Energy Policy 156 (2021) 112467

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Revisiting the sustainable versus conventional investment dilemma in COVID-19 times

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ARTICLE INFO

Keywords:
Wavelet coherence
Granger-causality
COVID-19
Sustainable investment
Sustainable indexes
Traditional indexes

ABSTRACT

Sustainable living has emerged as the need of the hour for mankind in present times. Practitioners, as well as scholarship in the area, are divided over the comparison of financial returns from sustainable indexes vis-à-vis conventional indexes, causing investors' dilemma. These questions loom larger during the times of global crises, such as COVID-19, which have brought sustainability concerns to the limelight. This dilemma of the investors leads us to approach the study on hand. We study the Thomson Reuters/S-Network global indexes (as a proxy for sustainability-based indexes), and their corresponding alternatives, using the daily closing prices from 1st January 2011 to 29th June 2020. We apply the time-frequency-based Granger-Causality test, and further attempt to understand the coherence between these indexes before and during the COVID-19 period by using the Wavelet Coherence and phase-difference mechanisms. Our results suggest short-run uni-directional causality from sustainable indexes to conventional indexes whereas bi-directional causality in medium and the long-runs. The coherence is particularly stronger at low frequencies, indicating the long-run coherence with sustainable indexes in the lead during COVID-19. The results and conclusions of the study have important implications for different audiences. The portfolio and fund managers can prefer to invest in such markets to avail of higher returns over a longer period.

1. Introduction

The United Nation's adoption of the Sustainable Development Agenda 2030 in September 2015 played a crucial role in broadening the sight of policymakers, practitioners, and researchers. Corporate sustainability concerns have also gained further prominence since then. Opoku and Boachie (2020) conclude that foreign direct investment in the absence of stringent environmental regulations can increase emissions and negatively impact the environment. Green et al. (2017) argues that the corporate sector should include the water, energy, environmental, and food security-related issues in their decision-making process. Stakeholders have started to evaluate companies not only based on growth efficiency but also on corporate sustainability. The consideration of sustainability-related factors by the investors, which began in 1990 with the launch of Morgan Stanley Capital International (MSCI) KLD 400 Social Index, continues to gain momentum in the wake of the Sustainable Development Agenda 2030. Theoretically, a new body of knowledge has emerged in the name of sustainable investing, which studies the investment preferences, trends, and biases towards sustainable indexes vis-à-vis conventional indexes. A recent study by Talan and Sharma (2019) reviews 213 papers and observes that the investment strategy focusing on Environment, Society, and Governance (ESG) approach is central to sustainable investments.

According to GSIA (2018), both actual and relative levels of sustainable investment have risen in almost all markets worldwide, including developing economies in Latin America and Africa. In addition, sustainable investment has witnessed a substantial increase of 34% since 2016 in developed regions like Europe, the US, Japan, Canada, Australia, and New Zealand. ESG integration remains the most common sustainable investment strategy in most of these regions (GSIA, 2018). The rise of sustainable investment paves the way for a shift towards renewable energy and curtailed overall energy consumption. Companies across the world primarily rely on fossil-fuel-based energy. Neufeld (2021) reveal that only 18% of the utility companies are aligned with the UN-SDG of Affordable and Clean Energy. Sustainable investment is instrumental in helping investors decarbonize their returns and invest in

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https://doi.org/10.1016/j.enpol.2021.112467
Received 2 February 2021; Received in revised form 10 May 2021; Accepted 5 July 2021
Available online 7 July 2021

environmentally sustainable companies. Increased interest of investors in sustainable investments also incentivizes the companies to adopt greener business practices. In addition, a meaningful collaboration between corporates and researchers is required for sustainable business practices (Green et al., 2017).

Besides the investor's financial returns, sustainable investment helps address their non-financial concerns in contributing to sustainability. Practitioners and academics in the field remain split on the issue of comparing financial returns from sustainable indexes to traditional indexes, creating an investor's dilemma (see, for example, Auer, 2016; Blank et al., 2016; Crifo and Mottis, 2016; Ur Rehman et al., 2016; Escrig-Olmedo et al., 2017; Lokuwaduge and Heenetigala, 2017; Pilaj, 2017; Revelli, 2017; Jain et al., 2019). This dilemma can be resolved to a large extent by examining the causality between sustainable indexes and conventional indexes. Understanding such causality will inform the investors whether conventional indexes follow sustainable indexes or vice-versa. It would be of additional value to comprehend if this causality holds ground for short-term, medium-term, or long-term; and is uni-directional or bi-directional. These questions loom larger during times of global crises, such as COVID-19, which have brought sustainability concerns to the limelight (Goodell, 2020).

This dilemma of the investors leads us to approach the study on hand. We study the causality between Thomson Reuters/S-Network global indexes, namely developed markets (excluding the US) ESG index (TRESGDX), emerging markets ESG index (TRESGEX), US large-cap ESG index (TRESGUS), and Europe ESG index (TRESGEU), and their corresponding alternatives namely, SN500, SND1000, SNE1000 and SNX 1000 using the daily closing prices from 1st January 2011 to 29th June 2020. We employ robust econometric analysis to attain our research objectives. We apply the time-frequency-based Granger-Causality test to determine if there is any uni-directional of bi-directional short-run, medium-run, or long-run causality between the said indexes. Further, we try to understand the coherence and lead-lag relationship between these indexes before and during the COVID-19 period using the Wavelet Coherence and phase-difference mechanisms.

Our results suggest short-run uni-directional causality from sustainable indexes to conventional indexes, whereas there is a bi-directional causality in medium and the long-runs. This implies conventional investors may increase their financial returns by engaging in or tracking sustainable indexes. Our results illustrate the criticality of sustainable investing. Furthermore, our analysis reveals that during the COVID-19 pandemic times, the coherence between the two sets of indexes (in the US and the emerging markets, specifically) increased further. The coherence is particularly stronger at low frequencies, indicating the long-run coherence with sustainable indexes in the lead during COVID-19. It underlines the fact that the investors started shifting towards sustainable avenues during this pandemic period. This is in line with the common parlance that during the times of crises, people tend to shift their preferences towards a broader and holistic perspective (His Holiness the Dalai Lama, 2012; Jain et al., 2019a; Nagraj, 2012, 2009; Sharma and Mahendru, 2017; Talan and Sharma, 2020). As observed from time-frequency-based Granger-Causality and Wavelet Coherence, the greater strength coherence lays in the long-run suggesting that the investors and fund-managers subtly shift their focus towards sustainable indexes for improving the financial returns in addition to getting addressed their sustainability-related concerns.

The rest of the paper is structured as follows. Section two highlights the theoretical background of our study. Section three presents the materials and methods used for the study. Section four discusses the results, section five presents the discussion, and section six concludes.

2. Theoretical background

2.1. Investing in sustainable assets

Sustainable investment provides an opportunity for investors to assert their values and ethics in their investment decisions and enable them to earn a financial return. Research evidence has suggested that this return is observed to be higher than that of conventional investing (Talan and Sharma, 2019). Sustainable investment is projected to rise rapidly in the future, as present and future generations support their values and beliefs and want those to be reflected in their investments (Joshi, 2020). Although sustainable investment is rising, it is still tough to recognize companies that follow its set parameters (Shah, 2020). Adam and Shavit (2008) suggest that while rating-based methodologies exclude many companies and have created a limited list of sustainable firms, ranking all the firms on sustainable parameters may include more firms to the list and, hence provide more choices to sustainable investors. Communicating non-financial information, parameters, and values with the investors may bring more transparency in sustainable indexes, which is key to the development of sustainable investment (Lo and Kwan, 2017). Mehta (2019) further asserts sustainable investment is a time-tested way of wealth creation.

2.2. Impact of sustainable investment on firms

Sustainable investment is known to affect the organizations in many ways, although the literature is divided over the direction and degree of this impact. A company's Corporate Social Performance (CSP) reduces its financial risk and positively impacts its overall financial performance (Brooks and Oikonomou, 2018). Transparency in ESG disclosures improves stakeholders' trust and increases the firm's value (Li et al., 2018). ESG performance is observed to be even better in case of sensitive firms in emerging markets (Garcia et al., 2017). Additionally, ESG disclosures may negatively impact and reduce the market information asymmetry (Siew et al., 2016). Finjord et al. (2018) present a model evaluating investments in renewable energy projects based out of Norway and Sweden. Their model shows that uncertainties and the possibility of timing the investments in such projects strongly affect firm's behavior. Ji et al. (2017) affirm that the sustainability of coal power plants in China is contingent on their selection of reusable environmental investments. Velte (2017) finds a mixed impact of ESG performance on the financial performance of a firm. While the ESG performance positively impacts the Return on Asset, it has no impact on Tobin's Q ratio (Velte, 2017). Michelfelder et al. (2019) demonstrate that decoupling revenues from commodity sales to incentivize renewable energy investments has no discernible effect on equity value. Eom and Nam (2017) also find no significant relationship between the integration of sustainable index and firms' value and further found that in the early stages of incorporating a sustainable index, firms reported a negative relationship with its cost of equity. On the other hand, Fatemi et al. (2018) assert that though ESG strength has a positive effect on firms' value, ESG weakness reduces it. Overall, the study believes that ESG discourses negatively impact firms' value (Fatemi et al., 2018). Furthermore, the exclusion of sin industries from the portfolio may lead to reduced risk-adjusted returns for the investors (Brooks and Oikonomou, 2018). Ferrero-Ferrero et al. (2016) suggest that the impact of ESG performance on financial performance is even higher for the companies that deliver interdimensional consistency.

2.3. Shortcomings of sustainable investment

Sustainable investment and its forms are not free of shortcomings. In a recent article,[1] Chamath Palihapitiya, CEO and founder of Social Capital, highlights that even though ESG investment is growing in popularity, it is nothing more than a marketing ploy and a means to raise cheaper finance (Stevens, 2020). Certain firms are engaged in

[1] An article in CNBC written by Pippa Stevens and accessible at: https://www.cnbc.com/2020/02/26/chamath-palihapitiya-esg-investing-is-a-complete-fraud.html.

"greenwashing" by revealing a lot of data on ESG parameters but perform poorly in these aspects (Yu et al., 2020). Also, the three pillars of ESG do not impact corporate sustainability equally (Jitmaneeroj, 2016). The growth of sustainable investment is also limited to developed countries, with emerging markets having an insignificant share in sustainable investment globally (Herringer et al., 2009). In addition, it becomes a difficult task for a single sustainable investment framework to cater to the requirements of heterogeneous investors (Escrig-Olmedo et al., 2017). The ambiguity and interchangeability of the terms like an ethical investment, sustainable investment, socially responsible investment, and impact investment also adds to this confusion (Höchstädter and Scheck, 2015). As a result, sustainable investment is struggling to prove itself as a tremendously successful instrument in bringing institutional change (Avetisyan and Hockerts, 2017).

2.4. Sustainable investment versus conventional investment

As investors progressively consider a blend of conscience and returns in their investment decisions, the impact of sustainable investment on investment strategies is bound to increase in future times (Mahn, 2016). There is a little consensus among the researchers on comparisons of sustainable investment with conventional investments. Jain et al. (2019) argue that the financial returns from sustainable investment are not different from conventional investment, implying that there is no extra cost to sustainable investment. Borgniet (2019) uses Capital Asset Pricing Model (CAPM) regression to ascertain that though sustainable indexes can outperform conventional indexes, the difference between them is not significant. In an important revelation from the US, the UK, and Japan, Managi et al. (2012) state that sustainable indexes carry similar risk and returns as conventional stock indexes. In a study of global and three regional indexes, Lean and Nguyen (2014) assert that sustainable indexes have lower Sharpe ratios as compared to conventional indexes and therefore are less volatile. Ortas (2010) argues that diversifying the portfolio in sustainable funds satisfies the ethical values and reduces the risk in investors' portfolio. In an example from India, Somvanshi (2020) reveals that the Nifty 100 ESG index has outperformed the Nifty 50 index in the long run. However, in a shorter period, the S&P BSE 100 ESG index has underperformed, compared to its benchmark Sensex, revealing that ESG is a good strategy for long-term investments (Somvanshi, 2020). However, the outperformance of sustainable investments over conventional investments may be due to concentration in a limited number of stocks (Goldberg, 2019). Goldberg (2019) further advises that sustainable indexes often perform better than conventional indexes due to overweight in the outperforming sector and reduced expense ratio. Gladysek and Chipeta (2012) also reveal that investing in sustainable indexes do not lead to better returns as compared to conventional indexes, at least in the short term. Although renewable investments offer returns comparable to traditional investments, they have quite a reduced risk (Paul, 2017). Paul (2017) further suggests that sustainable stocks typically have continuous value, and sustainable investment retains this value in an economic downturn, thus boosting economic expansion.

On the other hand, a study from Brazil suggests that sustainable investors don't have to compromise their financial results during a bullish period, but will need to take extra risks or lower returns during a financial crisis (Ortas et al., 2012). Adler and Kritzman (2008) also reveal that there is a significant cost of sustainable investment, and even moderately skilled investors cannot escape it. Ur Rehman et al. (2016) confirm that though sustainable indexes usually deliver similar risk-adjusted returns as conventional benchmarked indexes, market volatility is higher in sustainable indexes as compared to conventional indexes.

Although the performance of sustainable investment portfolios is heterogeneous across geographic regions, they may outperform a traditional investment in some regions (Cunha et al., 2020). A comparative study from France, Spain, and Japan reveals that firms' ESG performance is influenced by country-specific social and institutional systems (Ortas et al., 2015). While governance performance is better in French and Spanish firms than Japanese firms, Japanese firms are more committed to the environmental aspect than French and Spanish firms. This trend indicates that firms from different countries prioritize their ESG parameters according to local systems (Ortas et al., 2015). Rocchia and Bechet (2011) also confirm that the performance of sustainable investment vis-à-vis conventional investment varies from one region to another, and investing in sustainable assets can provide diversification benefits to investors. This suggests that comparing sustainable and conventional indexes is not a straightforward process and depends on population, regional area, and weighting of the sector (Fowler and Hope, 2007). However, cross-listing of firms may incentivize the investors by reducing the foreignness and enhancing the overall ESG performance (Del Bosco and Misani, 2016).

The summary of the reviewed literature, along with key findings, is elucidated as follows in Table 1:

As highlighted in the Table- 1, the research gaps across various themes raise many questions for future researchers and policymakers. On the one hand, the sustainable investment may not be effectively fulfilling its original purpose of providing value to socially conscious investors. On the other hand, the financial performance of sustainable investment vis-à-vis conventional investment is also unclear. Lack of a coherent plan dissuades many prospective investors in sustainable alternatives since they don't want to risk their investments' financial results for sustainable investments that may not be completely successful. This dilemma of investors is taking a new shape in the present times of global pandemic in the form of COVID-19. No contagious disease ever impacted stock market volatility as much as this COVID-19 pandemic (Palma-Ruiz et al., 2020). The magnitude of the impact has been varied across countries and asset classes (Al-Awadhi et al., 2020; Ashraf, 2020; Topcu and Gulal, 2020). Minimal literature has approached this idea so far, out of which Broadstock et al. (2020) find that in periods of a market-wide financial downturn, stocks with strong ESG results are more robust. This robust performance can be primarily due to the investor's perception of viewing ESG performance as a signal of potential market success and/or risk avoidance in crisis times (Broadstock et al., 2020).

We fill this gap by aiming to attain twin research objectives. First, by employing time-frequency domain Granger-Causality approach, we test the directional causality (i.e., lead-lag relationship) between sustainable and conventional indexes over various time-frequency domains to check if one of these indexes drives the other during short-, medium-, and long-term and during which periods. Second, we apply Wavelet coherence to understand the coherence between these indexes before and during the COVID-19 period which provides time-frequency dimension of squared correlations (i.e., R^2).

3. Materials and methods

Sustainable investment may mean differently to different investors. In the absence of a clear definition and conceptual clarity, terminologies like sustainable investment, socially responsible investment, impact investment, and social investment are often used interchangeably (Höchstädter and Scheck, 2015). However, ESG integration remains the most common approach to sustainable investment. Global Sustainable Investment Alliance (2012) define sustainable investment as "an investment approach making reference to environmental, social and governance (ESG) factors in the selection and management of investments. We have therefore selected ESG indexes from different regions as sustainable indexes for our analysis. We analyze the financial returns and risks of the Thomson Reuters/S-Network global indexes, namely developed markets (excluding the US) ESG index (TRESGDX), emerging markets ESG index (TRESGEX), US large-cap ESG index (TRESGUS), and Europe ESG index (TRESGEU), and their corresponding alternatives namely, SN500, SND1000, SNE1000 and SNX 1000 before

Table 1
Summary of the reviewed literature.

S. No.	Theme	Research Gaps		Key studies
1.	Investing in sustainable investment	Difficult to identify sustainable firms		Shah (2020)
		Varied values and belief systems of heterogenous investors		Escrig-Olmedo et al. (2017)
2.	Impact of sustainable investment on firms	No clear direction on the impact of Sustainable Investment on firms	Positive impact	Brooks and Oikonomou (2018) Li et al. (2018) Garcia et al. (2017) Siew et al. (2016)
			No or negative impact	Velte (2017) Eom and Nam (2017) Fatemi et al. (2018)
3.	Shortcomings of sustainable investment	ESG as greenwashing, a marketing ploy, and a means to raise cheaper finance		Stevens (2020) Yu et al. (2020)
		Unequal impact of ESG on corporate sustainability		Jitmaneeroj (2016)
		Fragmented growth across different geographical regions		Herringer et al. (2009)
		Ambiguity among different types of sustainable investment		Höchstädter and Scheck (2015)
4.	Comparison of sustainable investment with conventional investment	No clear consensus among researchers on the causal relationship between sustainable and conventional investments	Similar financial returns between sustainable and conventional investment	Jain et al. (2019) Borgniet (2019) Managi et al. (2012)
			Sustainable investments yield better financial performance as compared to conventional investments	Lean and Nguyen (2014) Ortas (2010) Somvanshi (2020) Paul (2017)
			Better financial performance of Sustainable indexes due to factors other than sustainability	Goldberg (2019)
			Sustainable investments carry higher cost as compared to conventional investment	Ortas et al. (2012) Adler and Kritzman (2008) Ur Rehman et al. (2016)
			Performance varies across geographical regions	Cunha et al. (2020) Ortas et al. (2015) Rocchia and Bechet (2011)

and during the COVID-19 period. The data for all the indexes is obtained from S-Network Global Indexes Inc (2020). All the benchmark indexes' daily closing prices are taken from 1st January 2011 to 29th June 2020. Prior to estimation, we transform each series into their natural logarithms (Tiwari et al., 2015).

3.1. Descriptive statistics and unit-root tests

The time series analysis begins with descriptive statistics. The paper then proceeds with the test for stationarity of both the time series using the Phillips and Perron's (1988) unit root test and the Augmented Dickey-Fuller (1979) unit root test. The following equation (1) explains the basic concept of the unit root testing:

$$y_t = p y_{t-1} + x_t^{'} + \varepsilon_t, \tag{1}$$

where $x_t^{'}$ are optional exogenous repressors, which consist of a constant, and ε_t is assumed to be white noise. If $|p| \geq 1$, then y is a non-stationary series. If $|p| \leq 1$, then y is a stationary series. Hence, we evaluate the hypothesis of stationary by testing whether the absolute value of $|p|$ is less than one. This is followed by the Frequency-specific Granger Causality (GC) test by Breitung and Candelon (2006).

3.2. Causality analysis in the frequency domain

The traditional Granger Causality (GC) tests measure the precedence and the information content, but does not indicate the causality in the conventional sense. The extent and the direction of causality differ between the frequency bands (Granger and Lin, 1995), which the conventional GC tests fail to identify. Since the stationary series is a composite of uncorrelated components, which is associated with each frequency ordinate, they allow for the decomposition of the full causal relationship by frequencies. The traditional approach of GC ignores the possibility that the strength and/or direction of the GC (if any) may vary over different frequencies (Lemmens et al., 2008). Granger (1969) was the first study to initiate the disentangling of the GC relationship between the series. Hence, this study adopts the Breitung and Candelon's (2006) approach to GC in the frequency domain, which is based on the work of Granger (1969).

The frequency-domain refers to the domain for analysis of mathematical functions or signals concerning frequency, rather than time. The frequency-domain graph highlights the signal that lies within each frequency band over a range of frequencies (Tiwari, 2012).

The advantage of implementing this measure of GC is that it can be applied across all periodicities (that is, both in the short run and the long run). This further clearly highlights as to which variable Granger causes the other for which specific period (Tiwari, 2014). Furthermore, it is critical to highlight that in a stationary system, causality at low frequencies implies that the additional variable can forecast the low-frequency component of the variable of interest, one period ahead (Tiwari, 2012).

Table 2
Descriptive statistics.

Indexes	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
D_L_SN500	0.000265	0.0894	−0.1272	0.0092	−1.1016	30.7771
D_L_SND1000	2.74E-05	0.0730	−0.1067	0.0079	−1.1108	22.0948
D_L_SNE1000	3.34E-05	0.0840	−0.1387	0.0100	−1.2501	22.0081
D_L_SNX1000	−2.24E-05	0.0427	−0.0677	0.0086	−0.9697	11.4469
D_L_TRESGDX	1.71E-05	0.0815	−0.1207	0.0086	−1.2330	24.2122
D_L_TRESGEU	2.41E-05	0.0840	−0.1404	0.0102	−1.2063	22.0752
D_L_TRESGEX	−4.20E-05	0.0513	−0.0809	0.0089	−0.8664	12.6293
D_L_TRESGUS	0.000226	0.1001	−0.1288	0.0095	−1.0720	31.0098

3.3. Wavelet Coherence (WC) analysis

To capture the nexus between the sustainable and the conventional indexes, sophisticated techniques seem to be more appropriate to depict the relationship at different times and frequencies. Thus, we implement the Wavelet Coherence (WC) technique. The wavelet transform routinely allows adjustments to the high and low frequencies, which reveals mathematical functions that transform the data into mathematically equivalent representations and split the data into different frequency components, with a resolution adapted to its scale. Wavelet analysis decomposes the data into several time-scales. Further, it decomposes the covariance between two stochastic processes over different time-scales, resulting in better estimates for the causality running between the time series (Tiwari et al., 2013). Other advantages of using the Wavelet approach are its ability to provide cross-analysis of data (Vyacheslav Lyashenko et al., 2020) or to provide the local analysis (Afshan et al., 2018). Furthermore, it captures the bi-directional (lead-lag) relationship between different time-frequency combinations simultaneously (Tiwari et al., 2019).

Since we intend to capture the extent of synchronization between the two concerned time series, it is informative to use coherence between them. The Wavelet coherence shares feature similar to the traditional coefficient of correlation. Aguiar-Conraria et al. (2008) define Wavelet coherence as 'the ratio of the cross-spectrum to the product of the spectrum of each series, and can be thought of as the local (both in frequency & time) correlation between two time-series.' Clare et al. (2021) assert that return smoothening is an important factor in enhancing returns. In this respect, return smoothening is found to be even more important than diversification across asset classes (Clare et al., 2021). According to Torrence and Webster (1998), we define the Wavelet coherence between two-time series as:

$$R_s^2(k) = \frac{\left|K\left(k^{-1} M_s^{xy}(k)\right)\right|}{K\left(k^{-1}\left|M_s^{x}\right|^{1/2}\right) . K\left(k^{-1}\left|M_s^{y}\right|^{1/2}\right)}, \quad (2)$$

where K is a smoothing operator and $M_s^{xy} = E[M_s^x \widetilde{M}_s^y]$ is the cross-spectrum, with $\widetilde{M}_s^y$ as the complex conjugate of M_s^y. Here, $0 \leq R_s(k) \leq 1$, which is similar to the traditional correlation coefficient (ρ) $0 \leq (\rho) \leq 1$. Without smoothing, coherency is identically one at all scales and times. We may further write the smoothing operator K as a convolution in time and scale:

$$K(M) = K_{scale}(K_{time}(M_s)) \quad (3)$$

where K_{scale} denotes smoothing along the Wavelet scale axis and K_{time} denotes smoothing in time. The time convolution is done with a Gaussian model, and the scale convolution is performed with a rectangular window (Torrence and Compo, 1998).

To understand the synchronization between two different time series, it is important to conceptualize the lead-lag relationship between the two-time series, which is achieved by computing the phase difference (Tiwari et al, 2015, 2016, 2019). The phase difference illustrates the phase relationship between the two-time series. A phase difference of zero (0) indicates that the time series move together at the specified frequency (Fig. 1). If it is between [0, π/2], the series moves in phase, with the time series y leading x. On the other hand, if it is between [-π/2, 0], the series moves in phase, but with x leading y. Alternatively, there is an anti-phase relationship (analogous to negative covariance) where, if we have a phase difference of π [or −π] meaning if the phase difference is between [π/2, π], then x is leading. The time series y is leading if it is in between [- π/2, -π].

4. Findings

We present the descriptive statistics in Table- 2 of the variables to see the sample property. Out of the time series data under study, the highest variation in values is evident in the case of the sustainable index; namely, TRESGEU followed by the conventional counterpart SNE1000. The maximum return is depicted by the TRESGUS and SN500, while TRESGEU provides minimum return at the cost of high variations. The data for all the time series is highly skewed, except for SNX1000 and TRESGEX. At the same time, the kurtosis for all the indexes is not within the normal range. This signifies that the series is asymmetric and leptokurtic, for which the Wavelet analysis is appropriate to investigate time movement with frequency (Grinsted et al., 2004).

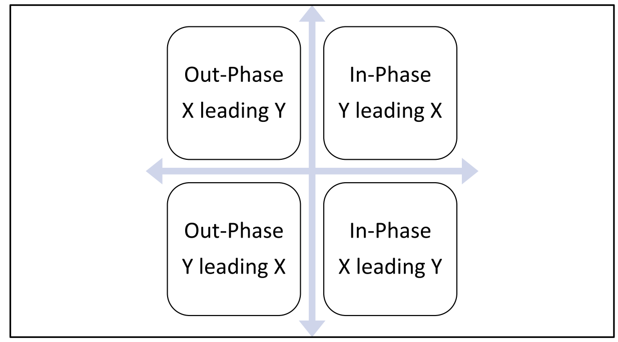

Fig. 1. Phase-difference matrix. For more details, see (Aguiar-Conraria and Soares, 2011).

Table 3 presents the application of the unit root tests, namely Phillips and Perron's (1988) and the Augmented Dickey-Fuller (1979) unit root test for all the eight series, revealing that all the time series under study are stationary. Further, the analysis proceeds with applying the Frequency-specific Granger Causality (GC) test by Breitung and Candelon (2006).

Beginning with the Frequency-specific Granger Causality (GC) test, we use the lag length decided based on AIC in the case of Breitung and Candelon (2006). The frequency (λ) on the horizontal axis can be translated into a cycle or periodicity of T by $T = 2\pi/\lambda$.; where T represents the period (Tiwari, 2012).

Figs. 2–5 present the results for frequency-domain Granger-Causality between the sustainable and conventional indexes. Fig. 2(a) presents the results for causality running from TRESGUS to SN500, while Fig. 2(b) presents the results for causality running from SN500 to TRESGUS. Fig. 2 (a) illustrates that at a 5% level of significance, TRESGUS Ganger-causes SN500 for all the frequencies up to the interval (0, 0.27) which is 23 days approximately, reflecting medium-run to long-run cycles. Similarly, Fig. 2(b) shows that at a 5% level of significance, SN500 Granger-causes TRESGUS for frequencies up to interval (0, 0.28), which again extends up to 22 days. Hence, bi-directional causality is evident at the intermediate frequencies for both the variables, reflecting medium-run to long-run cycles. Fig. 3(a) illustrates that at a 5% level of significance, TRESGDX Granger-causes SND1000 for frequencies in the interval (0, 0.38) that extends up to 16 days approximately, reflecting short-run to medium-run cycles. Conversely, the result for causality running from SND1000 to TRESGDX (Fig. 3(b)) does not provide evidence of GC running at any levels of frequencies. Fig. 4(a) and (b) does not provide any evidence of GC running from TRESGEU to SNE1000 and vice-versa,

Table 3
Unit root tests.

Indexes	ADF t-statistic	PP t-statistic
D_L_SN500	−17.56704***	−67.38710***
D_L_SND1000	−30.29807***	−52.51896***
D_L_SNE1000	−59.22960***	−59.26375***
D_L_SNX1000	−54.72139***	−54.71829***
D_L_TRESGDX	−54.47994***	−54.43236***
D_L_TRESGEU	−58.74261***	−58.77081***
D_L_TRESGEX	−52.56283***	−52.75083***
D_L_TRESGUS	−17.34189***	−66.35491***

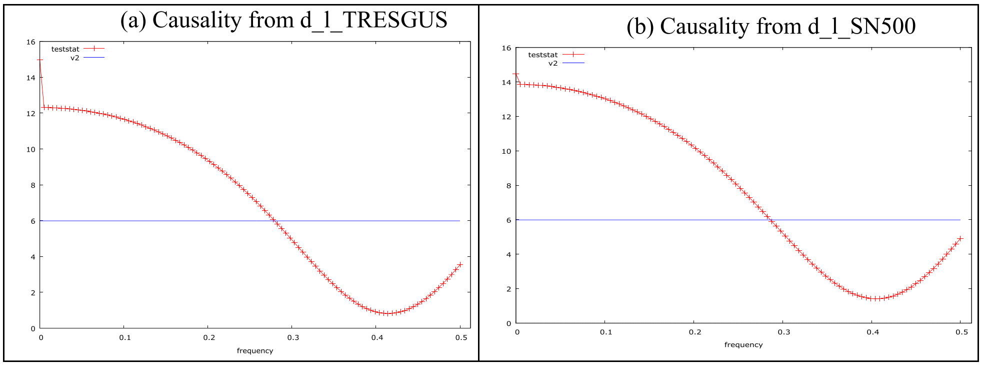

Fig. 2. Granger causality between TRESGUS & SN500.

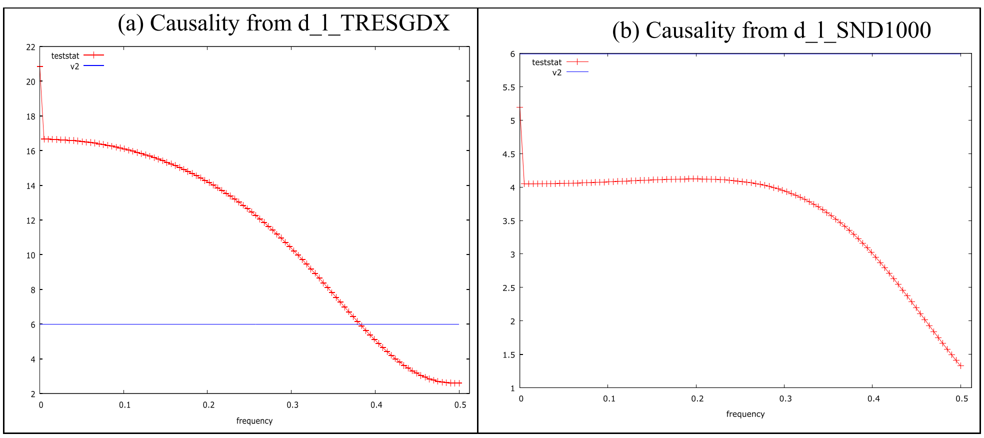

Fig. 3. Granger causality between TRESGDX & SND1000.

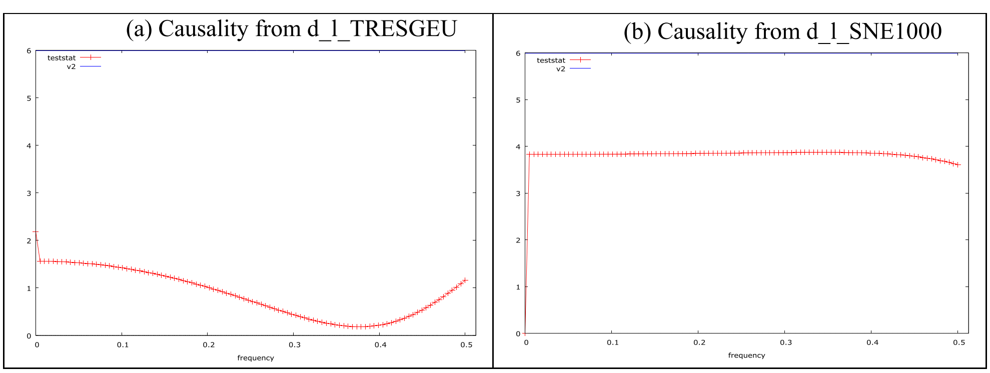

Fig. 4. Granger causality between TRESGEU & SNE1000.

respectively, for all the levels of frequencies. Fig. 5(a) illustrates that at a 5% level of significance, TRESGEX Granger-causes SNX1000 at all frequencies. This signifies that the sustainable index TRESGEX Granger-causes the conventional index SNX1000 over the short-term, medium-term, and long-term business cycles. Alternatively, Fig. 5(b) illustrates that at a 5% level of significance, SNX1000 Granger-causes TRESGEX for frequencies in the interval (0, 0.35) that extends up to 17 days, reflecting short-run to medium-run cycles.

We next move to check the coherence of conventional and sustainable indexes before and during the COVID-19 pandemic using the Wavelet Coherence analysis. Our results are presented in Fig. 6 – 9. The horizontal axis (X-axis) presents the daily sample period, while the vertical axis (Y-axis) deals with the frequency domain. The analysis considers five frequency cycles. The first two cycles (1–2 and 2–4 days bands) are associated with the short run or high-frequency bands, and the last three cycles (4–8, 8–16, and 16–64 days bands) are associated with the long-run analysis or low-frequency bands. The colour spectrum indicates the intensity of the co-movement between the variables under study. The red colour signifies no co-movement, while the blue colour means high positive co-movements between the variables. The black cone lining, known as the cone of influence (COI), represents the significance level. The thick black line and the thick grey line highlighted inside the COI represent 5% and 10% level of significance, respectively. Hence, the wavelet coefficients estimates located within the cone of influence are reliable and statistically significant at 95% and 90%, while all the areas outside the cone are out of consideration (Tiwari et al, 2015, 2016).

For SN500 and TRESGUS, small blue spots are visible across the 1–2

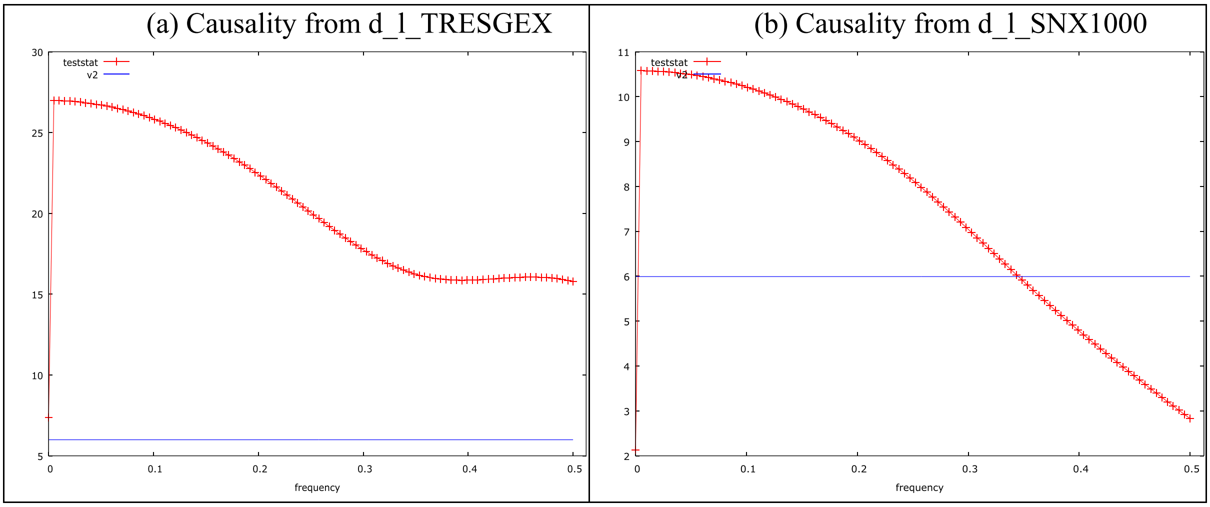

Fig. 5. Granger causality between TRESGEX & SNX1000.

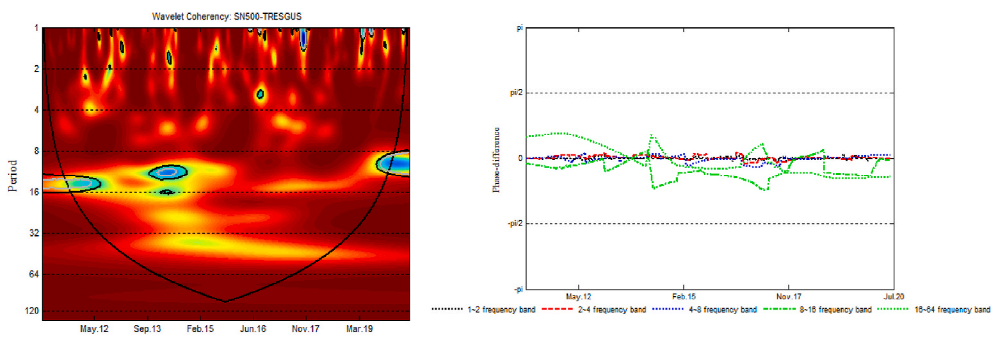

Fig. 6. WC: SN500 - TRESGUS

days band (Fig. 6), indicating strong co-movements between the variables and the relation between SN500 and TRESGUS is strong for high frequencies. The cases in the 2–4 and 8–16 days bands confirm significant coherence at a 5% level of significance, with TRESGUS leading majorly. Furthermore, co-movements are evident between the indexes during the COVID-19 era, which confirms that coherence between the indexes significantly increased after the pandemic outbreak. Fig. 7 reports strong coherence between the indexes in the lower frequency band (1–2 days band), while in the 4–8 days band, there is evidence of significant coherence at a 5% level of significance, with the variables being out-of-phase (0, -π/2) and TRESGDX leading. Fig. 8 presents the coherence between the variables in the short-run (1–2 days band). However, around November 2013, in the 8–16 days band, variables are out-of-phase (0, -π/2) and TRESGEU is leading. Also, the concerned indexes do not exhibit any significant co-movement post Covid-19 pandemic.

Compared to the previous indexes, significant and robust coherence is visible between SNX1000 and TRESGEX across all the five day-bands under consideration (Fig. 9). In the short run (1–2 days band and 2–4 days band), the variables exhibit to be in-the-phase (0, π/2) with SNX1000 leading. In the long run (4–8 days band and 8–16 days band), out of all the cases that report significant coherence between the variables, most cases confirm the variables to be out-of-phase (0, -π/2), with TRESGEX leading. For the 16–64 days band, the phase difference confirms the variables to be out-of-phase (-π, -π/2), with SNX1000 leading. Hence, in the short-run, most cases exhibit SNX1000 to be leading, while TRESGEX is leading the SNX1000 index in the long-run. Furthermore, the results also confirm strong co-movements between the indexes during the entire period under study (before and during the Covid-19 pandemic outbreak).

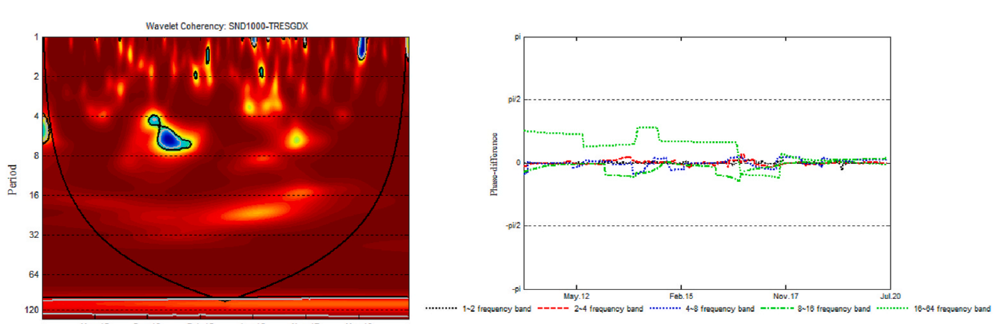

Fig. 7. WC: SND1000 - TRESGDX

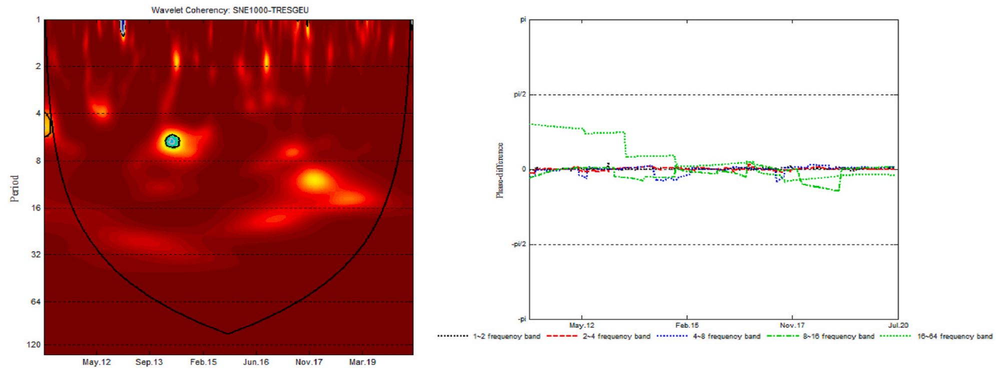

Fig. 8. WC: SNE1000 - TRESGEU

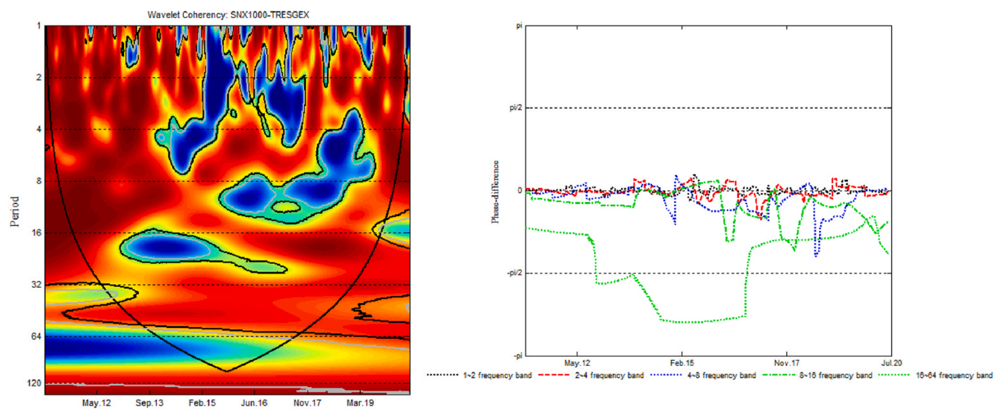

Fig. 9. WC: SNX1000 - TRESGEX.

5. Discussion

Sustainable investment has witnessed an increased interest in the last few decades. Yet, the investors often shy away from sustainable investment opportunities as they are perceived to be costlier or riskier than conventional investment. To address these concerns, we explore the relationship between sustainable and conventional indexes by studying uni-directional and bi-directional causality between these indexes. We also study the coherence between the two sets of indexes in both developed and emerging markets. Additionally, we also study the impact of COVID-19 pandemic on the coherence between these indexes.

We have applied the frequency-specific Granger Causality (GC) test to examine the cause-and-effect relationship between the variables, and the Wavelet Coherence technique to understand the coherence between these concerned sustainable and conventional indexes. Notably, the implementation of both the kinds of tests have resulted in similar findings across both lower and higher days bands, enabling us to further enhance the reliability and validity of the results. With reference to the SN500 and TRESGUS, both the tests conclude strong coherence and bi-directional causality between the said indexes that extends up to 22 days approximately. Additionally, TRESGDX Granger-causes SND1000 for a window of 16 days approximately, highlighting short to medium run cycles, and the wavelet technique further validates this result by exhibiting a strong coherence between the indexes in lower days bands. However, for TRESGEU and SNE1000, the Granger-Causality test reports no evidence of causality, and the wavelet technique also does not provide any significant co-movement between the indexes. Furthermore, both the tests confirm bi-directional causality and strong co-movement between TRESGEX and SNX1000 over both lower and higher day bands.

Our results provide three critical findings regarding the investors' preference for sustainable and conventional indexes. *One,* through frequency-specific GC model, we observe a bi-directional causality (sustainable indexes to conventional indexes and vice-versa) over the medium- and long-term (TRESGUS| SN500 and TRESGEX| SNX1000), and an uni-directional causality from sustainable indexes to conventional indexes (TRESGDX| SND1000). Bi-directional causality between these indexes signifies that both sustainable and conventional indexes impact each other in long run. This is a very significant finding in light of the growing academic and policy interest towards corporate sustainability. Figs. 2–5 exhibit that except for TRESGEU, all the sustainable indexes Granger-cause the corresponding conventional indexes. The bi-directional causality over medium to long-run cycle between TRESGUS and SN500 implies that there is a predictive power in TRESGUS in forecasting SN500 returns, and the other way round. It reflects that sustainable investments may set the tone for conventional indexes over the long-term, indicating the increasing investor interest towards sustainable investment. Our results suggest that sustainable investment has made its mark despite many inherent issues and has an important effect on conventional investments. Another surprising finding is that the causality between sustainable and conventional indexes does not exist for the European markets. However, Europe reported the highest number of sustainable investments worldwide by March 2020 (Hale, 2020). Furthermore, the bi-directional causality between TRESGEX and SNX1000 shall motivate the conscious investor to consider sustainable investment avenues in the emerging and under-developed nations that are also viewed as the next hot spot for socially conscious investments (Mellow, 2020).

Additionally, some developed nations (like Switzerland) continue to report a growing interest in value-based investing. By 2019, sustainable investment reached USD 30.7 trillion in assets under management in developed nations alone (Global Sustainable Investment Alliance, 2019). The GC model also highlights the uni-directional causality from TRESGDX to SND1000 in the developed nations (except the US), which can serve as a point of reference for the emerging markets to understand the socio-economic significance of these environmental and social impacts in the developed nations. This may help shift the corporate's and investor's attention to the sustainable investment avenues catering to the responsible and social issues, including healthcare, medicines, education, sustainable tourism, social bonds, renewable energy, and biodiversity.

In our second critical finding, the Wavelet Coherence results reveal strong coherence between the two sets of indexes in both the developed and emerging markets (except for TRESGEU and SNE1000). The coherence is particularly stronger at low frequencies, indicating the long-run coherence with sustainable indexes in the lead. This further indicates that sustainable investment has an enormous potential to surpass conventional investment in the long run. The pace at which this happens depends on how the inherent issues of sustainable investment highlighted above are addressed. Alike the frequency-specific GC results, the strong co-movement confirms that both the sets of indexes are integrated, and there is a flow of information between the two investment avenues (Jain et al., 2019). Sustainable investment offers a way of diversifying investment, as it has the potential to catalyze new capital flows into developing economies while at the same time translating experience, policies, and approaches from developed countries to emerging and under-developed nations (Wilson, 2016). Our finding adds to the discussion on the performance of sustainability indexes by suggesting that they have the potential to lead the conventional indexes and serve as a favorable investment option by providing risk-adjusted returns while incorporating sustainable investment practices, which is also in line with the results proven by Cunha et al. (2019).

Our third critical finding suggests that the coherence between the two sets of indexes (in the US and the emerging markets, specifically) increased even more during COVID-19 pandemic times. The coherence is particularly stronger at low frequencies, indicating the long-run coherence with sustainable indexes in the lead during and post COVID-19. It underlines that the investors started shifting towards sustainable avenues during this pandemic period since the COVID-19 crisis accelerated the growing relevance of ESG considerations to investors and sustainable avenues became the recovery plans for many governments (UBS Global, 2020). Sustainable investment, an already growing phenomenon, has gathered an even faster pace after the COVID-19 pandemic outbreak (Broom, 2020). The majority of people across different countries want a better, fairer, and sustainable world in post-COVID-19 times. The pandemic can also prove instrumental in fundamentally reshaping the way businesses operate globally while making them more sustainable than before (Bhattacharya, 2020). The long-run coherence further validates the long-term dynamics in sustainable investing, since the social and environmental issues, including the healthcare sector, renewable energy, sustainable transport, education, and biodiversity, were gaining momentum in early 2020, and will remain in focus in the aftermath of the pandemic. While the pandemic has triggered the most prominent global recession since World War II, it has proved to be a major turning point for sustainable investors (J.P. Morgan, 2020). ESG funds performed better than conventional funds during the global stock market crash triggered by the pandemic (UBS, 2020). ESG has been a preferred form of investment during the pandemic and has emerged as a clear winner in the COVID challenge (Mooney, 2020). The results confirm that sustainable investments in the post-pandemic era are poised to have an even stronger impact on conventional investments than before.

6. Conclusion and policy implications

We applied the frequency domain approach to the time-series data of eight stock indexes, including four sustainable indexes and their corresponding conventional indexes (four indexes), to examine the direction of Granger-causality between the variables, that enables us to capture the cyclical nature of the cause-and-effect relationship. We also employed the Wavelet-Coherence and phase-difference techniques to understand the coherence and lead-lag relationship between these indexes before and during the COVID-19 period. As suggested by Goodell (2020), there is a need to conduct financial market-related studies in the context of the COVID-19 pandemic. To the best of our knowledge, this is the first study that adds to the literature, as it implements both the Frequency-specific Granger Causality (GC) test of (Breitung and Candelon, 2006) and the Wavelet-Coherence and phase-differences techniques to explore the synchronization and lead-lag relationship between the sustainable and conventional indexes before and during the COVID-19 pandemic.

This research found its motivation to provide updated and robust information related to the performance of sustainable investments across global stock markets. Three prominent observations emerged from our analysis. *First,* through the frequency-specific GC model, we observe a bi-direction causality (sustainable indexes to conventional indexes and vice-versa) over the medium- and long-term, and an unidirectional causality from sustainable indexes to conventional indexes. It reflects that over the long-term, sustainable investments may serve as a benchmark of reference for conventional indexes, indicating the increasing investor interest towards sustainable investment. *Second,* the Wavelet-Coherence technique reveals a strong co-movement between the two sets of indexes in the developed and emerging markets, indicating long-run coherence with sustainable indexes in the lead using phase-differnces. *Third,* we establish more and significantly strong co-movements, implying that the coherence between the two sets of indexes increased even more during the times of the COVID-19 pandemic.

As with most viruses, the SARS-CoV-2 virus evolves over time, triggering second and even third waves in a number of countries. Countries such as India, Brazil, and the United States are particularly exposed to significant waves, which directly affect a large proportion of their populations. Apart from the number of cases and deaths, India is experiencing a severe shortage of critical supplies such as oxygen and vaccine during the second wave. In addition, nationwide and partial lockdowns are directly impacting the livelihoods of many. Amid all this chaos, some recent reports suggest that investors are increasingly attracted to sustainable investment hoping for a better future. Covid-19 pandemic has forced the governments, businesses, and investors to rethink their priorities for the future. Amid pandemic-induced disruptions, sustainable investment funds are on a constant rise in India. Investments in ESG mutual funds in India have witnessed an increase of 76% in financial year 2020–2021 as compared to 2019–20 (Iyengar, 2021). A recent poll by Verdict shows that climate change was voted as the most material issue of ESG factors (Verdict, 2021). Climate change is likely to remain the focus area of ESG, especially for companies and economies severely impacted by the pandemic. Investors are increasingly asking for better and transparent reporting from companies on climate change parameters. When policymakers, companies, and consumers continue to prioritize resilience over profitability, it is clear that renewable investing will gain momentum in the future.

The paper is not free of limitations. We conclude that there is a stronger coherence between sustainable and conventional indexes during the times of COVID-19 pandemic. In addition, the corresponding alternates to sustainable investment in the paper are taken as non-constrained conventional indexes which consist of both the sustainable and non-sustainable components. Future studies comparing sustainable investments and their alternates may drain the sustainable components out of the non-constrained conventional indexes before treating them as alternates. The results and conclusions of the study have important implications for different audiences. For practitioners of financial markets, allocations to ESG-engagement equities and high yield bonds can set the foundations for growth and return opportunities. Through the disruption that the COVID-19 pandemic has brought across the global economy and markets in 2020, sustainable investing strategies and avenues have delivered a comparatively better financial performance over their conventional counterparts (UBS Global, 2020).

Additionally, the long-term coherence with sustainable investment leading signals us to expect a diversified portfolio of global sustainable investment equities and bonds that may perform in line with the conventional strategies.

The portfolio and fund managers can prefer to invest in such markets to avail of higher returns over a longer period. This shift will lead to capital formation that will also trigger economic growth in the countries. This way, we will not only continue to pursue and prioritize sustainability targets, but will also be adequately positioned for catastrophic issues such as the COVID-19 pandemic.

Additionally, the government and policymakers may use such information while drafting public policies and employ them in monitoring and controlling the social and environmental responsibility of firms. Through this rapidly growing knowledge of financial markets, they are better positioned to handle the global crisis in the future and prepare for growth and recovery. Governments may also use the increased desire for a sustainable future from citizens (including investors) to develop urgent climate change policies.

For academicians, we contribute to the literature on sustainable investment, and suggest that future studies could benefit from assessing sustainable investments considering, for instance, (i) different asset classes such as fixed income, real state, private equity, and hedge funds; (ii) high-impact sectors related to sustainability issues, e.g., poverty, inequality, and climate change; (iii) diverse and more active sustainable investment strategies; (iv) not only portfolio but also ESG performance analysis; (v) the nexus between the sustainable indexes and their conventional counterparts may be studied further by employing other financial factors, or with other relevant econometric tools and methodologies.

Author contributions

Gagan Deep Sharma and Gaurav Talan: Conceptualization. Gagan Deep Sharma and Mansi Jain: Methodology. Aviral Kumar Tiwari: Validation, Data analysis, Supervision, Software. Gaurav Talan and Mansi Jain: Formal Analysis. Gaurav Talan and Mansi Jain: Data Curation. Mansi Jain: Writing–Original Draft Preparation. Gagan Deep Sharma and Aviral Kumar Tiwari: Writing – Review and Editing. Gagan Deep Sharma: Supervision.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data accessibility statement

The data shall be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We are grateful to our university for providing the research infrastructure for carrying out our study.

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