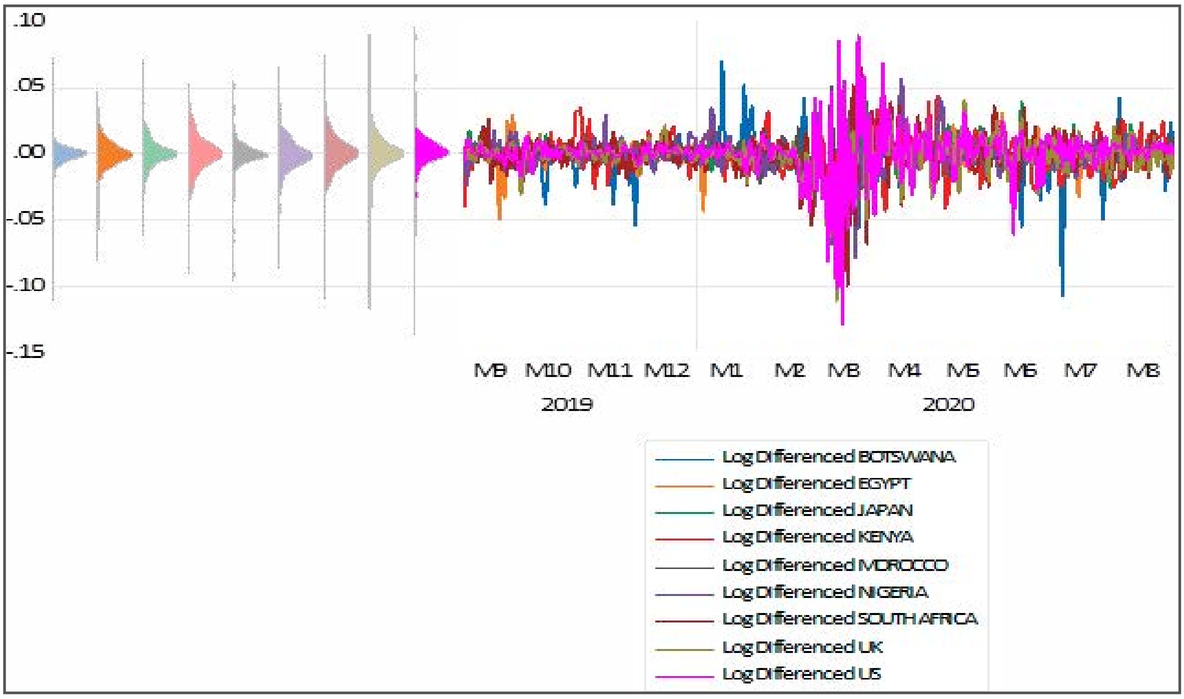
Discussion and Conclusions

This study tested the hypothesis of efficiency, in its weak form, in the stock markets of Botswana, Egypt, Japan, Kenya, Morocco, Nigeria, South Africa, the UK and the USA during the period from 2 September 2019 to 2 September 2020. The aim was to determine whether these markets have long memories in their returns, i.e. whether past prices help to predict future prices. For this purpose, two tests were conducted, namely an econometric and an economophysical.

The first tested market efficiency, in its weak form, through a non-parametric test, the position test (Ranks) for the homoscedasticity series, and the Signs test for the heteroskedasticity series. The second test examined the time dependency in non-stationary data series through the DFA methodology.

In the first test, the Wright's Rank and Signs variance ratios test was estimated. In both cases, the statistics were calculated for lags of 2, 4, 8 and 16 days. Considering the results of the Rank and Signs variance test, the RWH is rejected in all the stock indexes. The results thus support the conclusion that the RWH is not backed up by the financial markets analysed during this period of the global pandemic. The values of the variance ratios are lower than the unit, implying that returns are autocorrelated over time. There is a reversion to the mean and no differences between mature and emerging financial markets. Under these conditions, markets tend to overreact to information – irrespective of whether the news is good or bad – eventually correcting in the following days.

Figure 1. Evolution, in return, of the nine financial markets in the period between 02/09/2019 and 02/09/2020



Source: Authors

Table 2. Descriptive statistics, return, of the nine financial markets analysed, in the period from 02/09/2019 to 02/09/2020

	Botswana	Egypt	Japan	Kenya	Morocco	Nigeria	South Africa	UK	US
Mean	-0.001470	-0.001006	0.000298	-0.000407	-0.000504	-0.000946	-6.77E-05	-0.000714	0.000719
Std. Dev.	0.014387	0.013725	0.012811	0.016262	0.011857	0.014550	0.019396	0.017086	0.020652
Skewness	-1.572172	-1.493110	-0.133368	-0.760551	-2.349464	-0.867744	-1.184155	-1.185227	-1.100900
Kurtosis	18.81400	9.589017	8.185755	6.067979	22.43120	8.963956	9.911942	12.71763	14.05248
Jarque-Bera	2848.831***	73.4786***	95.4717***	128.5001***	379.512***	422.7801***	584.9979***	096.397***	1391.766***
Observations	263	263	263	263	263	263	263	263	263

Note: *** represent significance at 1%.
Source: Authors

The second DFA test shows signs of (in)efficiency in its weak form. Indicating persistence in profitability, or the existence of long memories, thus validates the results of the Wright's Rank and Signs variance test, which also shows the rejection of the RWH. These findings reveal that prices do not fully reflect the available information and that price changes are not i.i.d., in all markets.

Table 3. Levin, Lin and Chu (2002) stationary test, applied to the nine financial markets for the period from 09/02/2019 to 09/02/2020

Method	Statistic	Prob.***
Levin, Lin & Chut*	-46.9363	0.0000
Intermediate results on UNTITLED		

Series	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Bandwidth	Obs
Botswana	-0.96947	0.0002	1.E-05	0	15	40.0	262
Egypt	-0.71834	0.0002	3.E-06	0	15	122.0	262
Japan	-0.87115	0.0002	3.E-06	0	15	96.0	262
Kenya	-0.81164	0.0002	4.E-06	1	15	131.0	261
Morocco	-0.80662	0.0001	6.E-06	0	15	45.0	262
Nigeria	-0.70982	0.0002	1.E-05	0	15	34.0	262
South Africa	-1.05047	0.0004	1.E-05	0	15	66.0	262
UK	-1.00337	0.0003	1.E-05	0	15	58.0	262
US	-0.85068	0.0003	3.E-05	6	15	30.0	256
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-0.86535	-39.695	1.007	-0.508	0.740		2351

Note: *** represent significance at 1%.
Source: Authors

Table 4. Hadri (2000) stationary test, applied to the nine financial markets for the period from 09/02/2019 to 09/02/2020

Method	Statistic	Prob.***
Hadri Z-stat	2.45648	0.0070
Heteroscedastic Consistent Z-stat	2.79639	0.0026
Intermediate results on UNTITLED		

Series	LM	Variance HAC	Bandwidth	Obs
Botswana	0.1333	0.000211	1.0	263
Egypt	0.0927	0.000239	1.0	263
Japan	0.1225	0.000215	3.0	263
Kenya	0.0855	0.000363	3.0	263
Morocco	0.1393	0.000167	1.0	263
Nigeria	0.1265	0.000351	4.0	263
South Africa	0.0754	0.000416	6.0	263
UK	0.0843	0.000339	5.0	263
US	0.0911	0.000322	5.0	263

Note: *** represent significance at 1%.
Source: Authors

Figure 2. Stability tests performed on the residuals of the nine financial markets in the period from 02/09/2019 to 02/09/2020

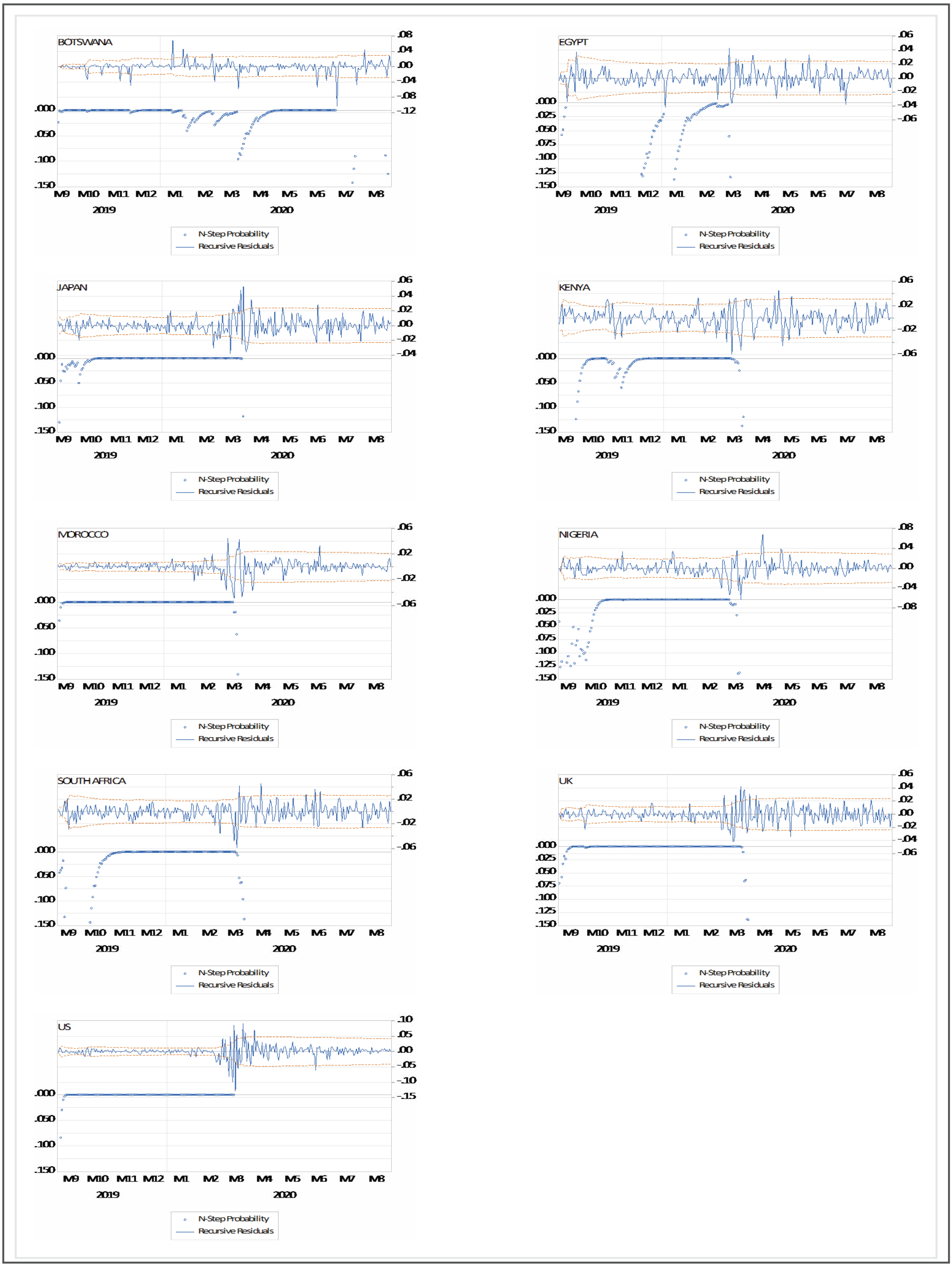


Figure 3. Stationary tests with breaks in the structure of Clemente et al. (1998), in return, related to the nine financial markets in the period from 09/02/2019 to 09/02/2020

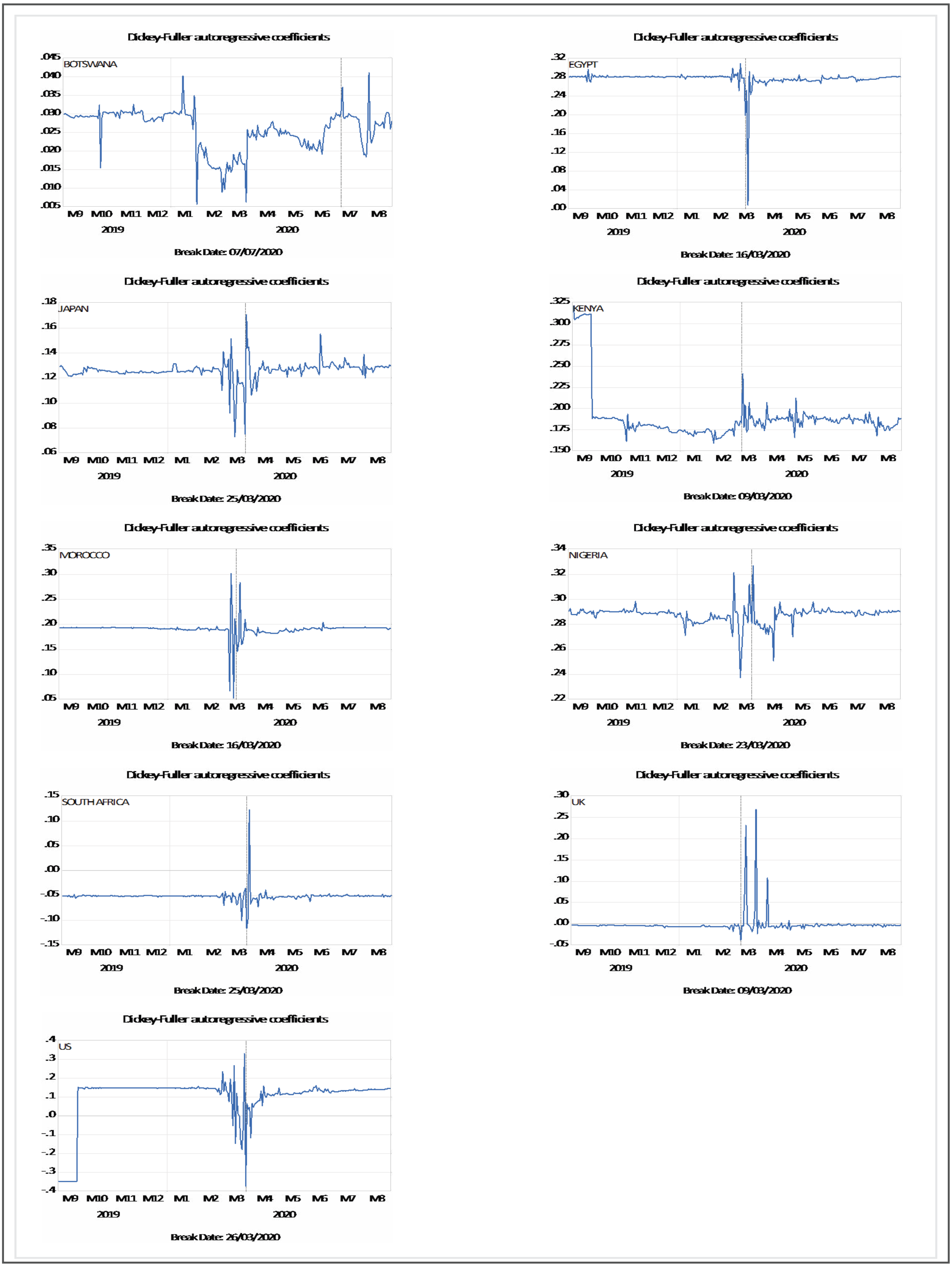


Table 5. Tests of the Wright's Rank and Signs Ratios (2000), in return, referring to the nine financial markets in the period from 09/02/2019 to 09/02/2020

Null Hypothesis: Botswana is a random walk (rank score variance ratio)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	7.769864	262	0.0000
Wald (Chi-Square)	60.68542	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.519976	0.061780	-7.769864	0.0000
4	0.285238	0.115580	-6.184123	0.0000
8	0.133499	0.182748	-4.741497	0.0000
16	0.094114	0.271938	-3.331219	0.0010

Null Hypothesis: Botswana is a martingale (sign variance ratio test)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	6.054460	262	0.0000
Wald (Chi-Square)	38.17342	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.625954	0.061780	-6.054460	0.0000
4	0.488550	0.115580	-4.425070	0.0000
8	0.351145	0.182748	-3.550539	0.0000
16	0.315840	0.271938	-2.515867	0.0040

Null Hypothesis: Egypt is a random walk (rank score variance ratio)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	6.083644	262	0.0000
Wald (Chi-Square)	40.47185	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.624151	0.061780	-6.083644	0.0000
4	0.313415	0.115580	-5.940335	0.0000
8	0.179850	0.182748	-4.487867	0.0000
16	0.106560	0.271938	-3.285454	0.0020

Table 5. Tests of the Wright's Rank and Signs Ratios (2000), in return, referring to the nine financial markets in the period from 09/02/2019 to 09/02/2020 (continued)

Egypt is a martingale (sign variance ratio test)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	3.368337	262	0.0060
Wald (Chi-Square)	11.75573	4	0.0230

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.839695	0.061780	-2.594769	0.0060
4	0.610687	0.115580	-3.368337	0.0010
8	0.515267	0.182748	-2.652461	0.0070
16	0.448473	0.271938	-2.028133	0.0290

Null Hypothesis: Japan is a random walk (rank score variance ratio)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	8.090627	262	0.0000
Wald (Chi-Square)	66.69285	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.500159	0.061780	-8.090627	0.0000
4	0.307603	0.115580	-5.990621	0.0000
8	0.162038	0.182748	-4.585334	0.0000
16	0.105081	0.271938	-3.290890	0.0010

Null Hypothesis: Japan is a martingale (sign variance ratio test)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	7.413625	262	0.0000
Wald (Chi-Square)	55.36321	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.541985	0.061780	-7.413625	0.0000
4	0.354962	0.115580	-5.580872	0.0000
8	0.255725	0.182748	-4.072677	0.0000
16	0.211832	0.271938	-2.898335	0.0050

Table 5. Tests of the Wright's Rank and Signs Ratios (2000), in return, referring to the nine financial markets in the period from 09/02/2019 to 09/02/2020 (continued)

Null Hypothesis: Kenya is a random walk (rank score variance ratio)				
Joint Tests				
		Value	df	Probability
	Max |z| (at period 2)	5.354766	262	0.0000
	Wald (Chi-Square)	29.69610	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.757748	0.061780	-3.921185	0.0000
4	0.381095	0.115580	-5.354766	0.0000
8	0.209973	0.182748	-4.323031	0.0000
16	0.119039	0.271938	-3.239563	0.0010

Null Hypothesis: Kenya is a martingale (sign variance ratio test)				
Joint Tests				
		Value	df	Probability
	Max |z| (at period 2)	3.953933	262	0.0000
	Wald (Chi-Square)	15.92664	4	0.0020

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.755725	0.061780	-3.953933	0.0000
4	0.618321	0.115580	-3.302291	0.0000
8	0.507634	0.182748	-2.694232	0.0040
16	0.468511	0.271938	-1.954446	0.0350

Null Hypothesis: Morocco is a random walk (rank score variance ratio)				
Joint Tests				
		Value	df	Probability
	Max |z| (at period 2)	6.847880	262	0.0000
	Wald (Chi-Square)	47.24316	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.576937	0.061780	-6.847880	0.0000
4	0.378446	0.115580	-5.377687	0.0000
8	0.232358	0.182748	-4.200545	0.0000
16	0.153260	0.271938	-3.113724	0.0010

Table 5. Tests of the Wright's Rank and Signs Ratios (2000), in return, referring to the nine financial markets in the period from 09/02/2019 to 09/02/2020 (continued)

Null Hypothesis: Morocco is a martingale (sign variance ratio test)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	4.695296	262	0.0000
Wald (Chi-Square)	22.93522	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.709924	0.061780	-4.695296	0.0000
4	0.603053	0.115580	-3.434383	0.0010
8	0.530534	0.182748	-2.568919	0.0130
16	0.400763	0.271938	-2.203577	0.0150

Null Hypothesis: Nigeria is a random walk (rank score variance ratio)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	6.476426	262	0.0000
Wald (Chi-Square)	42.91433	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.599885	0.061780	-6.476426	0.0000
4	0.391809	0.115580	-5.262071	0.0000
8	0.204557	0.182748	-4.352669	0.0000
16	0.127734	0.271938	-3.207590	0.0010

Null Hypothesis: Nigeria is a martingale (sign variance ratio test)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	4.571735	262	0.0000
Wald (Chi-Square)	22.14425	4	0.0010

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.717557	0.061780	-4.571735	0.0000
4	0.515267	0.115580	-4.193909	0.0000
8	0.381679	0.182748	-3.383455	0.0010
16	0.230916	0.271938	-2.828157	0.0030

Table 5. Tests of the Wright's Rank and Signs Ratios (2000), in return, referring to the nine financial markets in the period from 09/02/2019 to 09/02/2020 (continued)

Null Hypothesis: South Africa is a random walk (rank score variance ratio)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	7.221207	262	0.0000
Wald (Chi-Square)	52.90245	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.553872	0.061780	-7.221207	0.0000
4	0.283339	0.115580	-6.200557	0.0000
8	0.181556	0.182748	-4.478529	0.0000
16	0.116130	0.271938	-3.250261	0.0010

Null Hypothesis: South Africa is a martingale (sign variance ratio test)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	4.818856	262	0.0000
Wald (Chi-Square)	25.50291	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.702290	0.061780	-4.818856	0.0000
4	0.473282	0.115580	-4.557161	0.0000
8	0.410305	0.182748	-3.226813	0.0000
16	0.326336	0.271938	-2.477269	0.0080

Null Hypothesis: The UK is a random walk (rank score variance ratio)			
Joint Tests			
	Value	df	Probability
Max |z| (at period 2)	8.044168	262	0.0000
Wald (Chi-Square)	64.89393	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.503030	0.061780	-8.044168	0.0000
4	0.282822	0.115580	-6.205027	0.0000
8	0.177048	0.182748	-4.503196	0.0000
16	0.107695	0.271938	-3.281279	0.0000

Table 5. Tests of the Wright's Rank and Signs Ratios (2000), in return, referring to the nine financial markets in the period from 09/02/2019 to 09/02/2020 (continued)

Null Hypothesis: The UK is a martingale (sign variance ratio test)

Joint Tests	Value	df	Probability
Max |z| (at period 2)*	3.970425	262	0.0003

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.466014	0.134491	-3.970425	0.0001
4	0.239752	0.239710	-3.171532	0.0015
8	0.148832	0.367746	-2.314553	0.0206
16	0.071438	0.524701	-1.769699	0.0768

Null Hypothesis: The US is a random walk (rank score variance ratio)

Joint Tests	Value	df	Probability
Max |z| (at period 2)	10.25450	262	0.0000
Wald (Chi-Square)	113.7720	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.366475	0.061780	-10.25450	0.0000
4	0.244683	0.115580	-6.535007	0.0000
8	0.151129	0.182748	-4.645026	0.0000
16	0.078112	0.271938	-3.390064	0.0010

Null Hypothesis: The US is a martingale (sign variance ratio test)

Joint Tests	Value	df	Probability
Max |z| (at period 2)	7.413625	262	0.0000
Wald (Chi-Square)	55.36321	4	0.0000

Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.541985	0.061780	-7.413625	0.0000
4	0.354962	0.115580	-5.580872	0.0000
8	0.255725	0.182748	-4.072677	0.0000
16	0.211832	0.271938	-2.898335	0.0050

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Source: Authors

In reply to the research question, evidence was found in the results of both tests which confirm that mature and emerging financial markets show signs of (in)efficiency in their weak form. These findings have implications for investors, as some returns can be expected, thus creating opportunities for arbitrage and abnormal returns.

The overall conclusion that is to be highlighted, as supported by the results obtained through the tests performed using econometric and mathematical models, is that the global pandemic has had a significant impact on the memory properties of the markets analysed. The results show that the markets have persistence and long memories in their returns, implying in return that investors will be able to obtain abnormal returns without incurring additional risk. This study suggests that, in order to mitigate risk and improve portfolio efficiency, investors should diversify their portfolios and invest in less risky markets.

As for future research suggestions, this study used general indexes of a daily frequency to analyse efficiency in its weak form. In the continuation of this study, it would also be interesting to use higher frequency data, intraday-based, quotes per minute, to perform a more refined analysis of the data and highlight more robust results.

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Ali so afriški borzni trgi učinkoviti? Primerjalna analiza med šestimi afriškimi trgi, Združenim kraljestvom, Japonsko in ZDA v obdobju pandemije

Izvleček

Namen te študije je preizkusiti in primerjati hipotezo učinkovitega trga v njeni šibki obliki na borznih trgih Bocvane, Egipta, Kenije, Maroka, Nigerije, Južne Afrike, Japonske, Združenega kraljestva in ZDA od 2. septembra 2019 do 2. septembra 2020. Študija temelji na naslednjem raziskovalnem vprašanju: Ali je globalna pandemija (covida-19) v svoji šibki obliki zmanjšala učinkovitost afriških finančnih trgov v primerjavi z razvitimi trgi Združenega kraljestva, Japonske in ZDA? Rezultati potrjujejo dokaze, da finančni trgi, analizirani v obdobju te globalne pandemije, ne podpirajo hipoteze naključnega sprehoda. Vrednosti variančnih razmerij so nižje od ena, kar pomeni, da se donosi sčasoma samokorelirajo. Ugotovljen je bil tudi povratek k povprečju, pri čemer razlike med razvitimi finančnimi trgi in tistimi, ki so v vzponu, niso bile prepoznane. To potrjujejo eksponenti detrendne analize fluktuacije (DFA), ki prikazujejo, da finančni trgi kažejo znake (ne)učinkovitosti v svoji šibki obliki, kar kaže na obstojnost donosa. S tem implicirajo obstoj dolgih spominov in potrjujejo rezultate Wrightovega (2000) testa variance, kar dokazuje zavrnitev hipoteze slučajnega hoda.

Ključne besede: afriški borzni trgi, hipoteza učinkovitega trga, povprečna reverzija, naključni sprehod