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ESG Indices Efficiency in Five MENA Countries: Application of the Hurst Exponent

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Abstract

The efficient market hypothesis (EMH) is one of the main theories related to financial markets. This hypothesis is based on the idea that stock prices already reflect all available market information. In its weak form, the EMH states that future prices cannot be predicted by analyzing historical asset prices. This paper aims to test the effectiveness of environmental, social and governance (ESG) indices in the Middle East and North Africa region (MENA) and compare them with their conventional counterparts. The sample data covers the period from September 27 2018 to December 23 2021 in daily frequency. Our empirical approach is based on Hurst behavior using the R/S statistic. The results reject the market efficiency hypothesis for both ESG and conventional indices and show that these indices are significantly inefficient with persistent returns. In terms of the level of efficiency between the ESG and conventional indices, the study does not indicate significant differences.

Keywords

Efficient Market Hypothesis, Hurst Exponent, Long-Term Dependence, ESG Indices, Conventional Indices, MENA Region

1. Introduction

Sustainable finance emphasizes ethical and moral values, environmental and social awareness, and good governance to meet the needs of stakeholders who demand sustainable economic value integrating environmental, social, and governance (ESG) factors. It has seen considerable development in recent years. According to the 2021 UNCTAD's report, the value of sustainable investment products in global financial markets has grown to $3.2 trillion in 2020, repre-

senting an 80% increase from 2019.

This remarkable development of sustainable finance has attracted the interest of researchers and spawned a considerable literature. One of the most popular topics in socially responsible investing literature is the relationship between corporate social responsibility (CSR) and financial performance. More than 5314 researches study this relationship (Barnett et al., 2020; Wang, Dou, & Jia, 2016; Margolis & Walsh, 2003).

Some researches focus on analyzing the evolution of ESG investing (Luo et al., 2022; Krishnamoorthy, 2021; Ait El Mekki, 2020). Other researches analyze CSR and debt (Goss & Roberts, 2011; Xu et al., 2021; Cooper & Uzun, 2015; Hamrouni et al., 2019), the return and risk of socially responsible investments (Rudd, 1981; Diltz, 1995; de Souza Cunha & Samanez, 2013), the performance of sustainable funds (Mervelskemper et al., 2014; Allevi et al., 2019; Yue et al., 2020), etc.

The creation of socially responsible stock market indices has motivated researchers to expand their empirical thinking. Indeed, the providers of sustainability indices (such as S & P and FTSE) have strengthened their production of indices in several geographical areas in order to meet investors' demands in terms of sustainability. As a result, the number of indices measuring ESG factors increased by 13.85% in 2019, 40.20% in 2020, and 43% in 2021 (Index Industry Association, 2021).

As a result, with this emergence of socially responsible stock indices, some researchers have been focused on analyzing the performance of these indices compared to their conventional counterparts (Fowler & Hope, 2007; Jain et al., 2019; La Torre et al., 2020), and other researches analyze the volatility and risk of ESG indices (Sudha, 2015; Sabbaghi, 2022; Górka & Kuziak, 2022). Yet other studies test the relationship between redefinitions of socially responsible indices and financial performance (Capelle-Blancard & Couderc, 2009; Jain et al., 2019). Further studies focus on the analysis of valuation methodologies practiced by ESG indices (Ziegler & Schröder, 2010; Pagano et al., 2018; Hübel et al., 2022).

Despite the plethora of studies, too few focus on analyzing the efficiency of socially responsible stock indices. The efficient market hypothesis (EMH) assumes that stock prices are random and that past behavior is not useful in predicting future movements (Fama, 1965). The EMH states that rates of return have no memory, which prevents returns from being obtained in financial markets through trading strategies (Ferreira & Dionísio, 2016). Given this finding, our study responds to the gap in the literature by providing a better analysis of the efficiency of ESG indices in five Middle Eastern and North African (MENA) countries. The purpose of the paper is to analyze the efficiency of ESG indices, in their weak form, and compare it with that of conventional indices in the MENA region using the Hurst exponent.

The results reject the market efficiency hypothesis for both ESG and conventional indices by proving that these indices are significantly inefficient with per-

sistence in returns. Furthermore, in terms of the level of efficiency between the ESG and the conventional indices, the study does not indicate significant differences. The study is the first to analyze the efficiency of ESG indices and their conventional counterparts through the Hurst exponent and in a context marked by the Covid-19 pandemic.

The following sections present a conceptual framework of market efficiency and a review of the empirical literature that leads to the development of the research hypotheses. Next, we describe the study data and the methodological process and present the results of the study. Finally, we conclude with the empirical implications of our research.

2. Literature Review

The academic literature on the trend of stock prices has undergone considerable development. Fama (1965) is considered one of the first researchers who studied the dynamics of stock prices in a profound way by proposing the theory of market efficiency and the theory of the random market. The theory of the random market states that price changes are random and past behavior is of no use in predicting future movements (Fama, 1965). The study by Kendall and Hill (1953) is also considered to be one of the first studies that confirmed that stock prices exhibit a random behavior. On the other hand, market efficiency assumes that prices fully reflect all available market information (Fama, 1970). Fama (1970) distinguishes between three forms of market efficiency: the weak form, the semi-strong form, and the strong form.

The weak form of market efficiency considers that current prices only reflect the historical information generated by the market, such as price history and trading volumes, and therefore, it would be impossible to beat the market using investment strategies based on historical stock prices. On the other hand, the semi-strong form asserts that stock prices adjust effectively to public information, including annual earnings announcements, etc. Next, the strong form of market efficiency states that stock prices fully reflect all relevant information whether public or private, i.e. insider trading will not be rewarded because current stock prices incorporate all important non-public information, and therefore, no investor will be able to consistently earn above average risk-adjusted rates of return.

In the financial literature, several studies investigate the reaction of stock markets to unexpected information and events (Vega, 2006; Boudoukh et al., 2013; Baker et al., 2019; Khanthavit, 2020), informational efficiency and long-term stock price dependence (Chow et al., 1996; Mensi et al., 2019), and stock index volatility (Engle et al., 2013; Su et al., 2019). In addition, numerous studies focus on socially responsible investment in financial markets, including the impact of ESG criteria on financial performance (Friede et al., 2015; Revelli & Viviani, 2015; Capelle-Blancard & Petit, 2019; La Torre et al., 2020). In line with the contributions of the stakeholder theory, a few studies confirm that sustainable in-

vestment creates shareholder value (Fernández-Guadaño & Sarria-Pedroza, 2018; Miralles-Quirós et al., 2019; Nguyen et al., 2020). From this perspective, researchers also focus on analyzing the performance of ESG indices against conventional indices (Managi et al., 2012; Ur Rehman et al., 2016; Jain et al., 2019; de Souza Cunha et al., 2020).

Several studies have confirmed the outperformance of ESG indices compared to conventional indices (de Souza Cunha et al., 2020; Talan & Sharma, 2019). On the other hand, few studies focus on analyzing the persistence of ESG indices by investigating their degree of efficiency against conventional indices. These have been the subject of several empirical tests of their effectiveness (Smith et al., 2002; Manescu, 2010; Onali & Goddard, 2011; Rejichi & Aloui, 2012; Sensoy & Tabak, 2015; Mynhardt et al., 2017; Dias & Santos, 2020; Vadithala & Tadoori, 2021; Caporale et al., 2022; Bofinger et al., 2022; Wu et al., 2022).

In the European context, Sensoy and Tabak (2015) studied the long memory of EU stock markets after the introduction of the euro using the generalized Hurst exponent. The study found that European stock markets have different degrees of long memory, while providing evidence that the stock markets of Denmark, Hungary, Italy, and the United Kingdom are considered the most efficient. In contrast, the least efficient financial markets are those of Lithuania, Estonia, Malta, and Bulgaria.

In the U.S. context, Manescu (2010) studied the effective integration of ESG information into the stock prices of a sample of large listed companies between July 1992 and June 2008. The results confirmed that some ESG attributes had a relevant impact on value but were not integrated effectively into stock prices. In the same context, Bofinger et al. (2022) analyzed the impact of CSR on the efficiency of the US stock market between 2004 and 2017. They found that companies' ESG criteria affect their valuation significantly. In other words, an improvement in CSR leads to a higher ratio between the real and effective value of the company. The results of the analysis between ESG criteria and poor valuations separately imply that sustainability increases the existing overvaluation while it decreases the gap of undervalued companies to their actual value.

In the Chinese context, based on a comprehensive dataset of Chinese companies listed between 2010 and 2019, Wu et al. (2022) tested the impact of ESG certification on the price efficiency of companies listed in the ESG 300, ESG 40, and ESG 100 indexes. The researchers concluded that companies added to the ESG lists can improve their price efficiency, while those removed from the ESG lists experience a decline. The study revealed two potential internal mechanisms that improve ESG certification on price efficiency performance: improving stock liquidity and reducing information asymmetry.

In the African context, Smith et al. (2002) studied efficiency in African stock markets using the multiple variance ratio test. The study covered the financial markets of South Africa, Egypt, Kenya, Morocco, Nigeria, Zimbabwe, Botswana,

and Mauritius. The implications of the study reject the random walk hypothesis in the majority of African financial markets, with the exception of the South African stock market that follows a random walk. In the same context, and using unit root tests, Dias and Santos (2020) tested the weak form of the efficiency hypothesis in the financial markets of Morocco, Botswana, Egypt, Kenya, Nigeria, and South Africa during the Covid-19 health crisis. The results show that these financial markets are not efficient. Therefore, the random walk hypothesis is not supported by African financial markets.

In a broader context, Plastun et al. (2022) examined the price impact of abnormal one-day returns on developed and emerging market equity indices while distinguishing between ESG and conventional indices over the period between 2007 and 2020. Their study investigated whether the incorporation of ESG criteria influences the efficiency of stock market indices, and in particular, the vulnerability of ESG indices to price effects after abnormal returns is realized. The results indicate that ESG indices are generally consistent with conventional indices, and the types of effects detected are the same for both. The study implies evidence against the EMH and indicates that the indices are partially efficient.

The literature on financial market efficiency has been enriched by new methodologies for evaluating efficiency, notably the Hurst exponent (Hurst, 1951). The latter is considered a primary measure for detecting efficiency and long-run memory in financial time series (Corazza & Malliaris, 2002; Cajueiro & Tabak, 2005; Grech & Pamula, 2008; Onali & Goddard, 2011; Mynhardt et al., 2017; Al-Faryan & Dockery, 2021; Caporale et al., 2022; López & Mansilla, 2021; Tadoori & Vadithala, 2022; Vogl, 2023; Danila, 2022; Gómez-Águila et al., 2022; Metescu, 2022; Takaishi, 2022).

Using the Hurst exponent, Onali and Goddard (2011) analyzed the long memory of returns of eight European stock indices and revealed the existence of long memory for the stock market of the Czech Republic and weak dependence for the stock markets of Spain and Switzerland.

In analyzing the behavior of ESG indices relative to their traditional analogues, Mynhardt et al. (2017) used the Hurst exponent to test the effectiveness of several indices, including the Dow Jones Sustainability Index (DJSI), the S & P 500 Environmental & Socially Responsible Index, the FTSE4 Good Global Index, the MSCI World ESG Index, and the NASDAQ OMX CRD Global Sustainability Index. The findings of their study confirm that ESG indices are less effective than traditional indices, including the Dow Jones ESG Index. Emerging markets have a low degree of efficiency in terms of responsible investment.

In a broader context, Caporale et al. (2022) analyzed the persistence of two sets of 12 ESG and conventional indices over the period 2007-2020 in a large number of developed and emerging markets using R/S analysis and fractional integration techniques. Both methods led to the same conclusions by confirming the non-existence of significant differences between conventional and ESG indi-

ces in terms of persistence and dynamic behavior. In particular, emerging markets (BRICS) show a low degree of efficiency compared to other markets. For example, Tadoori and Vadithala (2022) evaluated the efficiency of 44 major global financial markets (Asia-Pacific-17, Europe-16, America-6, and Africa-5) for 15 months (November 2019 to January 2021).

The results of the Hurst exponent estimations proved that out of 44 selected global indices, only two indices have Hurst values close to 0.5. These indices include SSE Composite and NASADAQ. The rest of the indices have Hurst values above 0.5, which proves that they are not efficient. Similarly, López and Mansilla (2021) analyzed market efficiency for high-frequency automated stock markets in the US and Mexico using the Hurst exponent methodology. Their results show that the time series of high-frequency stock prices do not follow a random walk.

Takaishi (2022) examined the time evolution of market efficiency in Japanese stock markets through the Hurst exponent. The results reveal that Japanese markets are not efficient. Also, Danila (2022) evaluated the weak form of the efficiency of SRI/ESG indices in emerging markets while mobilizing the Augmented Dickey-Fuller (ADF) unit root test, the variance ratio test and the Hurst exponent test. Their implications confirm that not all indices follow a random walk. Thus, they indicate that lack of ESG disclosure, inadequate corporate governance regulations, and behavioral bias could be the reasons for market inefficiency.

In the Maghreb context, Rejichi and Aloui (2012) tested the evolutionary efficiency of MENA stock markets using an empirical approach based on the sliding Hurst exponent. The results show that the financial markets of Turkey and Egypt are considered the least inefficient in the MENA region. In contrast, Al-Faryan and Dockery (2021) studied the informational efficiency of the Saudi stock market. The Hurst exponent estimates indicate high long-run dependence, and therefore, suggest that the Saudi financial market is informationally inefficient.

After analyzing the literature review, we formulated the following hypotheses regarding the efficiency of ESG indices:

Hypothesis 1: *ESG and conventional indices are efficient.*

Hypothesis 2: *ESG indices compare to conventional indices.*

3. Data and Methodology

3.1. Data Description

This study covers conventional and socially responsible stock indices in MENA financial markets, including Morocco, Tunisia, Turkey, Qatar, and the UAE (see **Table 1**), which are considered the financial markets that adopt ESG indices. The observations are the daily quotes of each stock index that have been extracted from the website of each financial market.

Table 1. Sample composition.

Country	Indices	No. of obs.
Morocco	Moroccan All Shares Index	803
	Casa ESG 10 Index	803
Egypt	EGX 100 Index	791
	S & P/EGX ESG Index	791
Turkey	BIST All Shares Index	811
	BIST Sustainability Index	811
Qatar	QSE All Shares Index	809
	MSCI QSE 20 ESG Index	845
United Arab Emirates (UAE)	DFM General Index	809
	S & P/Hawhamah ESG UAE Index	977

We test the efficiency of the stock market indices over the period from 9/27/2018 to 12/23/2021. For comparison purposes, all quotes start on the same date, which corresponds to the date of implementation of the GSS index in Morocco. The number of observations is not exactly the same for all countries. It varies from one country to another depending on the availability of quotes. But globally, it turns around 800 observations. So, the difference is materially insignificant.

3.2. Methodology: Hurst Exponent Estimation

To measure the efficiency of stock market indices, we use the Hurst exponent, which is a measure for detecting the long-term memory of financial time series and their efficiency (Corazza & Malliaris, 2002; Cajueiro & Tabak, 2005; Grech & Pamula, 2008). The Hurst exponent (H) dates back to the work of Hurst (1951), who applied it to detect long dependence in hydrological time series. This method was introduced to the study of persistence in economic time series by Mandelbrot (1972). The Hurst exponent has been used for the detection of long memory in long-term financial series (Grech & Mazur, 2004; Cajueiro & Tabak, 2004). To compute the Hurst exponent, we mobilized the R/S statistic which is considered the most adaptable method for financial data analysis (Mynhardt et al., 2014).

The methodological process of the Hurst exponent is defined as follows: a time series of length M is transformed into a series of length $N = M - 1$ by using logs and converting prices into returns:

$$N_i = \log\left(\frac{Y_{t+1}}{Y_t}\right), \quad t = 1, 2, 3, \cdots, (M-1). \tag{1}$$

The period is divided into A contiguous sub-periods of length n, so that $A_n =$

N. Next, we identify each sub-period as I_a, given that $a = 1, 2, 3, \cdots, A$. Each I_a element is represented by N_k with $k = 1, 2, 3, \cdots, N$.

We calculate the Hurst exponent on the daily returns described above. We then divide each time series into A contiguous subperiods of length n, such that $A_n = N$ where N is the number of monthly returns.

For any I_a of length n, the mean and e_a are defined as follows:

$$e_a = \frac{1}{n}\sum_{k=1}^{n} X_{k,a} \tag{2}$$

The cumulative deviations $X_{k,a}$ from the mean e_a for each sub-period I_a are defined as follows:

$$X_{k,a} = \sum_{i=1}^{k}\left(N_{i,a} - e_a\right) \tag{3}$$

We define the range, $R_{I,a}$ as the maximum $X_{k,a}$ minus the minimum $X_{k,a}$ within each sub-period.

$$R_{I_a} = \max\left(X_{k,a}\right) - \min\left(X_{k,a}\right) \tag{4}$$

We calculate the standard deviation within each sub-period as follows:

$$S_{I_a} = \left(\frac{1}{n}\sum_{k=1}^{n}\left(N_{k,a} - e_a\right)^2\right)^{0.5} \tag{5}$$

Then, we normalize each range by dividing it by the corresponding standard deviation. Thus, the average R/S for length n is defined as follows:

$$\left(\frac{R}{S}\right)_n = \frac{1}{A}\sum_{i=1}^{A}\frac{R_{Ia}}{S_{Ia}} \tag{6}$$

The length n is taken to the next higher level, as $(M1)/n$, must be an integer. In this case, it is n-indices that include the initial and final points of the time series, and the steps are repeated until $n = (M-1)/2$. Next, we use ordinary least squares to estimate Equation (7):

$$\log\left(\frac{R}{S}\right)_n = \log(c) + H\log(n) \tag{7}$$

where H is the estimate of the Hurst exponent. It is defined on the interval [0, 1]. Based on the values of the Hurst exponent, the indices can be classified as follows:

- $0 \le H < 0.5$ - The EMH is not confirmed, the distribution has fat tails, the series are anti-persistent, and the returns are negatively correlated.
- $H = 0.5$ - The market efficiency hypothesis is confirmed, asset returns follow a random Brownian motion, returns are uncorrelated (no memory in the series), and traders cannot "beat" the market using any trading strategy.
- $0.5 < H \le 1$ - Low market efficiency is not confirmed, the distribution has fat tails, the series are persistent, the returns are positively correlated, and there is a trend in the market.

4. Results and Discussion

4.1. Descriptive Statistics

The descriptive statistics present a preliminary analysis of the performance of the five MENA conventional and GSE indices (Table 2). We can see that the conventional indices in these countries show higher average returns than the GSE indices. In Morocco, the Moroccan All Shares Index (MASI) posted an average daily return of 0.0191%, while the Casa ESG 10 index underperformed the conventional index, with an average return of 0.0096%. The BIST All Shares Index had an average return of 0.0852%, while the socially responsible companies listed in the BIST Sustainability Index had an average return of 0.0685% during the entire study period. Similarly, the other financial markets are characterized by an outperformance of the conventional indices in terms of returns. The average daily returns of the ESG indices are more dispersed compared to the conventional indices for Morocco, Turkey, and UAE.

We investigated the normality of the financial series studied. The skewness and kurtosis coefficient values show that all the MENA yield series do not follow the normal distribution, as their distributions are skewed and the tails of their distribution laws point to the left generating negative skewed values. The Jarcke-Berra (J-B) test confirms this non-normality, given that the values of the test exceed the critical threshold which is 5.99 for a = 0.05. Such a result has also been found by Agouram and Lakhnati (2015a, 2015b) for Moroccan stock market indices.

Table 2. Descriptive statistics of stock market indices returns in the MENA region.

	Morocco		Egypt		Turkey		Qatar		UAE	
	MASI	Casa ESG 10	EGX 100	EGX S & P	BIST All Shares	BIST Sust	QSE ALL SHARES	QSE20 ESG	DFM GENERAL	Hawhamah ESG UAE Index
Mean	0.0191%	0.0096%	0.0365%	−0.0165%	0.0852%	0.0685%	0.0303%	0.0150%	0.0132%	0.0108%
Median	0.0285%	0.0297%	0.1796%	0.1095%	0.1840%	0.1563%	0.0233%	0.0000%	0.0375%	0.0000%
Std. Dev	0.8174%	0.9195%	1.5314%	1.4147%	1.4918%	1.6067%	0.8802%	0.9533%	1.2538%	1.0801%
Kurtosis	34.1059	30.2661	4.2239	5.9421	7.9699	6.3760	23.7821	20.3555	11.4171	12.3423
Skewness	−2.6734	−2.3093	−1.2547	−1.0990	−1.4882	−1.1972	−2.0121	−1.8044	−0.9354	−1.1658
Min	−9.2317%	−10.1566%	−8.2199%	−8.3553%	−10.1997%	−10.2856%	−9.9983%	−10.2734%	−8.6578%	−7.9124%
Max	5.3054%	6.1858%	4.5795%	6.8641%	5.9735%	5.9181%	3.9962%	4.2664%	7.0642%	6.4732%
Obs.	802	802	790	790	810	810	808	844	808	976
Confidence Level (95.0%)	0.0006	0.0006	0.0011	0.0010	0.0010	0.0011	0.0006	0.0006	0.0009	0.0007
J-B test	33205.43	25556.17	256.58	443.94	1132.59	578.17	15085.74	11050.64	2503.02	3770.38
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

The ESG and conventional indices have daily returns that vary differently (Figure 1). For example, for the Moroccan financial market, we find that the MASI technically outperforms the Casa ESG 10 index. Similarly, the Egyptian financial market shows an outperformance of the daily returns of the EGX 100 index compared to the EGX S & P Index. The same is true for the Turkish stock market. We find that the ESG BIST Sustainability Index underperforms the conventional index. This is also the case for the financial market of Qatar and

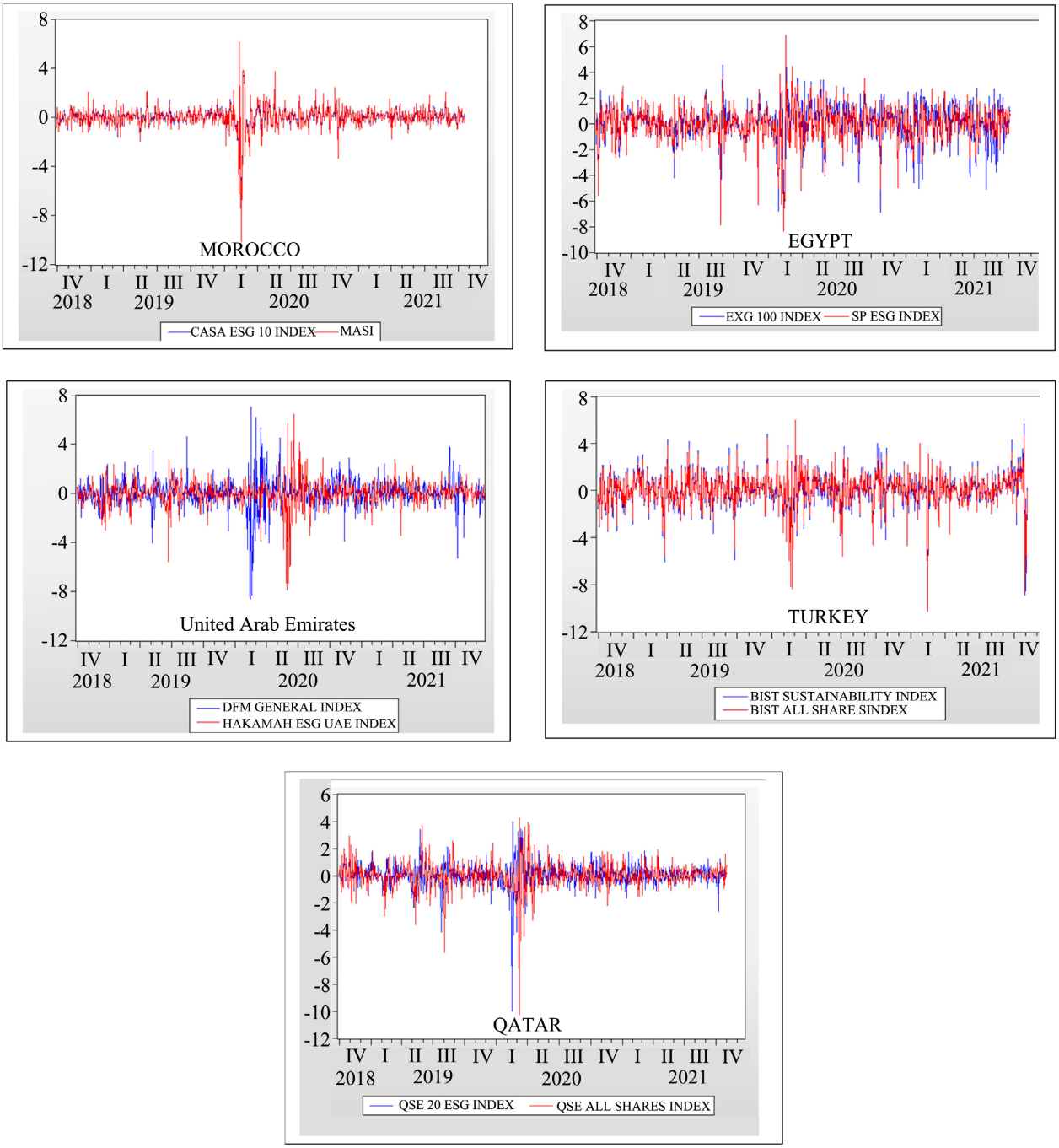

Figure 1. Daily logarithmic returns of the MENA indices.

the UAE. The latter show some technical performance of the conventional indices compared to the socially responsible indices. In sum, the conventional stock market indices show high technical performance relative to the ESG indices throughout the study period.

4.2. Hypotheses Tests and Discussion

Distinguishing between conventional and ESG indices, we estimated the Hurst exponent over the period from 9/27/2018 to 12/23/2021 for the financial markets in the five MENA countries. The aim is to compare the efficiency of the two types of indices (Table 3 and Table 4).

- ***Hypothesis 1*: *ESG and conventional indices are efficient***

We found that Moroccan financial indices are inefficient, with an exponent of 0.62352 for the MASI and 0.61844 for the Casa ESG 10 sustainability index. This finding is consistent with the results of Rejichi and Aloui (2012), Dias and Santos (2020), and Smith et al. (2002).

The Egyptian market, which has the highest Hurst exponent in the MENA region (0.68580), is found to be inefficient with evidence of persistent returns. It is also the case for the Egyptian sustainability index (EGX S & P) (exponent of 0.63747). These results align with the results of Al-Jafari and Abdulkadhim Altaee (2011), Dias and Santos (2020), and Smith et al. (2002). Al-Jafari and Abdulkadhim Altaee (2011) studied efficiency in the Egyptian stock market using several approaches including unit root test, run test, and variance ratio tests. They revealed that stock prices do not fully reflect all the infirmities, and hence, they rejection of the random walk hypothesis.

Table 3. Global results of Hurst exponent calculations for conventional indices.

Country	Index	Hurst Exponent	t-stat	*p*-value	Conclusion
Morocco	MASI	0.62352	5.3273	0.0018	The index is not efficient. Signs of persistence in returns
Egypt	EGX 100	0.68580	8.7939	0.0001	The index is not efficient. Signs of persistence in returns
Turkey	BIST ALL SHARES	0.66238	7.2814	0.0003	The index is not efficient. Signs of persistence in returns
Qatar	QSE ALL SHARES	0.58913	2.4072	0.0528	The index is not efficient. Signs of persistence in returns
UAE	DFM GENERAL	0.64702	5.7642	0.0012	The index is not efficient. Signs of persistence in returns

Table 4. Global results of Hurst exponent calculations for ESG indices.

Country	Index	Hurst Exponent	t-stat	*p*-value	Conclusion
Morocco	CASA ESG 10	0.61844	6.9340	0.0004	The index is not efficient. Signs of persistence in returns
Egypt	S & P/EGX ESG Index	0.63747	7.7944	0.0002	The index is not efficient. Signs of persistence in returns
Turkey	BIST Sust. Index	0.65980	7.1839	0.0004	The index is not efficient. Signs of persistence in returns
Qatar	QSE20 ESG	0.58911	2.8486	0.0292	The index is not efficient. Signs of persistence in returns
UAE	Hawhamah ESG UAE Index	0.62045	4.6633	0.0035	The index is not efficient. Signs of persistence in returns

In Turkey, the estimated Hurst exponents are 0.6623 for the BIST All Shares Index and 0.6598 for the BIST Sustainability Index. These results confirm that the Turkish financial market is far from efficient, with signs of persistence in returns. Ali et al. (2018) showed that the BIST All Shares Index is less efficient compared to the Islamic Index. This is in line with our implication regarding Turkey's stock market.

The Qatari stock market showed respective exponents of 0.5891 for the QSE All Shares indices and the QSE 20 ESG, proving the random walk rejection and the inefficiency of the Qatar stock market. This finding is consistent with the implications of Almujamed (2018, 2019). The study results reveal that the Qatar market is not efficient in terms of weak form (Almujamed, 2018, 2019).

For the United Arab Emirates (UAE), the Dubai Financial Market General (DFM General) has a value of 0.64702, while the Hawhamah ESG UAE index value is 0.62045. The UAE markets offer trading opportunities for traders. The same finding was revealed by Al-Shboul and Alsharari (2019), who examined the dynamic behavior of evolutionary efficiency in the UAE financial markets (including the DFM and the Abu Dhabi Stock Exchange) using the modified log periodogram (MLP) fractional differencing semi-parametric method. Their study revealed that the UAE financial markets are generally inefficient.

Overall, the results for all five countries and for both ESG and conventional indices show that the Hurst exponents are greater than 0.5. This indicates that the five MENA stock markets exhibit market inefficiency with persistence in returns. These indices show strong evidence of long-run dependencies, with significant deviation from the EMH.

Thus, Hypothesis 1 is rejected for both ESG and conventional indices in the five countries. *The five countries' markets are not efficient.*

These results align with those of Rejichi and Aloui (2012), Dias and Santos (2020), and Smith et al. (2002). They provide opportunities for investors to "beat the market" and generate excess returns by conducting speculative operations.

- ***Hypothesis 2: ESG indices compare to conventional indices***

In Qatar, the QSE All Shares and QSE 20 ESG indices have a very close estimate of the Hurst exponent, while showing 0.58911 for the QSE20 ESG index and 0.58913 for the conventional QSE ALL SHARES index.

In Turkey and Morocco, the conventional index exponent is higher than that of the ESG index, but the difference is small and insignificant. For Turkey, the estimated Hurst exponents are 0.6623 for the BIST All Shares Index and 0.6598 for the BIST Sustainability Index, which result in a percentage of 0.397% (of the ESG index). For Morocco, the MASI exponent is higher (0.62352) compared to the Casa ESG 10 sustainability index exponent (0.61844): a difference of 0.82%.

The exponents' difference percentage is higher for the UAE (4.28%) and Egypt (7.58%). In the UAE, the DFM GENERAL has a value of 0.64702 versus 0.62045 for the Hawhamah ESG UAE exponent, while in the Egyptian market, it is 0.6858 for the conventional index exponent versus 0.63747 for the sustainability

index-EGX S & P.

In sum, we conclude that the ESG indexes have lower exponents than those displayed by conventional indexes. In four markets out the five, the difference, when present is neglectable.

Thus, Hypothesis 2 cannot be rejected. The *ESG indices compare to the conventional indices in the markets analyzed.*

5. Conclusion

In the financial sphere, the efficient market hypothesis (EMH) is very controversial. This hypothesis is based on the idea that stock prices already reflect all available market information. In its weak form, the EMH states that future prices cannot be predicted by analyzing historical asset prices. The objective of this study was to test the efficiency of the MENA ESG indices. The study was based mainly on assessing the efficiency of the MENA ESG indices and comparing them with their conventional counterparts. The sample data covers the period from September 27, 2018, to December 23, 2021, in daily frequency. The analysis was conducted through the Hurst exponent.

The results rejected the EMH by proving that the indices are significantly inefficient with persistence in returns, which provides opportunities for investors to "beat the market" and generate excess returns by conducting speculative trades. Furthermore, the study does not indicate significant differences in the level of efficiency between ESG and conventional indices.

The study implies that we can determine the financial market that generates significant abnormal returns. In other words, the study helps MENA stock market participants predict the market while mobilizing the appropriate tools and generate abnormal returns by investing in the least efficient stock market.

The implications of the study may be useful to investors, technical analysts, and portfolio managers in their investment strategies in the context of the MENA.

In future research, it would be interesting to evaluate the market efficiency by other statistical methods, including the modified R/S analysis, the runs test, the unit root tests, and the variance ratio test. Also, it would be enriching to estimate the Hurst exponent evolving over time and compare it with the trend of stock market indices.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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