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TESTING WEAK FORM OF EFFICIENT MARKET HYPOTHESIS ON SOCIALLY RESPONSIBLE INDICES: COMPARATIVE STUDY BETWEEN DEVELOPED AND EMERGING MARKETS

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ABSTRACT

The study attempts to identify the presence of randomness in the socially responsible indices (SRI) of the stock markets of developed and emerging economies. 9 developed and 5 emerging economies were considered for the test of randomness on daily, weekly, monthly, quarterly and semiannual return of socially responsible and their benchmark indices. The Shapiro-Wilk test is used to test the data's normality, whereas the runs test and Augmented Dickey-Fuller test are used to find the randomness of the data. It has been observed that the market could be more efficient and random for all time durations. Most of the non-randomness is seen in daily and weekly returns. However, inefficiency disappears as the time frame increases. The combination of runs and ADF tests show that South Africa, Singapore, and South Korea show randomness for all time durations, whereas the same randomness pattern for Brazil, Australia, Japan, Singapore, and South Korea. Arab, Austria, Germany, Nordic, and USA are not present in daily return and randomness for all other durations for both the test combinations. India and Egypt show non-randomness in daily and weekly returns and randomness for all other durations under the first test combination. It is also observed that most socially responsible investment indices resonate with the randomness patterns of benchmark indices. Socially responsible investors such as pension funds may find the article resourceful in identifying socially responsible investment destinations and diversifying their portfolios.

INTRODUCTION

The price determination process in the securities market is characterized by the fact that they reflect all the information cumulatively at a given time. The implication of the model is that no investor can find any stock undervalued or overvalued through technical or fundamental analysis. Hence, it is futile to predict the trend in a securities market. This concept introduced by Eugene Fama in 1965 is referred to as the 'Efficient market Hypothesis' (EMH). Fama (1970) stated that financial markets are 'informationally efficient. There are three market efficiency forms: weak, semi-strong, and strong. Weak form suggests that prices of securities reflect all the past information. The semi-strong form states that prices reflect all publicly available and past information. The strong form of EMH indicates that prices instantaneously reflect even hidden information along with past and publicly available information.

Among the three forms of EMH, the weak form postulates that the stock market is completely random in that all information is reflected in it already, and the price on the next day cannot be predicted using past information. Researchers (Fama & French, 1988; Singh et al., 2016; Alexeev & Tapon, 2011) have used stock market indices as samples while testing the weak form of efficiency. Researchers have also tested the weak EMH on thematic indices such as the Islamic index and utility index; sectorial indices such as the banking and pharma indexes. In recent times, Socially Responsible Indices (SRIs) are new additions. As it is a new type of index, only some studies are devoted to it.

The world witnessed ethical degradation in the 2008 financial crisis, and SRI has consequently gained more importance. The advent of Corporate Social Responsibility (CSR), carbon credit, and sustainability in the corporate sector has an impetus to forming SRIs. Though the USA and European countries are pioneers in creating SRI assets, developing

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countries are following suit. High growth trajectory and higher infrastructure building in these developing economies, including Brazil, India, and China, lead to a high pollution level. In this scenario, society is expected to encourage companies that follow strict carbon emission norms and, thus, become socially responsible companies.

The thrust of the Global Reporting Initiative (GRI)[2] meanwhile, it has given an impetus to the social responsibility causes by making different sustainability stakeholders report their sustainable initiatives. However, developing countries have the least share of reporting among all. Though the reporting is mostly voluntary, mandatory reporting provisions have come up in many developing countries such as India in recent years. As a result, sustainable investment is expected to grow manifold in these countries in the near future, and more fund managers and stock markets are expected to get involved in socially responsible investment.

The year 2009 saw the United Nations sustainable stock exchange (UNSSE) pooling the investors, stock exchanges, and other related stakeholders in one platform for the promotion of sustainable investment and to improve ESG disclosures. As a result, many stock exchanges from developing countries have been partnering with the initiative recently.

Many researchers tried to figure out whether social responsibility is a driving force in earning above-average returns. Amenc et al. (2010) showed that social responsibility is a driving force in deriving above-average returns. Along the same line, it has been observed by Eccles et al. (2011) and Tripathi and Bhandari (2012) that a company with strong environmental and social policy tends to outperform stocks that are bereft at a policy level. A firm's social responsibility leads to looking after a diverse group of stakeholders in relation to the ESG principle without sacrificing profit (AON, 2007). On the other hand, Geczy et al. (2005) postulate that certainty-equivalent returns in SRI mutual funds get curtailed by a sizeable penalty compared to funds without such focus. Though the returns get positive or negative for SRI, some researchers look for significant high or low profits with socially responsible investments. Likewise, Hong and Kacperczyk (2009) pointed out that the "sin" firms related to alcohol, tobacco, and gambling industries earn significantly higher profits than comparable firms from other industries. However, Kempf and Osthoff (2007) and Statman and Glushkov (2009) differed from the earlier postulation and expressed those ethical stocks, too, can garner significantly high profits.

Meanwhile, Renneboog et al. (2008) suggested that investors need to bear the cost of ethics leading to potential downside risk for these funds. Returns based on emission allowances tend to be serially correlated, making them non-random and hence not in sync with a weak form of market efficiency (Daskalakis, 2008). Hence, it is pertinent to ask whether socially responsible indices behave randomly compared to traditional indices.

The progress report of the SSE initiative, 2018, shows that the UN-backed initiative, though it has fuelled more interest in sustainability among countries around the world, only 39 out of the 78 SSE partner exchanges have an ESG index presently. However, only 14 out of 39 countries have their data published on a public platform for more than five years; hence, they are considered for testing the randomness.

Therefore, an attempt has been made to investigate whether the SRI indices and their benchmark indices generate above-average returns and thereby test the weak form of market efficiency of 14 selected countries in this way. It has been shown by Kratz (1999) that portfolio managers, with their adept strategies, outperform benchmarks and exploit market inefficiencies. Clerk et al. (2001) concluded that EMH plays a pivotal role for regulatory authorities, investors, and academicians in analyzing investment decisions.

LITERATURE REVIEW

The randomness of speculative prices has been tested by Bachelier (1964) on Government bond prices in France. The behavior of stock price and independence of price differences of securities have been tested by Kendall (1953) and Moore (1964). A new method named Spectral analysis, which is from the field of sound waves, has been used by Granger and Morgenstern (1963) to test the random walk hypothesis by taking data from NYSE. The most notable work, though, has been offered by Fama (1965), who used Autocorrelation and ran a test to show the randomness of the behavior of share prices.

Meanwhile, applying the different statistical technique on security price behavior have augmented little evidence that successive prices are related. Studies like Fama and Blume (1968) and Alexander (1961) used ‘filter’ trading rules to trace the profitability among different strategies. Likewise, Jensen and Benington (1970) have demonstrated that buy-and-hold strategies cannot generate above-average returns. This finding supports the random walk model. The application of spectral analysis continued as Rao and Mukherjee (1971) experimented with Indian aluminum stocks from 1955 to 1970 to find the randomness. Likewise, Cooper (1982) worked with daily, weekly, and monthly data for 36 countries using spectral analysis and running tests to figure out that returns from U.K. and U.S. were random while non-randomness was found in other countries. DeBondt and Thaler (1985, 1987) attributed inefficiency to NYSE due to market overreaction to news related to corporate action in the listed companies. Autocorrelation was found in the weekly return of NYSE stocks by Lo and Mackinlay (1988).

The presence of randomness in the Athens stock market by Panas (1990). Frennberg and Hansson (1993) experimented with Swedish stock market data from 1919 to 1990 to find the non-presence of randomness in the data. Urrutia (1995) concluded that developed markets’ stocks are more efficient than emerging markets.

With necessary precautions, EMH is expected to play an important role in modern finance (Yen & Lee, 2008). Likewise, Borges (2010) tested EMH under weak, semi-strong, and strong forms worldwide under different economic conditions taking daily and weekly data. The EMH was rejected for Portugal and Greece due to positive autocorrelations and for France and the U.K. due to mean reversion in weekly data. Similarly, Gupta (2011) observed that EMH was rejected for ASEAN stocks for their daily returns.

[2]GRI is an independent international organization that promotes sustainable reporting among its member countries.

Of late, there have been a few studies regarding sustainable indices. Singh et al. (2016) found non-randomness in daily returns but randomness in monthly returns in sustainable indices of India, the USA, Japan, and Brazil. Adding another dimension to the analysis, Singh and Leepsa (2016) did not find any significant performance difference in return between sustainable and traditional indices. However, Mynhardt, Makarenk, & Plastun (2017) differed from it and found that traditional indices are more efficient than sustainable indices.

Research Gap

A developed country has been the harbinger of growth in sustainability research, as observed from the literature review above. Developing countries, though, need to catch up in this regard. Moreover, it has been noticed that testing the weak form of efficiency has not been the primary motto of most of this research. However, technical and fundamental analysts are at loggerheads on earning above-average returns keeping the flavor of social responsibility intact. Consequently, a research gap has been created on whether investing in SRI indices of the stock markets of developing and developed countries will provide investors with an above-average return.

MATERIALS AND METHODS

Objectives of Study

The objective of the study is given as follows:

- To investigate whether the returns of SRI indices and their benchmark indices of select developed and developing countries chart a random pattern.

Hypotheses of Study

The following hypotheses are formed:

- **H_{01}:** The daily returns of SRI indices of select developed and developing countries follow a random pattern;
- **H_{02}:** The weekly returns of SRI indices of select developed and developing countries follow a random pattern;
- **H_{03}:** The monthly returns of SRI indices of select developed and developing countries follow a random pattern;
- **H_{04}:** The quarterly returns of SRI indices of select developed and developing countries follow a random pattern;
- **H_{05}:** The semiannual returns of SRI indices of select developed and developing countries follow a random pattern.

Research Methodology

This is an empirical study. Socially responsible indices from several developed and developing countries across the globe are considered in this regard. Inclusion in a socially responsible index needs fulfilling several criteria. The index can be based on different themes, namely carbon emission, social sustainability, environmental awareness, governmental performance, etc. Based on these themes, indices such as carbon, green, ESG, etc., are formed. Our analysis considers all these indices as countries differ in their social responsibility investment approaches. Like any Scandinavian country, a carbon-efficient country may focus on governmental or social parameters. Likewise, another country may focus on the environment. Hence, capturing all approaches in a single analysis is pertinent to robustness.

The study, therefore, tests the randomness of these indices and their benchmark indices. If the indices are random, they are said to follow the weak form of market efficiency and vice versa. This approach leads to a research framework, as seen in figure 1.

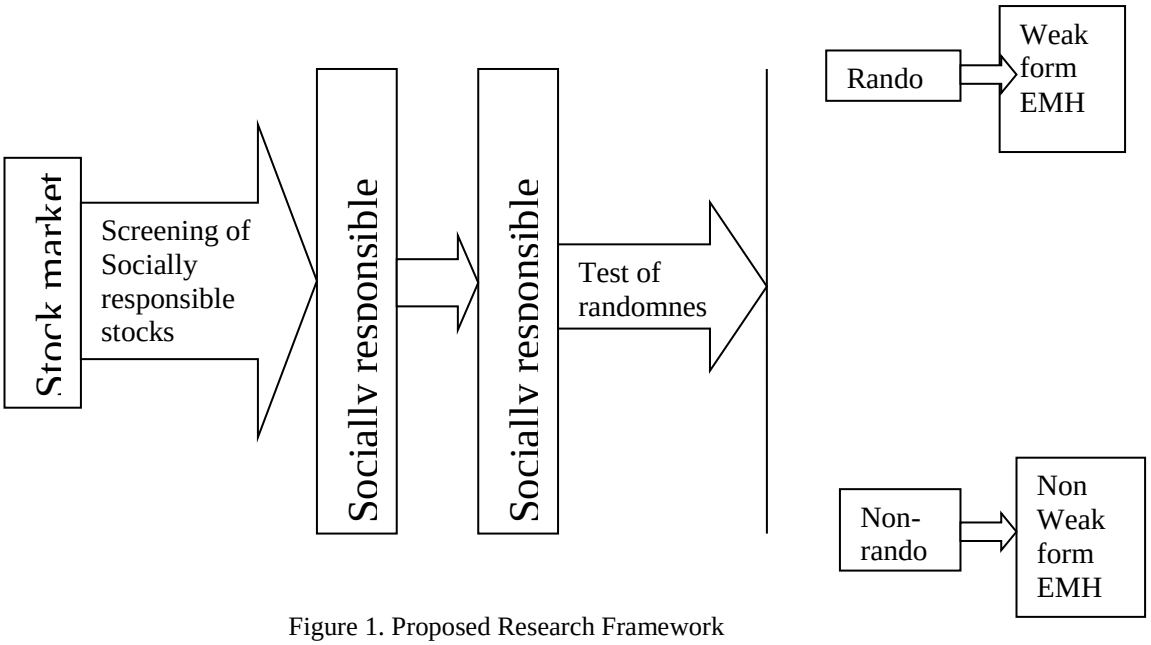

Figure 1. Proposed Research Framework

The study is based on SRI indices of developed and developing economies. According to United Nations, developed or developing countries do not have a definition. However, the high Human Development Index (HDI) and Gross

Domestic Product (GDP) are some of the tools used worldwide to determine developed and developing countries. 78 countries have participated in the sustainable stock exchange (SSE) initiative by United Nations, out of which only 39 have socially responsible indices. Out of these 39 countries, only 14 have publicly available data for 5 years or more. The 14 countries consist of 9 developed and 5 developing countries. The developed countries are Australia, Austria, Germany, Nordic, USA, Canada, Japan, Singapore, and South Korea, and developing countries include Brazil, India, Arab, Egypt, and South Africa. A few developing countries, including China, Mongolia, Bangladesh, and Hong Kong, have SRI indices, but the data availability is only for 2 to 3 years, excluding them from the analysis. The selected indices are provided in table 1.

Type of Data and Its Collection

Secondary data are collected from the stock exchanges related to the aforementioned indices for the study. Daily closing prices of the indices mentioned are extracted from their inception till 31st December 2018.

Table 1: Socially responsible indices and their benchmark indices

Country	SRI	Benchmark Index
Australia	D.J. Sustainable Australian	S&P ASX 200
Austria	CECE Sri Eur	CECE Eur
Brazil	ICo2	IBX 50
Canada	DJSI Canada	DJSI North America Composite
Egypt	S&P EGX ESG	EGX 100
Germany	Okodax	Dax
India	BSE Carbonex	BSE 100
Japan	S&P Topic 150 ESG	S&P Topic 150
Nordic	D.J. Sustainability Nordic	S&P Global BMI
Pan Arab	S&P ESG Pan Arab	S&P Pan Arab Composite
Singapore	SGX ESG	STI
South Africa	S&P SA Composite Carbon	S&P SA Composite
South Korea	DJSI Korea	S&P Global BMI
USA	S&P 500 Carbon efficient	S&P 500

Data Analysis

To check the normal distribution, the Shapiro-Wilk test (Shapiro & Wilk, 1965; Nomadiah Mohd Razali, 2011). If the sample size is below 2000, the Shapiro-Wilk test is ideal for assessing the goodness of fit (UNT, 2014). If the data is non-normal, a non-parametric Run test is used to check the randomness of return. However, if the data is normal, Autocorrelation and unit root test is used to determine randomness. The following formula gives the monthly return.

$$Ri = LN (P t / P t-1) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where

LN= Logarithmic return

Ri = The return obtained

Pt= End of the day price of SRI indices/benchmark market indices

Pt-1= End of day price of SRI indices/benchmark market indices.

Logarithm returns are better suited for the analysis as they are more likely to be distributed normally (Strong, 1994). Weekly and monthly data are nothing but mean weekly and mean monthly data. Quarterly and semiannual data are calculated by averaging the monthly mean over three months and six months, respectively.

RESULTS AND DISCUSSIONS

The normality of the distribution of social responsibility indices and benchmark indices of 14 countries through the Shapiro-Wilk (S.W.) test is presented in table 2.

Table 2. Test of normality of log-returns of the select indices

	Daily returns				**Weekly returns**			**Monthly Returns**			**Quarterly Returns**			**Yearly Returns**		
	Shapiro-Wilk				Shapiro-Wilk			Shapiro-Wilk			Shapiro-Wilk			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.	Statistic	df	Sig.	Statistic	df	Sig.	Statistic	df	Sig.
Australia	D.J. Sustainable Australian	0.949	1418	0.000	0.946	525	0.000	0.975	119	0.026	0.968	41	0.295	0.956	20	0.473
Australia	S&P ASX 200	0.948	1418	0.000	0.940	525	0.000	0.969	119	0.008	0.960	41	0.158	0.901	20	0.043
Austria	CECE Sri Eur	0.921	1418	0.000	0.878	659	0.000	0.920	136	0.000	0.905	47	0.001	0.912	23	0.045
Austria	CECE Eur	0.932	1418	0.000	0.916	659	0.000	0.948	136	0.000	0.926	47	0.005	0.896	23	0.021
Brazil	ICo2	0.982	1418	0.000	0.980	413	0.000	0.993	94	0.923	0.970	33	0.467	0.971	16	0.860
Brazil	IBX 50	0.985	1418	0.000	0.983	413	0.000	0.989	94	0.635	0.960	33	0.266	0.970	16	0.833
Canada	DJSI Canada	0.977	1418	0.000	0.987	359	0.003	0.982	81	0.324	0.939	28	0.105	0.958	14	0.687
Canada	DJSI North	0.964	1418	0.000	0.968	359	0.000	0.973	81	0.087	0.959	28	0.335	0.905	14	0.133

	America Composite														
Egypt	S&P EGX ESG	0.750	1418	0.000	0.878	388	0.000	0.984	89	0.362	0.813	31	0.000	0.915	15	0.160
Egypt	EGX 100	0.941	1418	0.000	0.926	388	0.000	0.984	89	0.365	0.604	31	0.000	0.768	15	0.001
Germany	Okodax	0.914	1418	0.000	0.946	734	0.000	0.976	167	0.005	0.976	56	0.337	0.954	28	0.247
Germany	Dax	0.895	1418	0.000	0.930	734	0.000	0.959	167	0.000	0.939	56	0.007	0.897	28	0.010
India	BSE Carbonex	0.988	1418	0.000	0.994	412	0.112	0.994	93	0.957	0.978	32	0.726	0.970	16	0.842
India	BSE 100	0.988	1418	0.000	0.994	412	0.124	0.994	93	0.959	0.979	32	0.780	0.965	16	0.756
Japan	S&P Topic 150 ESG	0.969	1418	0.000	0.951	492	0.000	0.983	112	0.152	0.980	39	0.715	0.975	19	0.868
Japan	S&P Topic 150	0.973	1418	0.000	0.943	492	0.000	0.979	112	0.073	0.967	39	0.311	0.975	19	0.871
Nordic	D.J. Sustainability Nordic	0.950	1418	0.000	0.913	522	0.000	0.974	119	0.021	0.778	41	0.000	0.687	20	0.000
Nordic	S&P Global BMI	0.900	1418	0.000	0.880	522	0.000	0.974	119	0.020	0.840	41	0.000	0.705	20	0.000
Pan Arab	S&P ESG Pan Arab	0.828	1418	0.000	0.877	522	0.000	0.970	119	0.009	0.859	41	0.000	0.618	20	0.000
Pan Arab	S&P Pan Arab Composite	0.824	1418	0.000	0.856	522	0.000	0.982	119	0.116	0.902	41	0.002	0.680	20	0.000
Singapore	SGX ESG	0.978	1418	0.000	0.980	304	0.000	0.970	69	0.099	0.895	25	0.014	0.925	12	0.327
Singapore	STI	0.975	1418	0.000	0.966	304	0.000	0.969	69	0.089	0.820	25	0.001	0.899	12	0.156
South Africa	S&P SA Composite Carbon	0.973	1418	0.000	0.987	296	0.011	0.980	67	0.343	0.972	24	0.707	0.945	12	0.565
South Africa	S&P SA Composite	0.984	1418	0.000	0.996	296	0.568	0.989	67	0.818	0.988	24	0.991	0.956	12	0.718
South Korea	DJSI Korea	0.913	1418	0.000	0.920	524	0.000	0.947	119	0.000	0.943	41	0.041	0.941	20	0.248
South Korea	S&P Global BMI	0.901	1418	0.000	0.883	524	0.000	0.928	119	0.000	0.894	41	0.001	0.802	20	0.001
USA	S&P 500 Carbon efficient	0.932	1418	0.000	0.962	505	0.000	0.977	115	0.049	0.939	40	0.032	0.944	20	0.287
USA	S&P 500	0.935	1418	0.000	0.961	505	0.000	0.976	115	0.036	0.933	40	0.020	0.944	20	0.287

Less than 0.05 P value (5% level of significance) signifies non-normality and more than 0.05 P value signifies normality. A run test is conducted to test the randomness of returns presented in tables 3, 4, 5, 6, and 7.

Table 3. Runs test on daily returns of select indices

Country	Indices	Test Value	Cases < Test Value	Cases >= Test Value	Total Cases	Number of Runs	Z	Asymp. Sig. (2-tailed)
Australia	D.J. Sustainable Australian	0.000	1275	1275	2550	1312	1.426	0.154
Australia	S&P ASX 200	0.000	1275	1275	2550	1302	1.030	0.303
Austria	CECE Sri Eur	0.000	1592	1593	3185	1517	-2.711	0.007
Austria	CECE Eur	0.000	1592	1593	3185	1584	-0.337	0.736
Brazil	ICo2	0.000	994	994	1988	976	-0.852	0.394
Brazil	IBX 50	0.000	994	994	1988	996	0.045	0.964
Canada	DJSI Canada	0.000	876	876	1752	895	0.860	0.390
Canada	DJSI North America Composite	0.000	876	876	1752	926	2.342	0.019
Egypt	S&P EGX ESG	0.001	906	907	1813	816	-4.299	0.000
Egypt	EGX 100	0.001	906	907	1813	796	-5.239	0.000
Germany	Okodax	0.000	1789	1790	3579	1681	-3.661	0.000
Germany	Dax	0.001	1789	1790	3579	1861	2.357	0.018
India	BSE Carbonex	0.001	981	982	1963	909	-3.319	0.001
India	BSE 100	0.001	981	982	1963	901	-3.680	0.000
Japan	S&P Topic 150 ESG	0.001	1158	1158	2316	1157	-0.083	0.934
Japan	S&P Topic 150	0.001	1158	1158	2316	1129	-1.247	0.212
Nordic	D.J. Sustainability Nordic	0.000	1288	1289	2577	1363	2.896	0.004
Nordic	S&P Global BMI	0.001	1288	1289	2577	1185	-4.118	0.000
Pan Arab	S&P ESG Pan Arab	0.000	1660	1661	3321	1475	-6.474	0.000
Pan Arab	S&P Pan Arab Composite	0.000	1660	1661	3321	1513	-5.155	0.000
Singapore	SGX ESG	0.000	736	745	1481	737	-0.233	0.816
Singapore	STI	0.000	729	752	1481	725	-0.849	0.396
South Africa	S&P SA Composite Carbon	0.000	706	712	1418	706	-0.212	0.832
South Africa	S&P SA Composite	0.001	709	709	1418	685	-1.328	0.184
South Korea	DJSI Korea	0.000	1277	1277	2554	1303	0.990	0.322
South Korea	S&P Global BMI	0.001	1277	1277	2554	1179	-3.919	0.000
USA	S&P 500 Carbon efficient	0.001	1220	1220	2440	1293	2.916	0.004
USA	S&P 500	0.001	1220	1220	2440	1279	2.349	0.019

Table 4. Runs test on weekly returns of select indices

Country	Indices	Test Value	Cases < Test Value	Cases >= Test Value	Total Cases	Number of Runs	Za	Asymp. Sig. (2-tailed)a
Australia	D.J. Sustainable Australian	0.001	262	263	525	260	-0.306	0.760
Australia	S&P ASX 200	0.001	262	263	525	272	0.743	0.458
Austria	CECE Sri Eur	0.000	329	330	659	319	-0.897	0.370
Austria	CECE Eur	0.000	329	330	659	327	-0.273	0.785
Brazil	ICo2	0.001	206	207	413	223	1.527	0.127
Brazil	IBX 50	0.001	206	207	413	203	-0.443	0.658
Canada	DJSI Canada	0.000	179	180	359	203	2.378	0.017
Canada	DJSI North America Composite	0.001	179	180	359	191	1.110	0.267
Egypt	S&P EGX ESG	0.001	194	194	388	162	-3.355	0.001
Egypt	EGX 100	0.001	194	194	388	165	-3.050	0.002
Germany	Okodax	0.000	367	367	734	373	0.369	0.712
Germany	Dax	0.001	367	367	734	406	2.807	0.005
India	BSE Carbonex	0.001	206	206	412	194	-1.282	0.200
India	BSE 100	0.001	206	206	412	194	-1.282	0.200
Japan	S&P Topic 150 ESG	0.001	246	246	492	233	-1.264	0.206
Japan	S&P Topic 150	0.001	246	246	492	227	-1.805	0.071
Nordic	D.J. Sustainability Nordic	0.001	261	261	522	260	-0.175	0.861
Nordic	S&P Global BMI	0.000	261	261	522	264	0.175	0.861
Pan Arab	S&P ESG Pan Arab	0.000	261	261	522	241	-1.840	0.066
Pan Arab	S&P Pan Arab Composite	0.002	261	261	522	237	-2.191	0.028
Singapore	SGX ESG	0.000	152	152	304	157	0.460	0.646
Singapore	STI	0.000	152	152	304	151	-0.230	0.818
South Africa	S&P SA Composite Carbon	0.000	148	148	296	157	0.932	0.352
South Africa	S&P SA Composite	0.000	148	148	296	157	0.932	0.352
South Korea	DJSI Korea	0.000	262	262	524	282	1.662	0.097
South Korea	S&P Global BMI	0.001	262	262	524	268	0.437	0.662
USA	S&P 500 Carbon efficient	0.001	252	253	505	261	0.668	0.504
USA	S&P 500	0.001	252	253	505	263	0.846	0.397

Table 5. Runs test on monthly returns of select indices

Country	Indices	Test Value (a)	Cases < Test Value	Cases >= Test Value	Total Cases	Number of Runs	Za	Asymp. Sig. (2-tailed)a
Australia	D.J. Sustainable Australian	0.000	59	60	119	62	0.277	0.782
Australia	S&P ASX 200	0.006	59	60	119	58	-0.460	0.646
Austria	CECE Sri Eur	0.000	68	68	136	73	0.689	0.491
Austria	CECE Eur	0.000	68	68	136	71	0.344	0.731
Brazil	ICo2	0.000	47	47	94	47	-0.207	0.836
Brazil	IBX 50	0.000	47	47	94	49	0.207	0.836
Canada	DJSI Canada	0.000	40	41	81	39	-0.558	0.577
Canada	DJSI North America Composite	0.001	40	41	81	38	-0.781	0.435
Egypt	S&P EGX ESG	0.000	44	45	89	46	0.108	0.914
Egypt	EGX 100	0.000	44	45	89	39	-1.385	0.166
Germany	Okodax	0.000	83	84	167	74	-1.630	0.103
Germany	Dax	0.001	83	84	167	88	0.544	0.587
India	BSE Carbonex	0.000	46	47	93	53	1.148	0.251
India	BSE 100	0.000	46	47	93	53	1.148	0.251
Japan	S&P Topic 150 ESG	0.000	56	56	112	56	-0.190	0.849
Japan	S&P Topic 150	0.000	56	56	112	52	-0.949	0.343
Nordic	D.J. Sustainability Nordic	0.000	59	60	119	57	-0.644	0.520
Nordic	S&P Global BMI	0.000	59	60	119	61	0.093	0.926
Pan Arab	S&P ESG Pan Arab	0.000	59	60	119	51	-1.749	0.080
Pan Arab	S&P Pan Arab Composite	0.000	59	60	119	53	-1.380	0.168
Singapore	SGX ESG	0.000	34	35	69	38	0.608	0.543
Singapore	STI	0.000	34	35	69	44	2.064	0.039
South Africa	S&P SA Composite Carbon	0.000	33	34	67	33	-0.368	0.713
South Africa	S&P SA Composite	0.000	33	34	67	34	-0.121	0.903
South Korea	DJSI Korea	0.000	59	60	119	53	-1.380	0.168
South Korea	S&P Global BMI	0.000	59	60	119	60	-0.091	0.927
USA	S&P 500 Carbon efficient	0.001	57	58	115	64	1.031	0.302
USA	S&P 500	0.001	57	58	115	64	1.031	0.302

Table 6. Runs test on quarterly returns of select indices

Country	Indices	Test Value (a)	Cases < Test Value	Cases >= Test Value	Total Cases	Number of Runs	Za	Asymp. Sig. (2-tailed)a
Australia	D.J. Sustainable Australian	0.000	20	21	41	22	0.004	0.997
Australia	S&P ASX 200	0.000	20	21	41	20	-0.313	0.755
Austria	CECE Sri Eur	0.000	23	24	47	20	-1.177	0.239
Austria	CECE Eur	0.000	23	24	47	20	-1.177	0.239
Brazil	ICo2	0.000	16	17	33	23	1.776	0.076
Brazil	IBX 50	0.000	16	17	33	19	0.359	0.719
Canada	DJSI Canada	0.000	14	14	28	14	-0.193	0.847
Canada	DJSI North America Composite	0.001	14	14	28	19	1.348	0.178
Egypt	S&P EGX ESG	0.000	15	16	31	14	-0.726	0.468
Egypt	EGX 100	0.000	15	16	31	14	-0.726	0.468
Germany	Okodax	-0.001	28	28	56	26	-0.809	0.418
Germany	Dax	0.000	28	28	56	27	-0.539	0.590
India	BSE Carbonex	0.000	16	16	32	12	-1.617	0.106
India	BSE 100	0.000	16	16	32	12	-1.617	0.106
Japan	S&P Topic 150 ESG	0.001	19	20	39	20	0.000	1.000
Japan	S&P Topic 150	0.001	19	20	39	20	0.000	1.000
Nordic	D.J. Sustainability Nordic	0.001	20	21	41	22	0.004	0.997
Nordic	S&P Global BMI	0.000	20	21	41	22	0.004	0.997
Pan Arab	S&P ESG Pan Arab	0.000	20	21	41	25	0.953	0.340
Pan Arab	S&P Pan Arab Composite	0.000	20	21	41	22	0.004	0.997
Singapore	SGX ESG	0.000	12	13	25	16	0.827	0.408
Singapore	STI	0.000	12	13	25	14	0.008	0.993
South Africa	S&P SA Composite Carbon	0.000	12	12	24	12	-0.209	0.835
South Africa	S&P SA Composite	0.000	12	12	24	13	0.000	1.000
South Korea	DJSI Korea	0.000	20	21	41	19	-0.629	0.529
South Korea	S&P Global BMI	0.001	20	21	41	22	0.004	0.997
USA	S&P 500 Carbon efficient	0.001	20	20	40	23	0.481	0.631
USA	S&P 500	0.001	20	20	40	25	1.121	0.262

Table 7. Runs test on semiannual returns of select indices

Country	Indices	Test Value (a)	Cases < Test Value	Cases >= Test Value	Total Cases	Number of Runs	Za	Asymp. Sig. (2-tailed)a
Australia	D.J. Sustainable Australian	0.000	10	10	20	10	-0.230	0.818
Australia	S&P ASX 200	0.000	10	10	20	12	0.230	0.818
Austria	CECE Sri Eur	0.000	11	12	23	13	0.009	0.993
Austria	CECE Eur	0.000	11	12	23	13	0.009	0.993
Brazil	ICo2	0.000	8	8	16	10	0.259	0.796
Brazil	IBX 50	0.000	8	8	16	10	0.259	0.796
Canada	DJSI Canada	0.000	7	7	14	7	-0.278	0.781
Canada	DJSI North America Composite	0.001	7	7	14	11	1.391	0.164
Egypt	S&P EGX ESG	0.001	7	8	15	7	-0.521	0.603
Egypt	EGX 100	0.001	7	8	15	8	0.000	1.000
Germany	Okodax	0.000	14	14	28	13	-0.578	0.563
Germany	Dax	0.000	14	14	28	14	-0.193	0.847
India	BSE Carbonex	0.000	8	8	16	8	-0.259	0.796
India	BSE 100	0.000	8	8	16	8	-0.259	0.796
Japan	S&P Topic 150 ESG	0.001	9	10	19	12	0.486	0.627
Japan	S&P Topic 150	0.001	9	10	19	12	0.486	0.627
Nordic	D.J. Sustainability Nordic	0.000	10	10	20	13	0.689	0.491
Nordic	S&P Global BMI	0.000	10	10	20	9	-0.689	0.491
Pan Arab	S&P ESG Pan Arab	0.000	10	10	20	12	0.230	0.818
Pan Arab	S&P Pan Arab Composite	0.000	10	10	20	10	-0.230	0.818
Singapore	SGX ESG	0.000	6	6	12	8	0.303	0.762
Singapore	STI	0.000	6	6	12	6	-0.303	0.762
South Africa	S&P SA Composite Carbon	0.000	6	6	12	6	-0.303	0.762
South Africa	S&P SA Composite	0.000	6	6	12	7	0.000	1.000
South Korea	DJSI Korea	0.000	10	10	20	13	0.689	0.491
South Korea	S&P Global BMI	0.000	10	10	20	9	-0.689	0.491
USA	S&P 500 Carbon efficient	0.001	10	10	20	14	1.149	0.251
USA	S&P 500	0.001	10	10	20	14	1.149	0.251

ADF test is conducted to test the randomness of returns on the same data, and the result is presented in tables 8, 9, 10, 11, and 12.

Table 8. ADF test on daily returns of select indices

Australia data: D.J. Sustainable Australian Dickey-Fuller = -11.499, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: S&P ASX 200 Dickey-Fuller = -11.693, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary	Austria data: CECE Sri Eur Dickey-Fuller = -9.9073, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: CECE Eur Dickey-Fuller = -10.694, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary
Brazil data: ICo2 Dickey-Fuller = -11.043, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: IBX 50 Dickey-Fuller = -11.132, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary	Canada data: DJSI Canada Dickey-Fuller = -12.423, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: DJSI North America Composite Dickey-Fuller = -11.416, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary
Egypt data: S&P EGX ESG Dickey-Fuller = -10.907, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: EGX 100 Dickey-Fuller = -9.7703, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary	Germany data: Okodax Dickey-Fuller = -12.145, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: Dax Dickey-Fuller = -11.024, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary
India data: BSE Carbonex Dickey-Fuller = -11.305, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: BSE 100 Dickey-Fuller = -11.298, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary	Japan data: S&P Topic 150 ESG Dickey-Fuller = -11.407, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: S&P Topic 150 Dickey-Fuller = -11.513, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary
Nordic data: D.J. Sustainability Nordic Dickey-Fuller = -11.225, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: S&P Global BMI Dickey-Fuller = -10.868, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary	Pan Arab data: S&P ESG Pan Arab Dickey-Fuller = -10.624, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: S&P Pan Arab Composite Dickey-Fuller = -10.118, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary
Singapore data: SGX ESG Dickey-Fuller = -10.191, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: STI Dickey-Fuller = -10.537, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary	South Africa data: S&P SA Composite Carbon Dickey-Fuller = -12.602, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: S&P SA Composite Dickey-Fuller = -12.113, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary
South Korea data: DJSI Korea Dickey-Fuller = -11.548, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: S&P Global BMI Dickey-Fuller = -10.79, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary	USA data: S&P 500 Carbon efficient Dickey-Fuller = -11.537, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary data: S&P 500 Dickey-Fuller = -11.466, Lag order = 11, p-value = 0.01 alternative hypothesis: stationary

Table 9. ADF test on weekly returns of select indices

Australia data: D.J. Sustainable Australian Dickey-Fuller = -7.1161, Lag order = 8, p-value = 0.01 alternative hypothesis: stationary data: S&P ASX 200 Dickey-Fuller = -7.0086, Lag order = 8, p-value = 0.01 alternative hypothesis: stationary	Austria data: CECE Sri Eur Dickey-Fuller = -7.1372, Lag order = 8, p-value = 0.01 alternative hypothesis: stationary data: CECE Eur Dickey-Fuller = -8.3757, Lag order = 8, p-value = 0.01 alternative hypothesis: stationary
Brazil data: ICo2 Dickey-Fuller = -7.8698, Lag order = 7, p-value = 0.01 alternative hypothesis: stationary data: IBX 50 Dickey-Fuller = -7.5325, Lag order = 7, p-value = 0.01 alternative hypothesis: stationary	Canada data: DJSI Canada Dickey-Fuller = -6.942, Lag order = 7, p-value = 0.01 alternative hypothesis: stationary data: DJSI North America Composite Dickey-Fuller = -7.1496, Lag order = 7, p-value = 0.01 alternative hypothesis: stationary
Egypt data: S&P EGX ESG Dickey-Fuller = -6.1507, Lag order = 7, p-value = 0.01 alternative hypothesis: stationary data: EGX 100 Dickey-Fuller = -6.4987, Lag order = 7, p-value = 0.01 alternative hypothesis: stationary	Germany data: Okodax Dickey-Fuller = -6.7097, Lag order = 7, p-value = 0.01 alternative hypothesis: stationary data: Dax Dickey-Fuller = -6.5778, Lag order = 7, p-value = 0.01 alternative hypothesis: stationary
India data: BSE Carbonex Dickey-Fuller = -8.0551, Lag order = 7, p-value = 0.01	Japan data: S&P Topic 150 ESG Dickey-Fuller = -5.8233, Lag order = 7, p-value = 0.01

alternative hypothesis: stationary	alternative hypothesis: stationary
data: BSE 100	data: S&P Topic 150
Dickey-Fuller = -8.0384, Lag order = 7, p-value = 0.01	Dickey-Fuller = -5.8142, Lag order = 7, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary
Nordic	Pan Arab
data: D.J. Sustainability Nordic	data: S&P ESG Pan Arab
Dickey-Fuller = -7.9798, Lag order = 7, p-value = 0.01	Dickey-Fuller = -7.1079, Lag order = 7, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary
data: S&P Global BMI	data: S&P Pan Arab Composite
Dickey-Fuller = -8.0816, Lag order = 7, p-value = 0.01	Dickey-Fuller = -6.7466, Lag order = 7, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary
Singapore	South Africa
data: SGX ESG	data: S&P SA Composite Carbon
Dickey-Fuller = -7.2163, Lag order = 6, p-value = 0.01	Dickey-Fuller = -6.7172, Lag order = 6, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary
data: STI	data: S&P SA Composite
Dickey-Fuller = -7.2683, Lag order = 6, p-value = 0.01	Dickey-Fuller = -8.0077, Lag order = 6, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary
South Korea	USA
data: DJSI Korea	data: S&P 500 Carbon efficient
Dickey-Fuller = -6.752, Lag order = 7, p-value = 0.01	Dickey-Fuller = -6.6593, Lag order = 7, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary
data: S&P Global BMI	data: S&P 500
Dickey-Fuller = -5.8478, Lag order = 7, p-value = 0.01	Dickey-Fuller = -6.6738, Lag order = 7, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary

Table 10. ADF test on monthly returns of select indices

Australia	Austria
data: D.J. Sustainable Australian	data: CECE Sri Eur
Dickey-Fuller = -3.733, Lag order = 4, p-value = 0.0285	Dickey-Fuller = -3.769, Lag order = 4, p-value = 0.0254
alternative hypothesis: stationary	alternative hypothesis: stationary
data: S&P ASX 200	data: CECE Eur
Dickey-Fuller = -3.9036, Lag order = 4, p-value = 0.01924	Dickey-Fuller = -3.3552, Lag order = 4, p-value = 0.07027
alternative hypothesis: stationary	alternative hypothesis: stationary
Brazil	Canada
data: ICo2	data: DJSI Canada
Dickey-Fuller = -4.1269, Lag order = 4, p-value = 0.01	Dickey-Fuller = -3.0777, Lag order = 4, p-value = 0.137
alternative hypothesis: stationary	alternative hypothesis: stationary
data: IBX 50	data: DJSI North America Composite
Dickey-Fuller = -4.6178, Lag order = 4, p-value = 0.01	Dickey-Fuller = -3.9796, Lag order = 4, p-value = 0.015
alternative hypothesis: stationary	alternative hypothesis: stationary
Egypt	Germany
data: S&P EGX ESG	data: Okodax
Dickey-Fuller = -3.0439, Lag order = 4, p-value = 0.150	Dickey-Fuller = -4.2686, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary
data: EGX 100	data: Dax
Dickey-Fuller = -3.6464, Lag order = 4, p-value = 0.035	Dickey-Fuller = -2.7097, Lag order = 4, p-value = 0.286
alternative hypothesis: stationary	alternative hypothesis: stationary
India	Japan
data: BSE Carbonex	data: S&P Topic 150 ESG
Dickey-Fuller = -3.1421, Lag order = 4, p-value = 0.111	Dickey-Fuller = -4.0896, Lag order = 4, p-value = 0.010
alternative hypothesis: stationary	alternative hypothesis: stationary
data: BSE 100	data: S&P Topic 150
Dickey-Fuller = -3.1282, Lag order = 4, p-value = 0.116	Dickey-Fuller = -4.017, Lag order = 4, p-value = 0.0141
alternative hypothesis: stationary	alternative hypothesis: stationary
Nordic	Pan Arab
data: D.J. Sustainability Nordic	data: S&P ESG Pan Arab
Dickey-Fuller = -3.8913, Lag order = 4, p-value = 0.019	Dickey-Fuller = -5.4765, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary
data: S&P Global BMI	data: S&P Pan Arab Composite
Dickey-Fuller = -4.1847, Lag order = 4, p-value = 0.01	Dickey-Fuller = -4.7307, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary
Singapore	South Africa
data: SGX ESG	data: S&P SA Composite Carbon
Dickey-Fuller = -3.7853, Lag order = 4, p-value = 0.024	Dickey-Fuller = -3.2927, Lag order = 4, p-value = 0.08026
alternative hypothesis: stationary	alternative hypothesis: stationary
data: STI	data: S&P SA Composite
Dickey-Fuller = -3.1245, Lag order = 4, p-value = 0.118	Dickey-Fuller = -4.3325, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary	alternative hypothesis: stationary
South Korea	USA
data: DJSI Korea	data: S&P 500 Carbon efficient
Dickey-Fuller = -4.6712, Lag order = 4, p-value = 0.01	Dickey-Fuller = -3.8686, Lag order = 4, p-value = 0.020
alternative hypothesis: stationary	alternative hypothesis: stationary
data: S&P Global BMI	data: S&P 500
Dickey-Fuller = -3.8239, Lag order = 4, p-value = 0.022	Dickey-Fuller = -3.899, Lag order = 4, p-value = 0.019
alternative hypothesis: stationary	alternative hypothesis: stationary

Table 11. ADF test on quarterly returns of select indices

Australia data: D.J. Sustainable Australian Dickey-Fuller = -4.6092, Lag order = 2, p-value = 0.01 alternative hypothesis: stationary data: S&P ASX 200 Dickey-Fuller = -4.9185, Lag order = 2, p-value = 0.01 alternative hypothesis: stationary	Austria data: CECE Sri Eur Dickey-Fuller = -2.538, Lag order = 2, p-value = 0.367 alternative hypothesis: stationary data: CECE Eur Dickey-Fuller = -2.6844, Lag order = 2, p-value = 0.311 alternative hypothesis: stationary
Brazil data: ICo2 Dickey-Fuller = -3.8867, Lag order = 2, p-value = 0.029 alternative hypothesis: stationary data: IBX 50 Dickey-Fuller = -3.5703, Lag order = 2, p-value = 0.054 alternative hypothesis: stationary	Canada data: DJSI Canada Dickey-Fuller = -2.4676, Lag order = 2, p-value = 0.394 alternative hypothesis: stationary data: DJSI North America Composite Dickey-Fuller = -2.0473, Lag order = 2, p-value = 0.554 alternative hypothesis: stationary
Egypt data: S&P EGX ESG Dickey-Fuller = -3.643, Lag order = 2, p-value = 0.0469 alternative hypothesis: stationary data: EGX 100 Dickey-Fuller = -2.9257, Lag order = 2, p-value = 0.219 alternative hypothesis: stationary	Germany data: Okodax Dickey-Fuller = -2.7974, Lag order = 2, p-value = 0.268 alternative hypothesis: stationary data: Dax Dickey-Fuller = -2.5088, Lag order = 2, p-value = 0.378 alternative hypothesis: stationary
India data: BSE Carbonex Dickey-Fuller = -2.3256, Lag order = 2, p-value = 0.448 alternative hypothesis: stationary data: BSE 100 Dickey-Fuller = -2.2883, Lag order = 2, p-value = 0.462 alternative hypothesis: stationary	Japan data: S&P Topic 150 ESG Dickey-Fuller = -2.3661, Lag order = 2, p-value = 0.432 alternative hypothesis: stationary data: S&P Topic 150 Dickey-Fuller = -2.401, Lag order = 2, p-value = 0.4196 alternative hypothesis: stationary
Nordic data: D.J. Sustainability Nordic Dickey-Fuller = -5.048, Lag order = 2, p-value = 0.01 alternative hypothesis: stationary data: S&P Global BMI Dickey-Fuller = -6.1911, Lag order = 2, p-value = 0.01 alternative hypothesis: stationary	Pan Arab data: S&P ESG Pan Arab Dickey-Fuller = -6.7144, Lag order = 2, p-value = 0.01 alternative hypothesis: stationary data: S&P Pan Arab Composite Dickey-Fuller = -5.5767, Lag order = 2, p-value = 0.01 alternative hypothesis: stationary
Singapore data: SGX ESG Dickey-Fuller = -2.6533, Lag order = 2, p-value = 0.323 alternative hypothesis: stationary data: STI Dickey-Fuller = -2.6264, Lag order = 2, p-value = 0.333 alternative hypothesis: stationary	South Africa data: S&P SA Composite Carbon Dickey-Fuller = -2.1345, Lag order = 2, p-value = 0.521 alternative hypothesis: stationary data: S&P SA Composite Dickey-Fuller = -2.119, Lag order = 2, p-value = 0.5271 alternative hypothesis: stationary
South Korea data: DJSI Korea Dickey-Fuller = -4.9423, Lag order = 2, p-value = 0.01 alternative hypothesis: stationary data: S&P Global BMI Dickey-Fuller = -5.8974, Lag order = 2, p-value = 0.01 alternative hypothesis: stationary	USA data: S&P 500 Carbon efficient Dickey-Fuller = -4.0221, Lag order = 2, p-value = 0.022 alternative hypothesis: stationary data: S&P 500 Dickey-Fuller = -4.1164, Lag order = 2, p-value = 0.019 alternative hypothesis: stationary

Table 12. ADF test on semiannual returns of select indices

Australia data: D.J. Sustainable Australian Dickey-Fuller = -1.4663, Lag order = 2, p-value = 0.775 alternative hypothesis: stationary data: S&P ASX 200 Dickey-Fuller = -1.4285, Lag order = 2, p-value = 0.790 alternative hypothesis: stationary	Austria data: CECE Sri Eur Dickey-Fuller = -2.3068, Lag order = 2, p-value = 0.455 alternative hypothesis: stationary data: CECE Eur Dickey-Fuller = -2.1194, Lag order = 2, p-value = 0.526 alternative hypothesis: stationary
Brazil data: ICo2 Dickey-Fuller = -3.3483, Lag order = 2, p-value = 0.084 alternative hypothesis: stationary data: IBX 50 Dickey-Fuller = -1.9846, Lag order = 2, p-value = 0.578 alternative hypothesis: stationary	Canada data: DJSI Canada Dickey-Fuller = -4.7328, Lag order = 2, p-value = 0.01 alternative hypothesis: stationary data: DJSI North America Composite Dickey-Fuller = -1.8228, Lag order = 2, p-value = 0.639 alternative hypothesis: stationary
Egypt data: S&P EGX ESG Dickey-Fuller = -1.459, Lag order = 2, p-value = 0.7785 alternative hypothesis: stationary data: EGX 100 Dickey-Fuller = -1.4926, Lag order = 2, p-value = 0.765 alternative hypothesis: stationary	Germany data: Okodax Dickey-Fuller = -3.1612, Lag order = 2, p-value = 0.13 alternative hypothesis: stationary data: Dax Dickey-Fuller = -2.2992, Lag order = 2, p-value = 0.458 alternative hypothesis: stationary
India data: BSE Carbonex Dickey-Fuller = -1.372, Lag order = 2, p-value = 0.8116	Japan data: S&P Topic 150 ESG Dickey-Fuller = -1.688, Lag order = 2, p-value = 0.6912

alternative hypothesis: stationary	alternative hypothesis: stationary
data: BSE 100	data: S&P Topic 150
Dickey-Fuller = -1.3849, Lag order = 2, p-value = 0.806	Dickey-Fuller = -1.5948, Lag order = 2, p-value = 0.726
alternative hypothesis: stationary	alternative hypothesis: stationary
Nordic	Pan Arab
data: D.J. Sustainability Nordic	data: S&P ESG Pan Arab
Dickey-Fuller = -1.3465, Lag order = 2, p-value = 0.821	Dickey-Fuller = -1.1629, Lag order = 2, p-value = 0.891
alternative hypothesis: stationary	alternative hypothesis: stationary
data: S&P Global BMI	data: S&P Pan Arab Composite
Dickey-Fuller = -1.3178, Lag order = 2, p-value = 0.832	Dickey-Fuller = -1.1995, Lag order = 2, p-value = 0.877
alternative hypothesis: stationary	alternative hypothesis: stationary
Singapore	South Africa
data: SGX ESG	data: S&P SA Composite Carbon
Dickey-Fuller = -2.2099, Lag order = 2, p-value = 0.492	Dickey-Fuller = -1.6525, Lag order = 2, p-value = 0.704
alternative hypothesis: stationary	alternative hypothesis: stationary
data: STI	data: S&P SA Composite
Dickey-Fuller = -2.4025, Lag order = 2, p-value = 0.419	Dickey-Fuller = 0.21103, Lag order = 2, p-value = 0.99
alternative hypothesis: stationary	alternative hypothesis: stationary
South Korea	USA
data: DJSI Korea	data: S&P 500 Carbon efficient
Dickey-Fuller = -0.9547, Lag order = 2, p-value = 0.927	Dickey-Fuller = -2.7147, Lag order = 2, p-value = 0.300
alternative hypothesis: stationary	alternative hypothesis: stationary
data: S&P Global BMI	data: S&P 500
Dickey-Fuller = -1.1836, Lag order = 2, p-value = 0.883	Dickey-Fuller = -2.6134, Lag order = 2, p-value = 0.338
alternative hypothesis: stationary	alternative hypothesis: stationary

An autocorrelation test is conducted to test the randomness of returns on the same data, and the result is presented in table 13.

Table 13. Test of randomness (Autocorrelation)

	Brazil								**India**				
	ICo2			**IBX 50**				**BSE Carbonex**			**BSE 100**		
Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)	Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)
daily	-0.01	0.10	**0.76**	-0.01	0.14	**0.71**	daily	0.09	15.05	0.00	0.09	15.41	0.00
weekly	0.04	0.72	**0.40**	0.04	0.71	**0.40**	weekly	0.04	0.62	**0.43**	0.04	0.67	**0.41**
monthly	-0.04	0.19	**0.66**	-0.04	0.18	**0.67**	monthly	0.13	1.98	**0.16**	0.14	2.18	**0.14**
quarterly	0.08	0.21	**0.65**	0.07	0.16	**0.69**	quarterly	0.01	0.00	**0.97**	0.00	0.00	**0.98**
semi-annually	0.25	1.18	**0.28**	0.25	1.20	**0.27**	semi-annually	0.03	0.02	**0.90**	0.02	0.01	**0.92**
	Pan Arab								**Egypt**				
	S&P ESG Pan Arab			**S&P Pan Arab Composite**				**S&P EGX ESG**			**EGX 100**		
Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)	Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)
daily	0.23	177.82	0.00	0.20	133.70	0.00	daily	0.19	65.83	0.00	0.22	85.70	0.00
weekly	-0.06	1.02	**0.31**	-0.01	0.03	**0.87**	weekly	-0.07	2.28	**0.13**	-0.01	0.10	**0.75**
monthly	-0.01	0.00	**0.96**	-0.29	6.15	0.01	monthly	0.04	0.24	**0.62**	0.18	4.22	0.04
quarterly	0.01	0.00	**0.97**	-0.08	0.19	**0.67**	quarterly	0.21	1.93	**0.16**	0.25	2.70	**0.10**
semi-annually	-0.02	0.00	**0.95**	-0.04	0.03	**0.87**	semi-annually	-0.10	0.23	**0.63**	-0.12	0.35	**0.56**
	South Africa								**Australia**				
	S&P SA Composite Carbon			**S&P SA Composite**				**D.J. Sustainable Australian**			**S&P ASX 200**		
Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)	Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)
daily	0.03	1.20	**0.27**	-0.02	0.34	**0.56**	daily	-0.01	0.14	**0.71**	-0.01	0.45	**0.50**
weekly	-0.06	1.97	**0.16**	-0.06	1.93	**0.17**	weekly	-0.10	5.38	0.02	-0.09	4.55	**0.03**
monthly	-0.02	0.05	**0.82**	-0.02	0.06	**0.80**	monthly	0.07	0.53	**0.47**	0.07	0.57	**0.45**
quarterly	-0.24	2.47	**0.12**	-0.25	2.65	**0.10**	quarterly	0.15	0.99	**0.32**	0.16	1.09	**0.30**
semi-annually	-0.42	4.04	0.04	-0.44	4.38	0.04	semi-annually	-0.16	0.56	**0.45**	-0.18	0.72	**0.40**
	Austria								**Germany**				
	CECE Sri Eur			**CECE Eur**				**Okodax**			**Dax**		
Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)	Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)
daily	0.13	50.60	0.00	0.08	21.21	0.00	daily	0.09	30.60	0.00	0.01	0.08	**0.78**
weekly	0.07	3.11	**0.08**	0.02	0.39	**0.54**	weekly	-0.04	0.75	**0.39**	-0.02	0.17	**0.68**
monthly	0.25	8.72	0.00	0.06	0.50	**0.48**	monthly	0.04	0.12	**0.73**	0.06	0.30	**0.59**
quarterly	0.28	3.77	**0.05**	0.27	3.62	**0.06**	quarterly	-0.30	3.26	**0.07**	-0.21	1.59	**0.21**
semi-annually	-0.19	0.90	**0.34**	-0.14	0.48	**0.49**	semi-annually	-0.36	2.52	**0.11**	-0.30	1.74	**0.19**
	Nordic								**USA**				
	DJ Sustainability Nordic			**S&P Global BMI**				**S&P 500 Carbon efficient**			**S&P 500**		
Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)	Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)
daily	-0.01	0.22	**0.64**	0.15	60.88	0.00	daily	-0.06	9.96	0.00	-0.07	10.69	0.00
weekly	-0.08	2.04	**0.15**	-0.11	4.43	0.04	weekly	0.05	1.11	**0.29**	0.14	7.12	0.01
monthly	0.06	0.35	**0.55**	-0.11	1.11	**0.29**	monthly	-0.03	0.08	**0.78**	0.00	0.00	**0.98**

quarterly	0.02	0.02	**0.89**	-0.23	1.60	**0.21**	quarterly	0.04	0.06	**0.81**	0.05	0.08	**0.77**
semi-annually	0.06	0.07	**0.79**	-0.07	0.09	**0.77**	semi-annually	-0.20	0.71	**0.40**	-0.22	0.91	**0.34**
	Canada							**Japan**					
	DJSI Canada			**DJSI North America Composite**				**S&P Topic 150 ESG**			**S&P Topic 150**		
Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)	Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	AC	Box-Ljung Statistic	Significance (p-value)
daily	0.05	4.45	0.04	-0.01	0.34	**0.56**	daily	0.01	0.16	**0.69**	0.02	0.78	**0.38**
weekly	0.02	0.39	**0.53**	-0.09	5.77	0.02	weekly	-0.08	3.08	**0.08**	-0.02	0.19	**0.67**
monthly	0.19	6.32	0.01	0.12	2.54	**0.11**	monthly	0.18	3.84	**0.05**	0.18	4.04	**0.04**
quarterly	0.15	1.25	**0.26**	0.06	0.24	**0.62**	quarterly	0.22	2.12	**0.15**	0.29	3.72	**0.05**
semi-annually	0.22	1.49	**0.22**	0.12	0.44	**0.51**	semi-annually	-0.10	0.24	**0.62**	-0.09	0.19	**0.66**
	Singapore							**South Korea**					
	SGX ESG			**STI**				**DJSI Korea**			**S&P Global BMI**		
Lag 1	AC	Box-Ljung Statistic	Significance (p-value)	A.C.	Box Ljung Statistic	Significance (p-value)	Lag 1	AC	Box-LjungStatistic	Significance (p-value)	AC	Box-LjungStatistic	Significance (p-value)
daily	0.01	0.06	**0.80**	0.04	2.77	**0.10**	daily	-0.01	0.13	**0.72**	0.15	58.27	0.00
weekly	0.02	0.17	**0.68**	0.06	2.16	**0.14**	weekly	0.04	0.47	**0.49**	0.07	1.63	**0.20**
monthly	0.35	15.53	0.00	0.23	6.39	0.01	monthly	-0.08	0.48	**0.49**	-0.10	0.73	**0.39**
quarterly	0.25	2.79	**0.10**	0.25	2.79	**0.10**	quarterly	-0.02	0.01	**0.92**	0.06	0.11	**0.74**
semi-annually	-0.08	0.15	**0.70**	-0.04	0.03	**0.86**	semi-annually	0.11	0.19	**0.66**	0.23	0.81	**0.37**

Tables 14 and 15 show the results of the normality tests of the returns of socially responsible indices.

Table 14. Tests of Normality (developing countries)

	Daily	**Weekly**	**Monthly**	**Quarterly**	**Semiannually**
Brazil	Not normal	Not normal	Normal	Normal	Normal
India	Not normal	Normal	Normal	Normal	Normal
Pan Arab	Not normal	Not normal	Not normal	Not normal	Not normal
Egypt	Not normal	Not normal	Normal	Not normal	Normal
South Africa	Not normal	Not normal	Normal	Normal	Normal

Source: Compiled by authors

Table 15. Tests of Normality (developed countries)

	Daily	**Weekly**	**Monthly**	**Quarterly**	**Semiannually**
Australia	Not normal	Not normal	Not normal	Normal	Normal
Austria	Not normal	Not normal	Not normal	Not normal	Not normal
Germany	Not normal	Not normal	Not normal	Normal	Normal
Nordic	Not normal	Not normal	Not normal	Not normal	Not normal
USA	Not normal	Not normal	Not normal	Not normal	Normal
Canada	Not normal	Not normal	Normal	Normal	Normal
Japan	Not normal	Not normal	Normal	Normal	Normal
Singapore	Not normal	Not normal	Not normal	Not normal	Not normal
South Korea	Not normal	Not normal	Not normal	Not normal	Normal

When the test of normality is done, tests of randomness are conducted. For a non-normal, non-parametric, and normal distribution, parametric tests are conducted. The runs test is the non-parametric test, and Autocorrelation and Augmented Dickey-Fuller (ADF) is the parametric tests used. If autocorrelation and ADF tests give similar results, the result is chosen as it is considered a better test than Autocorrelation (Higgs, 2005). In this scenario, the Autocorrelation test only plays a supportive role along with the findings of the ADF test. The randomness test results for developing, and developed countries are shown in Table 16.

Table 16. Tests of randomness

	Daily return	**Weekly return**	**Monthly return**	**Quarterly return**	**Semiannually return**
			Developing country		
Brazil	random	random	non-random	non-random	random
India	non-random	non-random	random	random	random
Pan Arab	non-random	random	random	random	random
Egypt	non-random	non-random	random	random	random
South Africa	random	random	random	random	random
			Developed country		
Australia	random	random	random	non-random	random
Austria	non-random	random	random	random	random
Germany	non-random	random	random	random	random
Nordic	non-random	random	random	random	random
USA	non-random	random	random	random	random

Canada	random	non-random	random	Random	non-random
Japan	random	random	non-random	Random	random
Singapore	random	random	random	random	random
South Korea	random	random	random	random	random

CONCLUSIONS

The analysis shows that Brazil, South Africa, Australia, Canada, Japan, Singapore, and South Korea has randomness. In contrast, India, Arabs, Egypt, Austria, Germany, Nordic, and the USA have non-randomness in daily returns. Weekly returns show randomness in Brazil, Arab, South Africa, Australia, Austria, Germany, Nordic, USA, Japan, Singapore, and South Korea, and non-random in India, Egypt, and Canada. Monthly returns show randomness in India, Arab, Egypt, South Africa, Australia, Austria, Germany, Nordic, USA, Canada, Singapore, and South Korea and non-randomness in Brazil and Japan. Quarterly returns show randomness in India, Arab, Egypt, South Africa, Austria, Germany, Nordic, USA, Canada, Japan, Singapore, and South Korea and non-randomness for Brazil and Australia. Semiannual returns are random in all countries except Canada. For non-random markets, technical trading can be applied to predict future prices, and above-average returns can be obtained. However, the result comes with a rider as markets tend to overreact over a given information which may create a prediction error (Singh, 2011). It has also been observed that SRI returns get normal as the period of return calculation is increased to half yearly from daily except in Canada. The finding coincides with Fama (1998), Mondal & Singh (2020), and Singh et al. (2016), who propagated that market is efficient in the long run.

It can be observed that market efficiency is not uniform across countries. This is in line with the Adaptive market hypothesis for socially responsible indices (Lo, 2004). Lo (2004) and Grossman and Stiglitz (1980) argued that arbitrage opportunities exist in the market in contrast with the EMH principle. With adequate arbitrage opportunities, investors will get incentivized to collect and act on the information. Hence, markets are irrational and not always random, as postulated by the EMH (Singh, 2019). It may indicate a seasonality factor in SRIs at different times (Sah, 2009).

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