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Extreme risk connection among the European Tourism, energy and carbon emission markets

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ABSTRACT

This article presents a novel examination of the risk connectedness patterns and causality relationships between European Tourism and the Energy and Carbon Emissions Market. The findings indicate that the risk connectedness between European Tourism and the Energy and Carbon Emissions Market exhibits asymmetric characteristics, displaying weaker connectedness in median and high states compared to normal market conditions. Notably, connectedness is more pronounced in extreme tail cases. Additionally, the European Tourism Sector Index is less susceptible to risks in the European Energy and Carbon Emissions market during bear markets. Furthermore, Rotterdam Coal Futures and Dutch TTF Natural Gas Futures contribute significantly to the volatility connectedness of the European Tourism Sector Index. The findings of the quantile Granger causality test confirmed the existence of causality between the European Tourism Index and the European Energy and Carbon Markets across all market states.

1. Introduction

Europe is a leading global tourist destination, renowned for its rich history and cultural heritage, offering numerous delights and experiences to travelers. In 2019, Europe attracted 51 % of the world's international travelers, generating a direct economic impact of €60–70 billion. Tourism contributes 4 % to GDP and supports 12 million jobs. Thus, European tourism significantly contributes to economic growth, employment, and foreign exchange earnings (Manzoor et al., 2019). COVID-19 severely impacted tourism, causing the overall contribution of European tourism to GDP to decline from 9.5 % in 2019 to 4.9 % in 2020. Additionally, international tourist arrivals in Europe declined by 70 % in 2020 compared to the previous year, 2019.[1] The tourism downturn can be directly attributed to the pandemic and is closely linked to economic policies (Khalid et al., 2021; Zhao et al., 2023). Strict pandemic control measures have resulted in the closure of borders and tourist attractions across many European countries, leading to significant tourism losses (Madani et al., 2020). Many businesses face the risk of bankruptcy and debt default, potentially leading to financial losses for investors

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[1] https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690884/IPOL_STU(2021)690884_EN.pdf

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(Bouteska et al., 2023). Currently, the European tourism industry continues to face significant uncertainty due to an unpredictable economic environment. Investors must carefully assess the tourism sector's outlook and adopt effective risk management strategies to mitigate potential losses.

Energy plays a crucial role in contemporary industry and economic growth, significantly influencing various markets and economic participants (Klotz et al., 2014; Lovcha et al., 2022; Bouteska et al., 2023; Zeng et al., 2024). European countries have consistently acted as energy importers. Conventional energy sources, such as coal, oil, and gas, remain the primary energy supplies for the European economy. Consequently, the price volatility and supply risks of these traditional energy sources have significantly impacted the European economy (Min et al., 2022; Dhifqaui et al., 2022). Following the onset of the 2022 Russo-Ukrainian conflict, the supply-demand disparity for these energy sources, particularly crude oil and natural gas, due to the EU's stringent sanctions against Russia, has led to a surge in prices. This triggered an energy crisis and inflation, raising significant concerns among policymakers and market participants regarding Europe's energy situation (Yadav et al., 2023; Goodell et al., 2023; Zeng et al., 2024).

Energy plays a key role in supporting tourism (Waheed et al., 2020). The tourism industry requires significant energy to function effectively, which establishes a theoretical link between energy and tourism that can be viewed through two main aspects. First, fluctuations in energy prices, such as supply shortages, lead to increased costs for tourism businesses, including fuel for transportation and energy consumption at attractions. This increase in costs directly impacts the profitability of the tourism industry. Additionally, energy price fluctuations directly influence the operating costs of public institutions (Adi et al., 2023). Consequently, the government may need to adjust its budget to cover rising energy costs and ensure normal infrastructure operations. However, such budget adjustments can impact government investment in tourism development and the overall tourism market (Khan et al., 2020; Hou et al., 2024). Second, the profitability and growth of the tourism sector influence the overall economy, energy demand, and prices—key indicators of economic health. Consequently, changes in tourism market performance may also affect relevant energy indices (Qin et al., 2021). This article examines the quantile interconnections between stock indices in the tourism and leisure sector and the European Energy and Carbon Emissions Index within the European region. Specifically, the analysis focuses on the quantile interconnections among several indices, including Rotterdam Coal Futures (ICE), Brent Crude Oil Futures (Oil), Dutch TTF Natural Gas Futures (TTF), the European Union Allowance (EUA), the carbon emissions market EU Allowance (EUA), and the STOXX Europe 600 Travel & Leisure index (EURO) under varying market conditions.

Theoretically, the relationship among energy markets, tourism, and the broader economy can be analyzed through various economic frameworks. The energy-led growth hypothesis asserts that energy consumption is a vital driver of economic growth, indicating that disruptions in energy supply or price fluctuations can significantly affect economic output, including the tourism sector (Erdoğan et al., 2022; Zeng et al., 2025). Moreover, the tourism-led growth hypothesis suggests that the expansion of tourism can drive economic growth by enhancing foreign exchange earnings, generating employment opportunities, and promoting the development of infrastructure and related industries (Ozturk et al., 2023; Banerjee et al., 2024). These theoretical foundations underscore the complex interconnect between energy markets, tourism, and overall economic performance.

However, traditional energy sources have contributed to environmental issues and climate change. Furthermore, measures are necessary to mitigate their environmental impact and carbon footprints. In response to these challenges, European governments and companies are actively developing clean energy to decrease reliance on traditional energies and foster sustainable economic development (Shahbaz et al., 2021; Sadiq et al., 2022; Bouteska et al., 2023; Zeng et al., 2024). The EU Green Deal mandates a 50–55 % reduction in emissions by 2030 and emphasizes the necessity to decouple economic growth from resource demand. It also stipulates the aim to establish the world's first zero-carbon emissions region by 2050. Realizing this goal necessitates collaboration between governments and businesses to adopt proactive measures for reducing carbon emissions. This effort will facilitate a transition to clean energy. The implementation of this process is likely to induce significant price volatility in the energy market and have profound effects on the economy. Therefore, it is particularly pertinent in the current context to investigate the interconnectedness between energies and other sectors. This can be achieved by analyzing the dynamic relationships among various energy indices (Bouteska et al., 2024).

Although some previous studies employed an average-based connectedness framework to investigate the relationships between financial markets and energy industries (e.g., Fasanya and Oyewole, 2023; Zeng et al., 2023; Ha et al., 2024), they neglected the spillover mechanism of conditional quantiles in the tails. As a result, this study addresses this significant gap in existing literature. In summary, we examined the patterns of cross-market information transmission based on lower, middle, and upper quantile levels, effectively illustrating bear, stable, and bull market regimes, respectively. Thus, the QVAR approach enabled a thorough exploration of the interconnectedness among variables, especially in contexts characterized by asymmetry and heteroskedasticity. Additionally, the inclusion of the factor framework significantly simplified the evaluation process by rendering the components of the VAR function cross-sectionally independent, thereby alleviating the empirical burden. Moreover, the QVAR connectedness approach's unique advantage is its focus on specific risk shocks and contagion, which typically exhibit different patterns of shock propagation during market abnormalities (tail states) compared to normal periods (Ando et al., 2022; Wang et al., 2024; Zeng et al., 2024). In other words, concentrating on tail spillover effects is anticipated to yield reliable evidence regarding how markets dynamically evolve and interconnect under extreme conditions.

Our findings provide robust insights that will inform investors about timely strategies for portfolio adjustment and risk loss mitigation. Secondly, our results will be visually represented through charts and other formats to illustrate time-varying dynamic connectedness. This visualization is crucial for verifying the magnitude and direction of time-domain connectedness, aiding investors in understanding changing trends. As a result, investors and analysts will better understand related market risks and volatility changes, enhancing the effectiveness and operability of risk management tools. Ultimately, this will facilitate improved investment decisions. Thirdly, this approach allows us to gather relevant information on net shock senders and receivers within the system under varying market conditions and to assess overall connectedness among systemic risks and their determinants. Finally, previous studies typically employed standard Granger causality tests to evaluate causal relationships; in contrast, our paper employs quantile methods, allowing us to observe the nonlinear and asymmetric characteristics among the European Energy and Carbon Emissions markets and the European Tourism Sector Index.

This paper makes significant contributions by significantly advancing the insights of the intricate relationships between the European tourism and energy industry, addressing a critical gap in the current research landscape. Recently, many studies have shifted their focus to the influence of tail events on financial markets, particularly following the COVID-19 outbreak (e.g., Lu et al., 2023; Zeng et al., 2024; Chai et al., 2022). However, research on the connection between the European tourism and energy industry has been scarce. Our work addresses this gap by providing key contributions: 1) To our knowledge, it is the first instance where we explore risk spillovers between the European Tourism Sector Index and the EU energy and carbon industries, enriching the literature by deepening the understanding of interconnections among the tourism sector, energy, and other asset classes. 2) This work applies the quantile connectedness method to analyze risk linkages between the European Energy and Carbon Emissions Index and the European Tourism Sector Index for the first time. This innovative methodological approach captures the complex dynamics of these relationships across various market conditions, offering a more nuanced understanding than traditional average-based methods. 3) This provides valuable insights for policymakers and regulators in the tourism industry, allowing them to adopt existing policies to mitigate the negative environmental impacts of energy consumption in tourism, achieving this across varying market conditions. Additionally, it promotes sustainable tourism development, ensuring long-term profitability in the industry. More importantly, it introduces innovative ideas and approaches for the development of the tourism market as we transition towards an inclusive green economy. 4) This aims to provide investors with updated insights into investment diversification, hedging, and risk aversion, assisting them in conducting risk management analyses even under extreme (volatile) market conditions. With these informed investment decisions, investors can mitigate the impacts of turbulence to achieve reliable returns. 5) Lastly, we provide compelling evidence across all quantile levels examined in our study, demonstrating the strong risk predictability of the European energy and carbon industries on the European Tourism Sector Index, using the quantile-based Granger causality method. This comprehensive analysis across various market conditions provides a more thorough understanding of the causal relationships between these sectors compared to previous studies. By addressing these key areas, our study contributes to academic literature and offers practical insights for industry stakeholders, policymakers, and investors navigating the complex relationships between the tourism and energy sectors in Europe.

Our research indicates a significant risk dependence of the European Energy and Carbon Emissions Index on the European Tourism Sector Index during favorable market conditions. Additionally, our findings show that Rotterdam Coal Futures and Dutch TTF Natural Gas Futures exhibit greater risk connectedness to the tourism market across all market conditions. Investors in the tourism market should be aware of the risk linkage between the energy and carbon markets and the tourism sector. Thirdly, the time-varying pairwise connectedness results indicate that the EU energy and carbon sectors exert less influence on the European Tourism Sector Index during bear markets, whereas they exert a greater influence during bull markets. Finally, our research shows that the dynamic net connectedness behavior of the subdivided variables is influenced by specific factors across different market conditions and over time, with no single dominant net contributor. Most of these variables are sensitive to crisis periods, which alters the net connectedness pattern. Lastly, we established a robust Granger causal relationship among the European energy and carbon markets and the European Tourism Index under varying market conditions using quantile-based Granger causality tests. These results offer valuable recommendations for policymakers, investors, and other stakeholders to address similar major events in the future and to evaluate the effects of various policies and strategies.

The remainder of the research is structured as follows: Section 2 offers a comprehensive literature review; Section 3 reviews the methodology and dataset; Section 4 presents the primary empirical findings; and Section 5 discusses the conclusions and their implications for market participants.

2. Literature review

This article aligns with a growing body of study examining patterns in energy investment, renewable energy consumption, and consumer behavior. Our literature review is organized into four main topics: (1) interdependencies between traditional fossil energy and other markets; (2) dynamic connections among renewable energy markets and other markets; (3) linkages between carbon markets and others; and (4) interactions between the tourism sector and other assets.

2.1. The relationship between traditional fossil energy and other markets

Traditional fossil energy sources have attracted significant academic interest due to their considerable impact on the global economy and environment. Recent studies by Cao and Xie, (2023) integrated quantile vector autoregressions with extended joint connectedness methods, revealing that markets showed closer linkages under extreme risks, with time-varying and cyclical patterns. Additionally, Billah et al. (2022) examined market correlations among energy and BRIC markets using a quantile connectedness approach, indicating that market uncertainty intensified the effect of connectedness. The frequency and quantile connections between energy and non-energy commodities were found to be low, while some non-energy commodities showed a neutral co-movement with international energy commodities. Yoon, (2022) investigated the time-frequency connection between fuel and agricultural commodity prices using covariance and causality analysis, highlighting the significant finding that no evidence of cointegration existed among the quartiles of WTI oil, ethanol, and corn prices. However, significant short-run bivariate causality was identified among the returns of these markets across all quartiles.

2.2. *The relationship between renewable energy markets and other markets*

As renewable energy rises in the background of carbon neutrality and carbon peaking, traditional energy markets will face significant impacts, and their prices may be influenced. Furthermore, broad investment opportunities in the renewable energy market have attracted more investors to include it in their portfolios, promoting risk connectedness among different markets through the investor channel. Recent research by Chatziantoniou et al. (2022) estimated the quantile connectedness between the Green Bond Index and the Sustainability Index, confirming the interconnections between the S&P Global Clean Energy Index and the S&P Green Bond Index. Lorente et al. (2023) examined the interrelations among climate transition indices, green finance, and geopolitical risk indices using QVAR and wavelet coherence (WC) methods, observing a decline in the TCI after the second wave of the COVID-19 crisis, followed by an increase during the first 100 days of the 2022 Russo-Ukrainian war. Tiwari et al. (2023) employed a quantile VAR framework to analyze the dynamic connectedness and correlations between bitcoin prices and clean and renewable energy sectors, confirming that Bitcoin became a net recipient of spillovers. Moreover, the evolution of indices in the markets examined was primarily driven by their own spillovers. According to Le et al. (2023), cryptocurrencies were identified as net shock recipients in the long-term dynamic, except for short-term connectedness following the outbreak of the Russo-Ukrainian war in 2022.

2.3. *The connection between carbon and other markets*

Carbon markets play a crucial role in enhancing a low-carbon economy and addressing global climate change, prompting extensive research into their interconnections with other financial assets. Studies have revealed complex relationships between carbon markets and various financial instruments. For instance, Adekoya et al. (2021) demonstrated that carbon markets primarily receive spillovers from all markets, except for copper and dollar currencies, while Ren et al. (2022) identified positive effects and relatively weak short-term associations between carbon assets and the Green Bond over the medium to long-term using distinct quantile approaches. Further research by Asl et al. (2022) found that carbon allowance prices are associated with stock prices across all sectors, except traditional utility stock returns, showing significance in a single Granger test for long-term investment horizons. In the Chinese context, Li et al. (2023) employed a connectedness method based on a quantile VAR function to analyze volatility and interconnections in the Chinese carbon emissions trading (CET) market, revealing that carbon emission price returns were influenced by economic fundamental shocks and pilot connectedness. Additionally, Qi et al. (2023) discovered that petrochemicals are the largest recipients in the carbon emission commodity system, with cross-quantile dependence between the carbon emission market and commodities showing gradual increases as the quantile expands.

2.4. *The relationship between the travel industry sector and other assets*

A previous limited correlation study of travel sector indices with other asset market linkages by Fasanya and Oyewole, (2023) found that the relationships between contagion-induced uncertainty, the Southeast Asian tourism stock index, and the four precious metal markets mainly occur in the lower and normal quartiles. Yousaf et al. (2023) found only weak static connectedness between travel tokens and other assets under typical economic conditions; however, the intensity of this connectedness significantly rise during the COVID-19 period. Zeng et al. (2024) found that during stable market periods, the US Travel and Leisure Index has the highest connection with clean energy stocks.

In summary, the European Energy and Carbon Emissions industry and the European Tourism Sector Index are two areas of interest for market participants, yet there are currently gaps in research regarding the linkages between the two. Specifically, no study has comprehensively examined the volatility spillover mechanisms and causal relationships between the European Energy and Carbon Emission Indices and the European Tourism Industry Index under varying market conditions. Therefore, this article aims to fill this gap and offer empirical and practical contributions by examining the mechanisms of quantile risk transmission between the European Energy and Carbon Emissions Index and the European Tourism Sector Index.

3. Methodology and data

3.1. *Quantile VAR connectedness*

To investigate the dynamic relationships among the European Energy Index, Carbon Emissions Index, and European Tourism Sector Index, we measure connectedness at each quantile π, Following Ando et al. (2022), we employ an extended version of the DY (2012) mean-based measure. We express the infinite order vector moving average (MA) process through the following equation: $\beta'(\pi) = \text{a } rmin_{\beta(\pi)} \sum_{t=1}^{T} \pi - 1_{\{z_t < y_y \beta(\pi)\}} \Big) \left| z_t - y_t \beta(\pi) \right|$ for the process of performing an infinite order vector moving average (MA), which would be derived as below:

$$z_t = \theta_\pi + \sum_{k=0}^{\infty} A_s(\pi) e_{t-s}(\pi), t = 1, T \tag{1}$$

Here, $z_t$represents the residuals $e_t(\pi)$, where: $\theta_\pi = \left(I_n - B_1(\pi) - \ldots - B_p(\pi)\right)^{-1} \mathrm{c}(\pi), A_s(\pi) = 0, \mathrm{s} < 0; I_n, \mathrm{s} = 0$ and $B_1(\pi) A_{s-1}(\pi), \mathrm{s} > 0$

In the subsequent process, we implement the methodology of Koop et al. (1996) and Pesaran and Shin (1998), which provides robustness to index ranking. The Generalized Forecast Error Variance Decomposition (GFEVD) over forecast horizon H is defined as:

$$\rho_{ij}^{g}(\mathrm{H}) = \frac{\varphi_{ij}^{-1}\sum_{h=0}^{H-1}\left(e_i'A_s\sum e_j\right)2}{\sum_{h=0}^{H-1}\left(e_i'A_s\sum e_j\right)} \tag{2}$$

In equation $\rho_{ij}^{g}(\mathrm{H})$, variable j measures its contribution to the prediction error of variable i over the specified horizon. Here, $\sum$ represents the variance matrix of the error vector, augmented by φ_{jj} the j, which corresponds to the diagonal element of the $\sum$ matrix. Additionally, e_i signifies a vector with a amount of 1 for the variable i and 0 for all other variables.

The normalization of the variance decomposition matrix is expressed as:

$$\rho_{ij}^{g'}(\mathrm{H}) = \frac{\rho_{ij}^{g}(H)}{\sum_{j=1}^{N}\rho_{ij}^{g}(H)} \tag{3}$$

We then construct four connectedness indicators at each quantile using the GFEVD and Total Connectedness Index (TCI):

$$\mathrm{TCI} = \frac{\sum_{i=1}^{N}\sum_{j=1,i\neq j}^{N}\rho_{ij}^{g'}(H)}{\sum_{i=1}^{N}\sum_{j=1}^{N}\rho_{ij}^{g'}(H)} \tag{4}$$

In addition, to measure the directional connectedness from i to j at quantile π, we define the "TO" index as:

$$\mathrm{TO} = \frac{\sum_{j=1,i\neq j}^{N}\rho_{ij}^{g'}(\pi)}{\sum_{j=1}^{N}\rho_{ij}^{g'}(\pi)} \quad {}^{*}100 \tag{5}$$

For measuring the total directional connectedness from index j to i, we calculate the "FROM" index at quantile π, as bellows:

$$\mathrm{FROM} = \frac{\sum_{j=1,i\neq j}^{N}\rho_{ji}^{g'}(\pi)}{\sum_{j=1}^{N}\rho_{ji}^{g'}(\pi)} * 100 \tag{6}$$

The net total directional connectedness (NET) at quantile π is calculated by subtracting the "TO" connectedness from the "FROM" connectedness:

$$\mathrm{NET}(\pi) = \frac{\sum_{j=1,i\neq j}^{N}\rho_{ij}^{g'}(\pi)}{\sum_{j=1}^{N}\rho_{ij}^{g'}(\pi)} * 100 - \frac{\sum_{j=1,i\neq j}^{N}\rho_{ji}^{g'}(\pi)}{\sum_{j=1}^{N}\rho_{ji}^{g'}(\pi)} * 100 \tag{7}$$

Following Mensi et al. (2022), we use three quantile levels (0.05, 0.5, 0.95) to represent extreme downside, average market conditions, and extreme upside states, respectively.

3.2. Granger causality-in-quantiles

We applied the nonlinear causality-in-quantile methodology developed by Balcilar et al. (2016). Following Jeong et al. (2012), we assume that index x_t has no causal effect on variable y_t in the θ-quantile, given the lag-vector $\left\{y_{t-1},\dots,y_{t-p},x_{t-1},\dots,x_{t-p}\right\}$. if:

$$Q_\theta\left(y_t \mid y_{t-1},\dots,y_{t-p},x_{t-1},\dots,x_{t-p}\right) = Q_\theta\left(y_t \mid y_{t-1},\dots,y_{t-p}\right) \tag{8}$$

Conversely, x_t causes y_t in the θ-th quantile with respect to $\left\{y_{t-1},\dots,y_{t-p},x_{t-1},\dots,x_{t-p}\right\}$ if.

$$Q_\theta\left(y_t \mid y_{t-1},\dots,y_{t-p},x_{t-1},\dots,x_{t-p}\right) \neq Q_\theta\left(y_t \mid y_{t-1},\dots,y_{t-p}\right)Q_\theta\left(y_t \mid y_{t-1},\dots,y_{t-p},x_{t-1},\dots,\mathrm{x}_{t-p}\right)$$

$$\neq Q_\theta\left(y_t \mid y_{t-1},\dots,y_{t-p}\right) \tag{9}$$

In this context, $Q_\theta(y_t \mid \bullet)$ denotes the θ-th quantile of y_t. The conditional quantiles of $y_t, Q_\theta(y_t \mid \bullet)$ are contingent on t, and these quantiles are limited within the range of 0 and 1, indicted as $0 < \theta < 1$.

Then define the vectors: $Y_{t-1} \equiv \left(y_{t-1},\dots,y_{t-p}\right)Y_{t-1} \equiv \left(y_{t-1},\dots,y_{t-p}\right)$, $X_{t-1} \equiv (x_{t-1},\dots,x_{t-p})$, and $Z_t = (X_tY_t)$. The functions $F_{y_t|Z_{t-1}}\left(y_t \mid Z_{t-1}\right)$ and $F_{y_t|Y_{t-1}}\left(y_t \mid Y_{t-1}\right)$ represent the conditional distribution structures of y_t, given vectors Z_{t-1} and Y_{t-1}, respectively. We assume that the conditional distribution $F_{y_t|z_{t-1}}\left(y_t \mid Z_{t-1}\right)$ is continuous in y_t for almost all values of Z_{t-1}.

Based on the definitions $Q_\theta(Z_{t-1}) \equiv Q_\theta\left(y_t \mid Z_{t-1}\right)$and $Q_\theta(Y_{t-1}) \equiv Q_\theta\left(y_t \mid Y_{t-1}\right)Q_\theta(Y_{t-1}) \equiv Q_\theta\left(y_t \mid Y_{t-1}\right)$, we can show that $F_{y_tZ_{t-1}}\{Q_\theta(Z_{t-1}) \mid Z_{t-1}\} = \theta$ holds with probability one. Therefore, the causality-in-quantile hypotheses from Eqs. (8) and (9) can be formally stated as:

$$H_0 : P\left\{F_{y_t|Z_{t-1}}\{Q_\theta(Y_{t-1}) \mid Z_{t-1}\} = \theta\right\} = 1 \tag{10}$$

$$H_1 : P\left\{F_{y_t|Z_{t-1}}\{Q_\theta(Y_{t-1}) \mid Z_{t-1}\} = \theta\right\} < 1 \tag{11}$$

Note that the causal relationships in the tail regions may differ from those at the distribution centre.

This study employs the STOXX Europe 600 Travel & Leisure index (EURO) to represent the EU travel sector. The index tracks major European travel and leisure companies, providing comprehensive market coverage. Following Su et al. (2023), we analyze dynamic linkages using five additional indices: Rotterdam Coal Futures (ICE), Brent Crude Oil Futures (OIL), Dutch TTF Natural Gas Futures (TTF), European Union Allowance (EUA), and European Renewable Energy Total Return (ERIX). The EUA futures price serves as a proxy for the carbon market, given the significance of the European Climate Exchange (ECX).

The traditional energy markets are represented by three futures contracts: Rotterdam Coal (ICE), Brent Crude Oil, and Dutch TTF Natural Gas. The ERIX index serves as a proxy for the European clean energy market, encompassing major producers in wind, solar, biomass, and hydropower sectors. The data obtained from DataStream covers the range from January 1, 2018, to April 25, 2023. We compute first-order log returns for analysis.

4. Empirical results

Table 1 provided summary statistics for the returns of both the variables. Among all indices, EUA exhibits the highest mean return (0.18), whereas EURO shows the lowest (-0.008). TTF demonstrates the highest variance (65.862), contrasting with EURO's lowest variance (3.313). These findings indicate lower price volatility in the EU tourism market. The skewness and kurtosis values indicate non-normal distributions characterized by spikes and heavy tails across all variables. The Jarque-Bera test confirms the non-normal distribution of returns across all variables. ERS statistics indicate stationarity in all return series. The ARCH-LM test reveals significant GARCH effects in all return series, justifying the use of GARCH (1,1) models for volatility estimation in subsequent empirical analyses.

Fig. 1 illustrates market trends throughout the study period. The carbon trading system demonstrates a consistent upward trend. The COVID-19 significantly impacted European tourism, carbon emissions, and new energy market indices. Rotterdam Coal Futures and Dutch TTF Natural Gas Futures maintained relatively stable performance during this period. The onset of the Russia-Ukraine war in 2022 triggered increased volatility across all markets. These market dynamics necessitate an investigation into the interconnectedness among these markets under varying conditions. Following Zeng and Ahmed (2023), return series were converted to volatility measures using a GARCH(1,1) model for subsequent analysis.

Panel B of Table 2 shows the quantile connectedness results for median market conditions ($q = 0.5$). TCI shows a moderate value of 21.67 %, indicating limited interaction between the European energy industry and tourism sector under median market conditions.

ICE exhibits the highest net risk impact (6.78 %) on other markets, emerging as the primary risk transmitted during bear markets. Conversely, EURO and EUA serve as net risk premium recipients, with EURO showing the highest sensitivity to other indices. Given the distinct risk premia patterns in extreme conditions, this study analyzes market connectedness in both downward ($q = 0.05$) and upward ($q = 0.95$) market scenarios.

Panel C of Table 2 provides the volatility connectedness patterns under downside market conditions ($q = 0.05$). The TCI increases to 28.49 % during bear market conditions, exceeding the median period value. During this period, EURO (1.1 %), OIL (0.12), and TTF (1.00) function as net volatility transmitters, while EUA (-0.13 %), ERIX (-1.41 %), and ICE (-0.68 %) act as net receivers. This pattern likely reflects the negative impact of market downturns on energy sectors. This finding aligns with Su et al. (2023).

Panel A of Table 2 illustrates quantile transmission patterns during extreme upward market conditions ($q = 0.95$). The TCI reaches 80.63 %, with all indicators showing connectedness indices exceeding 60 %, indicating strong market integration during extreme upward periods. Net directional connectedness analysis reveals EURO (-25.78 %) as the primary net receiver. Within energy markets, ERIX (-11.76 %) and Oil (-24.25 %) emerge as risk recipients, while EUA (0.94 %), ICE (31.87 %), and TTF (28.98 %) function as volatility transmitters. These results demonstrate the predominant role of energy and carbon emissions indices during upward market movements.

During upward market periods, improved economic conditions and increased investor risk appetite drive higher energy demand and carbon emissions prices. Market optimism stimulates tourism activity through increased real income and positive economic expectations (Zeng, 2024). Energy availability further supports tourism growth under optimistic market conditions (Mao et al., 2021).

The analysis examines pairwise dynamic connectedness between the Euro and EU energy and carbon markets across different market conditions. This analysis reveals the tourism sector's role as either a net receiver or transmitter of volatility across various market scenarios. Fig. 2 illustrates these relationships throughout the research period. In Fig. 2, positive values indicate net risk senders, while negative values represent net risk recipients. The tourism sector's net connectedness with other variables exhibits

Table 1
Summary statistics.

	EURO	EUA	ERIX	ICE	OIL	TTF
Mean	−0.008	0.18	0.055	0.08	0.014	0.055
Variance	3.313	9.053	3.225	5.726	7.835	65.862
Skewness	−0.487 * **	−0.630 * **	−0.228 * **	2.247 * **	−1.356 * **	−0.185 * **
Kurtosis	6.802 * **	4.553 * **	4.392 * **	43.302 * **	18.903 * **	29.029 * **
JB	2638.457 * **	1246.886 * **	1089.407 * **	105896.406 * **	20376.214 * **	47092.146 * **
ERS	−15.203 * **	−17.311 * **	−14.904 * **	−14.726 * **	−8.785 * **	−17.653 * **
ARCH-LM	372.48 * **	86.389 * **	169.07 * **	679.11 * **	171.53 * **	261.7 * **

Note: * ** ,* *,* denote significance at 1 %, 5 % and 10 % significance level. ERS unit-root test.

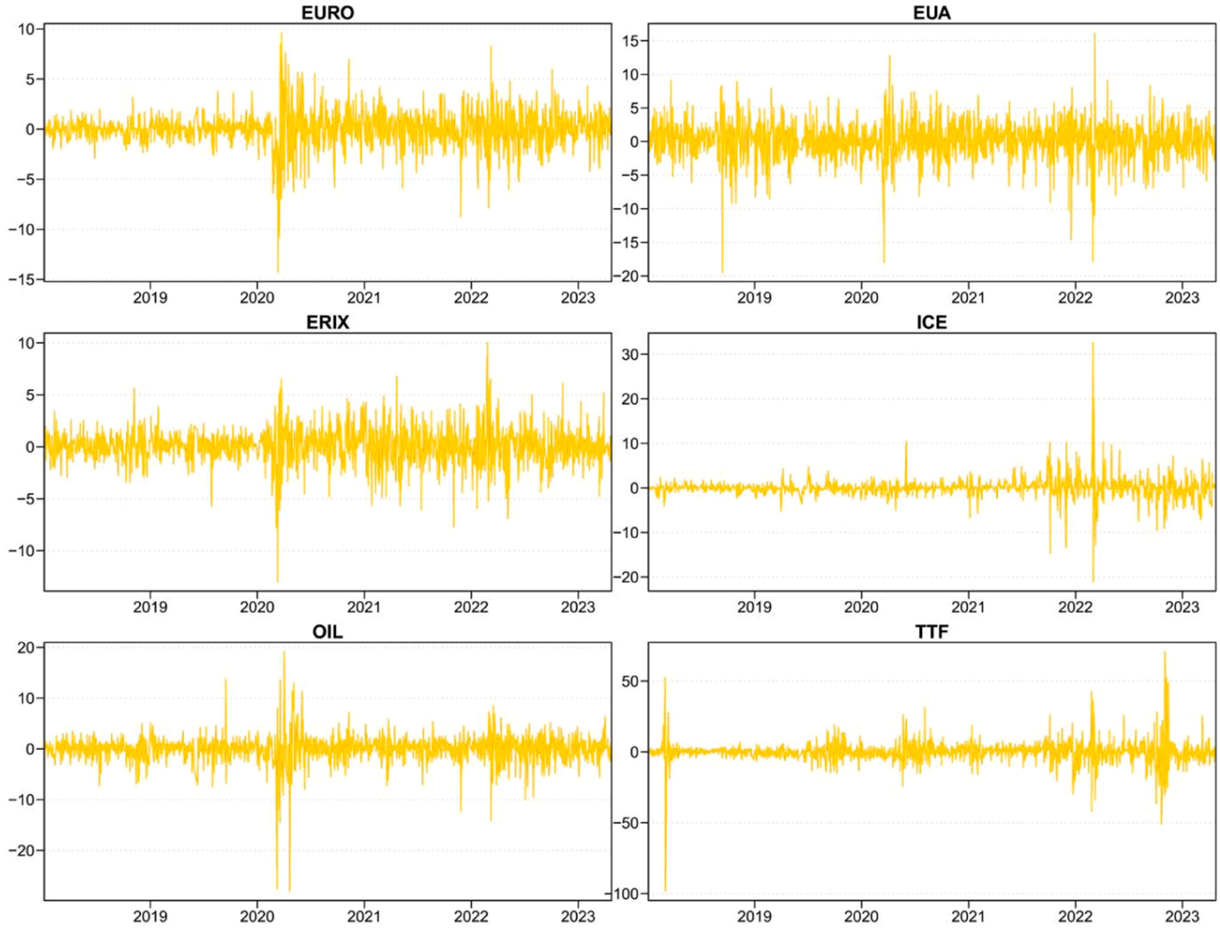

Fig. 1. Return Plot of Each Index.

temporal variations across different quartiles.

Panels A and B of Fig. 2 show that during upper and median market conditions, the tourism sector consistently acted as a net recipient of volatility from EU energy and carbon markets. Under bear market conditions, the tourism sector transformed into a volatility transmitter to EU energy and carbon indices. Bear markets reduce consumer travel propensity, leading to decreased tourism activity and subsequent reductions in energy demand and carbon emissions. The influence of EU energy and carbon markets on the tourism sector varies asymmetrically: weakening during bear markets while strengthening in bull markets.

Fig. 3 presents a time-varying quantile connectedness heat map between tourism and energy market volatility. The vertical axis displays 91 quantile levels (5–95 %), with darker shading indicating stronger connectedness. The heat map visualizes temporal and quantile-level variations in connectedness between European tourism and energy indices. Market connectedness exhibits maximum strength during upward market conditions (q=0.95). Following the Russia-Ukraine conflict in early 2022, total connectedness intensified across all quartiles, persisting through mid-2022 amid unprecedented challenges in Europe’s energy system. The subsequent implementation of the ’RePower EU’ energy transition program contributed to normalizing connectedness levels (Lambert et al., 2022).

Firstly, Fig. 4 reveals that time-varying net connectedness patterns vary across variables and market conditions, with no persistent dominant contributor. Market instability, particularly during the 2022 Russia-Ukraine conflict, significantly influences net connectedness patterns. TTF connectedness intensified across all market conditions from mid-2022, evidenced by prominent red vertical bands in the heat map. This intensification reflects European gas market supply constraints following sanctions against Russia during the 2022 conflict.

ERIX exhibits concentrated periods of net connectedness transmission. ERIX’s net contribution increased substantially from Q1 to mid-2020. This pattern reflects both COVID-19 impacts (Zeng et al., 2022) and the historic transition to renewable energy consumption surpassing coal in May 2020 (Lahiani et al., 2021). ERIX demonstrates high quantile sensitivity, particularly in upside and normal market conditions. These results partially align with Khalfaoui et al. (2022).

ICE exhibits selective sensitivity to upper quartile movements and cyclical patterns. ICE functions as a periodic net transmitter during bull markets, a characteristic unique to this market condition. The heat map’s warm tones indicate OIL’s role as a risk

Table 2
Quantile VAR-based risk connectedness.

Panel A. Upper Quantile (q=0.95)							
	EURO	EUA	ERIX	ICE	Oil	TTF	From
EURO	14.12	17.29	15.30	21.30	12.96	19.03	85.88
EUA	12.15	18.55	14.41	20.95	12.29	21.65	81.45
ERIX	12.11	17.00	16.36	22.38	11.64	20.51	83.64
ICE	11.92	16.14	14.18	24.49	11.37	21.91	75.51
Oil	12.40	15.58	14.71	20.79	16.67	19.86	83.33
TTF	11.52	16.38	13.28	21.96	10.83	26.02	73.98
To	60.10	82.39	71.88	107.38	59.08	102.96	483.79
NET	−25.78	0.94	−11.76	31.87	−24.25	28.98	TCI=*80.63 %*
NPDC	0.00	3.00	2.00	5.00	1.00	4.00	
Panel B. Medium Quantile (q=0.5)							
	EURO	EUA	ERIX	ICE	Oil	TTF	From
EURO	67.63	4.63	9.98	3.84	10.29	3.63	32.37
EUA	4.78	79.62	3.15	3.72	3.05	5.68	20.38
ERIX	4.39	2.33	80.80	4.44	3.31	4.73	19.20
ICE	1.50	2.55	2.91	83.70	2.98	6.35	16.30
Oil	9.24	2.77	3.08	3.02	78.62	3.26	21.38
TTF	2.64	5.16	2.60	8.05	1.95	79.61	20.39
To	22.54	17.43	21.73	23.07	21.58	23.66	130.01
NET	−9.82	−2.95	2.53	6.78	0.20	3.27	TCI=*21.67 %*
NPDC	1.00	0.00	2.00	5.00	3.00	4.00	
Panel C. Lower Quantile (q=0.05)							
	EURO	EUA	ERIX	ICE	Oil	TTF	From
EURO	66.37	7.63	6.80	3.30	11.22	4.68	33.63
EUA	8.07	69.89	4.91	4.91	5.53	6.69	30.11
ERIX	7.09	5.15	74.59	3.99	4.18	4.99	25.41
ICE	3.58	5.08	3.88	74.60	4.26	8.59	25.40
Oil	11.40	5.53	3.88	3.98	71.39	3.83	28.61
TTF	4.60	6.59	4.53	8.54	3.53	72.21	29.79
To	34.73	29.98	24.00	24.72	28.72	28.79	107.95
NET	1.10	−0.13	−1.41	−0.68	0.12	1.00	TCI=*28.49 %*
NPDC	4.00	2.00	0.00	1.00	3.00	5.00	

Notes: Table 2 is based on a quantile VAR function with a 100-day rolling window, and lag length of order 1 (BIC) and10-step-ahead forecast horizon.

transmitter during bullish and normal market conditions from late 2019 through H2 2020, with additional transmission effects in early 2022’s bull market.

EUA displays pronounced net risk connectedness during upside and median market periods, though its transmission mechanisms vary temporally. EUA transformed into a significant net recipient in the upper quartile during early 2021, coinciding with stricter EU carbon controls implemented in April 2021, including a 2.2 % reduction in annual allowances and the suspension of CDM emission reduction credits.[2]

Analysis of EURO’s net connectedness dynamics reveals significant temporal patterns. Fig. 4 demonstrates EURO’s significant net risk absorption in upper and middle quartiles. This pattern peaked in mid-2020, driven by COVID-19-related travel restrictions and embargo measures. From 2022, EURO resumed its position as a net risk recipient in the upper quartile. EU sanctions against Russia restricted energy imports, triggering energy price spikes and inflation, which increased economic uncertainty (Mensi et al., 2023) and impeded tourism sector growth, reinforcing EURO’s position as a net risk recipient. Major shifts in connectedness patterns typically stem from crisis-induced shocks (Umar et al., 2021). Crisis periods prompt investors to seek alternative risk-hedging assets.

To establish causality beyond connectedness measures, this study employs quantile Granger causality to analysis relationships between the European Tourism Index and Energy and Carbon Markets. Table 3 reveals significant Granger causality between the Tourism sector and Energy and Carbon Markets across all quantiles, aligning with the connectedness analysis. Fluctuations in Energy and Carbon indices demonstrate predictive power for Tourism Index movements across various market conditions. These causal relationships confirm the robust interconnectedness between European Tourism and Energy-Carbon markets, validating our empirical findings.

4.1. Sensitivity analysis and further tests

The study tests the robustness of quantile connectedness results using alternative daily rolling windows. Fig. 5 presents robustness test results based on a 150-day rolling window and 10-day prediction horizon. Comparison between Figs. 3 and 5 demonstrates that dynamic total connectedness patterns across quartiles remain consistent despite varying rolling window specifications. These results confirm the reliability of our primary findings in modeling connectedness magnitude and direction across both extreme tail events and

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[2] https://ec.europa.eu/commission/presscorner/detail/en/qanda_23_4756.

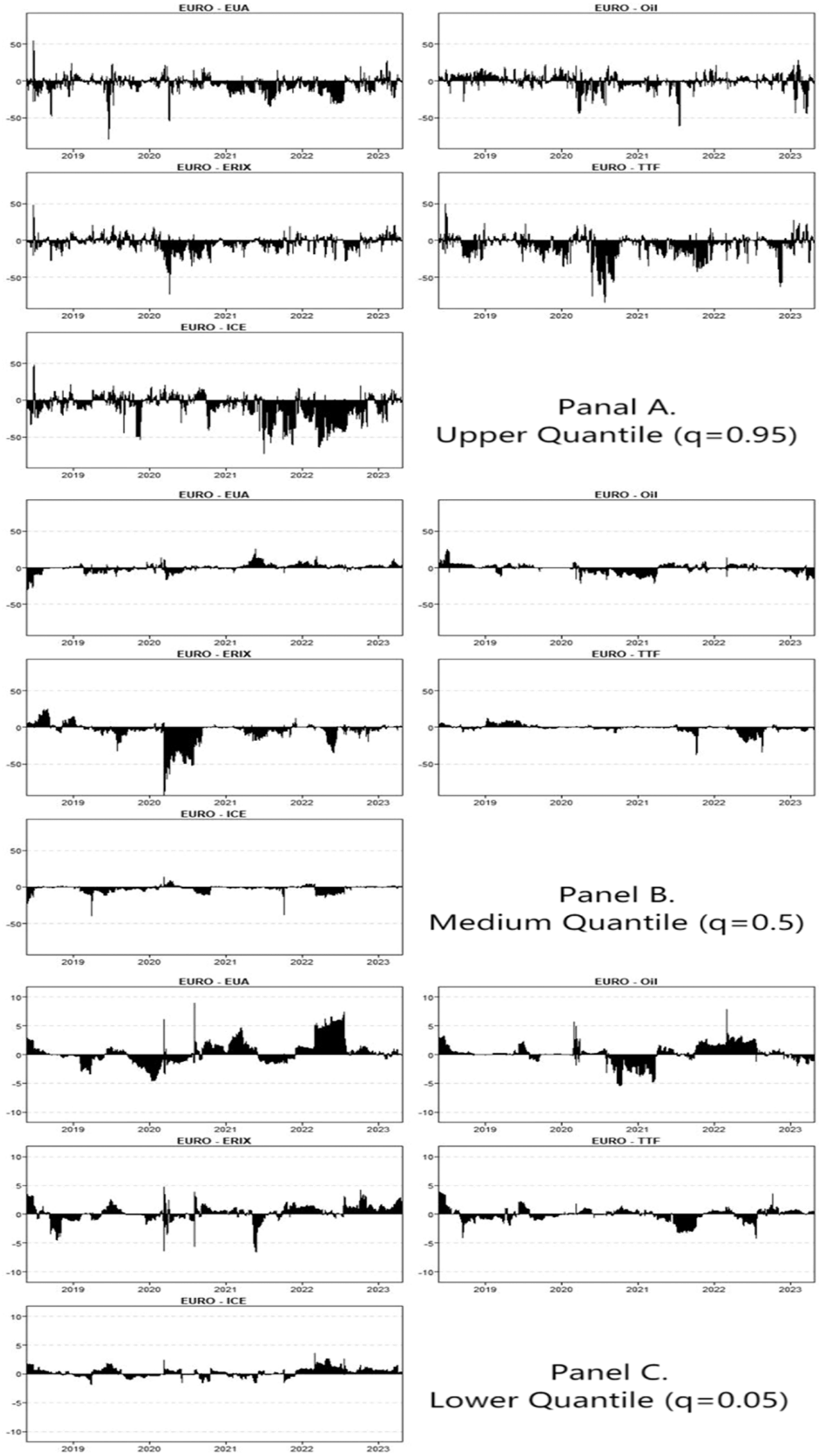

Fig. 2. Net dynamic direction Connectedness among the European Tourism Sector Index and other Market. Notes: The result estimation is based on a quantile VAR function with a 100-day rolling window, lag length of order 1 (BIC) and 10-step-ahead forecast horizon.

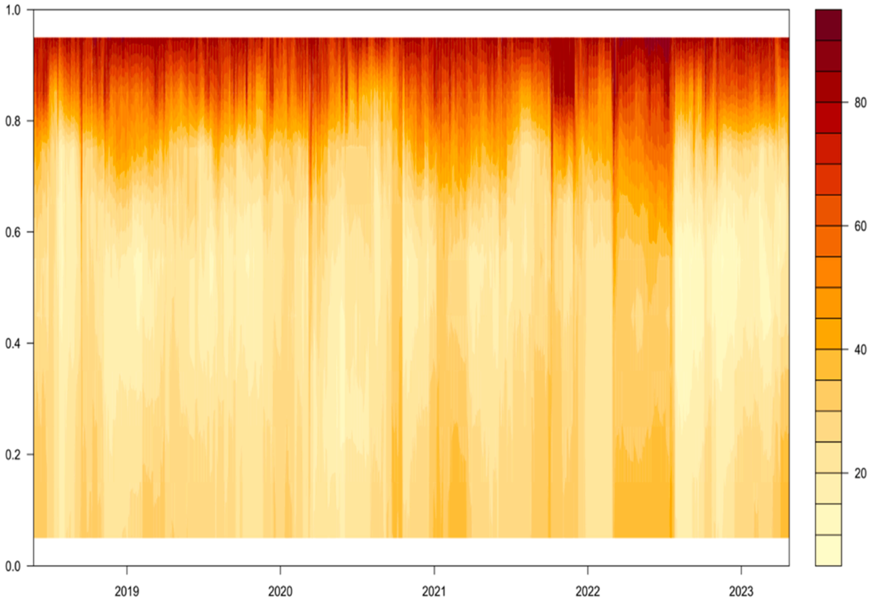

Fig. 3. Heatmap of dynamic total quantile connectedness. Notes: The result estimation based on a quantile VAR function with a 100-day rolling window, and lag length of order 1 (BIC) and10-step-ahead forecast horizon (Mensi et al., 2022).

normal market conditions.

5. Conclusions and policy implications

This study examines risk connectedness between the European Travel & Leisure sector index and energy and carbon emissions markets from January 2018 through April 2023. The analysis incorporates the STOXX Europe 600 Travel and Leisure index alongside major energy and carbon markets: Rotterdam Coal Futures (ICE), Brent Crude Oil Futures (Oil), Dutch TTF Natural Gas Futures (TTF), European Renewable Energy Total Return (ERIX), and European Union Allowance (EUA).

Using QVAR methodology, this research investigates risk linkages between tourism and energy-carbon markets across extreme tail and normal market conditions. Results reveal quantile-asymmetric connectedness between energy and tourism sectors, with peak connectivity occurring in extreme tail conditions, especially during bullish markets ($q=0.95$). Time-varying pairwise connectedness analysis reveals asymmetric influence patterns: energy and carbon markets exhibit stronger impact on tourism during bull markets compared to bear markets. Net connectedness patterns vary across variables, market conditions, and time periods, with heightened sensitivity during crisis periods. Quantile-based Granger causality tests confirm robust causal relationships between energy-carbon indices and tourism sector risks across all quantiles.

Given increasing global market uncertainty, this research provides insights for market participants considering climate-adaptive energy investments and strategies for enhancing financial stability and returns. The following section details the implications of these findings.

Based on our findings, we introduce the following policy recommendations: 1). Dynamic Risk Management Policies: Policymakers must pay much attention to the network framework and dynamics of shock connectedness among the concerned indices. Indeed, policymakers should understand the pathways of net risk connectedness and the direction and magnitude of risk connectedness. They should therefore intervene appropriately by developing regulatory policies in times of extreme market upswings or calm markets. Specifically, given the asymmetric connectedness found in our study, policymakers should design flexible regulatory frameworks that can adapt to different market conditions, with more stringent measures during bullish markets when connectedness is higher. 2). Tail Risk Management: Our results are also informative for policymakers and investors, who need to understand the dynamics and level of connectedness in different tails for better decision making. This will help them understand how tail risks propagate through the system. We suggest developing and implementing tail risk management strategies, to better capture and mitigate extreme risks in both the tourism and energy sectors. 3). Portfolio Diversification Strategies: Analysts for investors should consider closely examining the dynamics of net directional connectedness among indices. This can be done by distinguishing among net contributors and/or net receivers of risk connectedness, fully considering the possible impact of other markets on their own portfolios and adjusting their positions and risk expectations to changing market conditions. This has a bearing on portfolio returns stability in times of extreme risk and on risk management efficiency. We recommend that investors adopt dynamic asset allocation strategies that account for the varying connectedness between the tourism and energy sectors across different market conditions. 4). Sustainable Tourism Development: For policy makers, this timely analysis provides valuable new insights and recommendations for policymakers and regulators in the tourism sector. This will enable them to adopt existing policies to control or reduce tourism's negative impact on energy markets

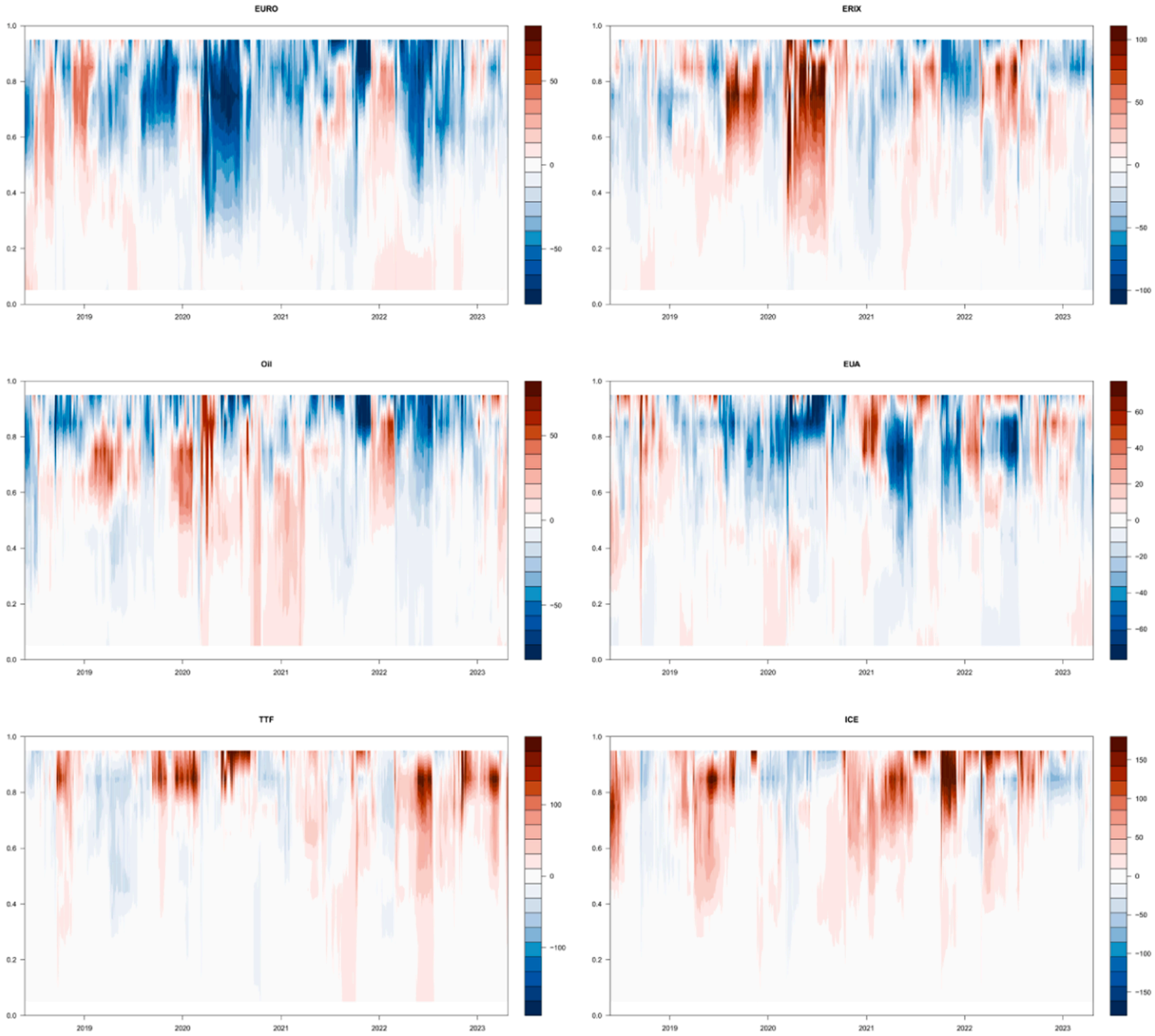

Fig. 4. Heatmap of NET quantile and dynamic connectedness of all indices. *Notes*: The result estimation based on a quantile VAR function with a 100-day rolling window, and lag length of order 1 (BIC) and10-step-ahead forecast horizon.

Table 3
Findings for Granger-causality in quantiles between the European Tourism Sector and European Energy with Carbon Emissions Market.

	To EURO *From*				
τ	*EUA*	*ERIX*	*ICE*	*Oil*	*TTF*
All	0.001 * **	0.001 * **	0.001 * **	0.001 * **	0.001 * **
0.05	0.001 * **	0.001 * **	0.001 * **	0.001 * **	0.001 * **
0.10	0.001 * **	0.001 * **	0.001 * **	0.001 * **	0.001 * **
0.25	0.001 * **	0.001 * **	0.001 * **	0.001 * **	0.001 * **
0.50	0.001 * **	0.001 * **	0.001 * **	0.001 * **	0.001 * **
0.75	0.001 * **	0.001 * **	0.001 * **	0.001 * **	0.001 * **
0.90	0.001 * **	0.001 * **	0.001 * **	0.001 * **	0.001 * **
0.95	0.001 * **	0.001 * **	0.001 * **	0.001 * **	0.001 * **

Note: Table 3 presented *p*-values for the Granger causality check, spanning from 0.05 to 0.95, in line with Zeng et al. (2024). We adopted the QAR(1) specification while testing the null hypothesis of Granger non-causality. The subsample comprised 89 observations. The symbols * , * *, and * ** indicated the 10 %, 5 %, and 1 % significance levels, respectively.

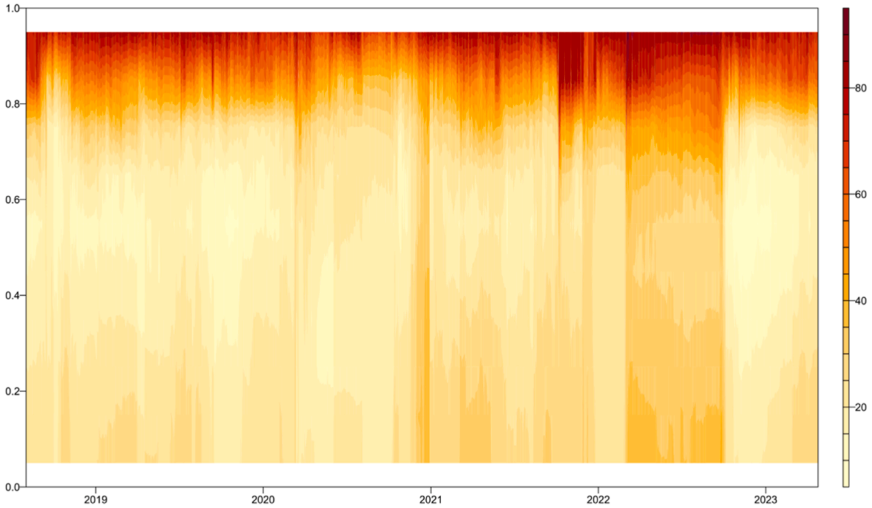

Fig. 5. Sensitivity Check for dynamic total quantile connectedness. *Notes*: The result estimation based on a quantile VAR function with a 100-day rolling window, and lag length of order 1 (BIC) and10-step-ahead forecast horizon.

under different market conditions. As energy is closely linked to tourism, this will also contribute to tourism's sustainable development and ensure a stable and resilient tourism market. We propose implementing incentive schemes for the adoption of renewable energy sources in the tourism sector, which could help mitigate the sector's vulnerability to energy price fluctuations and contribute to environmental sustainability. 5). Cross-Sector Coordination: Given the strong causal connection between energy and carbon indices and the tourism sector, we recommend establishing a cross-sector coordination mechanism. This would facilitate information sharing and coordinated policy responses between energy regulators and tourism authorities, ensuring a more holistic approach to managing the interconnected risks in these sectors. 6). Investment in Climate-Adaptive Infrastructure: In light of the significant impact of energy markets on the tourism sector, especially during bull markets, we recommend increasing investments in climate-adaptive and energy-efficient infrastructure in the tourism industry. This could help reduce the sector's vulnerability to energy price fluctuations and contribute to long-term sustainability.

Despite the empirical and practical contributions of our study, there are some issues to address in future work. Firstly, the coverage could be extended by studying energy and tourism indices in other countries, or even the influence of energy on tourism markets among different countries, such as Asia or North America; and secondly, other frameworks, such as quantile-to-quantile regressions, could be further used to offer more comprehensive insights of the quantile connections of variables.

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CRediT authorship contribution statement

Hongjun Zeng: Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Mohammad Zoynul Abedin:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Investigation, Conceptualization. **Abdullahi D. Ahmed:** Writing – review & editing, Visualization, Validation, Supervision. **Qingcheng Huang:** Writing – original draft, Supervision, Software, Project administration, Investigation.

Declaration of Competing Interest

There is no competing interest among the authors.

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Consent for publication

All authors are very positive to publish this manuscript on this journal.

Data availability

Data will be made available on request.

References

Adekoya, O.B., Oliyide, J.A., Noman, A., 2021. The volatility connectedness of the EU carbon market with commodity and financial markets in time-and frequency-domain: the role of the US economic policy uncertainty. Resour. Policy 74, 102252.

Adi, T.W., 2023. Influence of fuel price, electricity price, fuel consumption on operating cost, generation and operating income: a case study on PLN. Int. J. Energy Sect. Manag. 17 (2), 227–250.

Ando, T., Greenwood-Nimmo, M., Shin, Y., 2022. Quantile connectedness: modeling tail behavior in the topology of financial networks. Manag. Sci. 68 (4), 2401–2431.

Asl, M.G., Adekoya, O.B., Oliyide, J.A., 2022. Carbon market and the conventional and Islamic equity markets: where lays the environmental cleanliness of their utilities, energy, and ESG sectoral stocks? J. Clean. Prod. 351, 131523.

Balcilar, M., Gupta, R., Pierdzioch, C., 2016. Does uncertainty move the gold price? New evidence from a nonparametric causality-in-quantiles test. Resour. Policy 49, 74–80.

Banerjee, A.K., Sensoy, A., Goodell, J.W., 2024. Connectivity and spillover during crises: highlighting the prominent and growing role of green energy. Energy Econ. 129, 107224.

Billah, M., Karim, S., Naeem, M.A., Vigne, S.A., 2022. Return and volatility spillovers among energy and BRIC markets: evidence from quantile connectedness. Res. Int. Bus. Financ. 62, 101680.

Bouteska, A., Hajek, P., Fisher, B., Abedin, M.Z., 2023. Nonlinearity in forecasting energy commodity prices: evidence from a focused time-delayed neural network. Res. Int. Bus. Financ. 64, 101863.

Bouteska, A., Sharif, T., Abedin, M.Z., 2024. Does stock return affect decomposed energy shocks differently? Evidence from a time frequency quantile-based framework. Int. Rev. Financ. Anal., 103128

Cao, G., Xie, F., 2023. Extreme risk spillovers across energy and carbon markets: evidence from the quantile extended joint connectedness approach. Int. J. Financ. Econ.

Chai, S., Chu, W., Zhang, Z., Li, Z., Abedin, M.Z., 2022. Dynamic nonlinear connectedness between the green bonds, clean energy, and stock price: the impact of the COVID-19 pandemic. Ann. Oper. Res. https://doi.org/10.1007/s10479-021-04452-y.

Chatziantoniou, I., Abakah, E.J.A., Gabauer, D., Tiwari, A.K., 2022. Quantile time–frequency price connectedness among green bond, green equity, sustainable investments and clean energy markets. J. Clean. Prod. 361, 132088.

Dhifqaui, Z., Khalfqoui, R., Abedin, M.Z., Shi, B., 2022. Quantifying information transfer among clean energy, carbon, oil, and precious metals: a novel transfer entropy-based approach. Financ. Res. Lett. 49, 103138.

Erdoğan, S., Gedikli, A., Cevik, E.I., Erdoğan, F., 2022. Eco-friendly technologies, international tourism and carbon emissions: evidence from the most visited countries. Technol. Forecast. Soc. Change 180, 121705.

Fasanya, I., Oyewole, O., 2023. Dynamic spillovers among precious metals and travel & tourism stocks in South-East Asia: do infectious disease outbreaks matter? Econ. Res. Èkon. Istraživanja 36 (1), 2166968.

Goodell, J.W., Yadav, M.P., Ruan, J., Abedin, M.Z., Malhotra, N., 2023. Traditional assets, digital assets and renewable energy: investigating connectedness during COVID-19 and the Russia-Ukraine war. Financ. Res. Lett. 58 (A)), 104323.

Ha, L.T., Bouteska, A., Sharif, T., Abedin, M.Z., 2024. Dynamic interlinkages between carbon risk and volatility of green and renewable energy: a TVP-VAR analysis. Res. Int. Bus. Financ. 69, 102278.

Hou, Y.G., Xu, D., Oxley, L., Goodell, J.W., 2024. Price discovery of climate risk and green bonds: a dynamic information leadership share approach. Financ. Res. Lett. 69, 106098.

Jeong, K., Härdle, W.K., Song, S., 2012. A consistent nonparametric test for causality in quantile. Econom. Theory 28 (4), 861–887.

Khalfaoui, R., Jabeur, S.B., Dogan, B., 2022. The spillover effects and connectedness among green commodities, Bitcoins, and US stock markets: Evidence from the quantile VAR network. Journal of environmental manag. 306, 114493.

Khalid, U., Okafor, L.E., Burzynska, K., 2021. Does the size of the tourism sector influence the economic policy response to the COVID-19 pandemic? Curr. Issues Tour. 24 (19), 2801–2820.

Khan, N., Hassan, A.U., Fahad, S., Naushad, M.(2020). Factors affecting tourism industry and its impacts on global economy of the world. Available at SSRN 3559353..

Klotz, P., Lin, T.C., Hsu, S.H., 2014. Global commodity prices, economic activity and monetary policy: the relevance of China. Resour. Policy 42, 1–9.

Koop, G., Pesaran, M.H., Potter, S.M., 1996. Impulse response analysis in nonlinear multivariate models. J. Econom. 74 (1), 119–147.

Lahiani, A., Mefteh-Wali, S., Shahbaz, M., Vo, X.V., 2021. Does financial development influence renewable energy consumption to achieve carbon neutrality in the USA? Energy Policy 158, 112524.

Lambert, L.A., Tayah, J., Lee-Schmid, C., Abdalla, M., Abdallah, I., Ali, A.H., Ahmed, W., 2022. The EU's natural gas Cold War and diversification challenges. Energy Strategy Rev. 43, 100934.

Le, T.H., 2023. Quantile time-frequency connectedness between cryptocurrency volatility and renewable energy volatility during the COVID-19 pandemic and Ukraine-Russia conflicts. Renew. Energy 202, 613–625.

Li, Z.Z., Li, Y., Huang, C.Y., Peculea, A.D., 2023. Volatility spillover across Chinese carbon markets: evidence from quantile connectedness method. Energy Econ. 119, 106542.

Lorente, D.B., Mohammed, K.S., Cifuentes-Faura, J., Shahzad, U., 2023. Dynamic connectedness among climate change index, green financial assets and renewable energy markets: novel evidence from sustainable development perspective. Renew. Energy 204, 94–105.

Lovcha, Y., Perez-Laborda, A., Sikora, I., 2022. The determinants of CO2 prices in the EU emission trading system. Appl. Energy 305, 117903.

Lu, R., Xu, W., Zeng, H., Zhou, X., 2023. Volatility connectedness among the Indian equity and major commodity markets under the COVID-19 scenario. Econ. Anal. Policy 78, 1465–1481.

Madani, A., Boutebal, S.E., Benhamida, H., Bryant, C.R., 2020. The impact of Covid-19 outbreak on the tourism needs of the Algerian population. Sustainability 12 (21), 8856.

Manzoor, F., Wei, L., Asif, M., Haq, M.Z.U., Rehman, H.U., 2019. The contribution of sustainable tourism to economic growth and employment in Pakistan. Int. J. Environ. Res. Public Health 16 (19), 3785.

Mao, Y., He, J., Morrison, A.M., Andres Coca-Stefaniak, J., 2021. Effects of tourism CSR on employee psychological capital in the COVID-19 crisis: from the perspective of conservation of resources theory. Curr. Issues Tour. 24 (19), 2716–2734.

Mensi, W., Gubareva, M., Ko, H.U., Vo, X.V., Kang, S.H., 2023. Tail spillover effects among cryptocurrencies and uncertainty in the gold, oil, and stock markets. Financ. Innov. 9 (1), 1–27.

Mensi, W., Nekhili, R., Kang, S.R., 2022. Quantile connectedness and spillovers analysis between oil and international REIT markets. Fin. Res. Lett. 48, 102895.

Min, H., 2022. Examining the impact of energy price volatility on commodity prices from energy supply chain perspectives. Energies 15 (21), 7957.

Ozturk, I., Sharif, A., Godil, D.I., Yousuf, A., Tahir, I., 2023. The dynamic nexus between international tourism and environmental degradation in top twenty tourist destinations: new insights from quantile-on-quantile approach. Eval. Rev. 47 (3), 532–562.

Pesaran, H.H., Shin, Y., 1998. Generalized impulse response analysis in linear multivariate models. Econ. lett. 58 (1), 17–29.

Qi, H., Wu, T., Chen, H., Lu, X., 2023. Time-frequency connectedness and cross-quantile dependence between carbon emission trading and commodity markets: evidence from China. Resour. Policy 82, 103418.

Qin, Y., Chen, J., Dong, X., 2021. Oil prices, policy uncertainty and travel and leisure stocks in China. Energy Econ. 96, 105112.

Ren, X., Li, Y., Wen, F., Lu, Z., 2022. The interrelationship among the carbon market and the green bonds market: evidence from wavelet quantile-on-quantile method. Technol. Forecast. Soc. Change 179, 121611.

Sadiq, M., Amayri, M.A., Paramaiah, C., Mai, N.H., Ngo, T.Q., Phan, T.T.H., 2022. How green finance and financial development promote green economic growth: deployment of clean energy sources in South Asia. Environ. Sci. Pollut. Res. 29 (43), 65521–65534.

Shahbaz, M., Topcu, B.A., Sarıgül, S.S., Vo, X.V., 2021. The effect of financial development on renewable energy demand: the case of developing countries. Renew. Energy 178, 1370–1380.

Su, C.W., Pang, L.D., Qin, M., Lobonţ, O.R., Umar, M., 2023. The spillover effects among fossil fuel, renewables and carbon markets: evidence under the dual dilemma of climate change and energy crises. Energy 274, 127304.

Tiwari, A.K., Abakah, E.J.A., Rehman, M.Z., Lee, C.C., 2023. Quantile dependence of Bitcoin with clean and renewable energy stocks: new global evidence. Appl. Econ. 1–15.

Umar, Z., Adekoya, O.B., Oliyide, J.A., Gubareva, M., 2021. Media sentiment and short stocks performance during a systemic crisis. Int. Rev. Financ. Anal. 78, 101896.

Waheed, R., Sarwar, S., Dignah, A., 2020. The role of non-oil exports, tourism and renewable energy to achieve sustainable economic growth: what we learn from the experience of Saudi Arabia. Struct. Change Econ. Dyn. 55, 49–58.

Wang, Y., Liu, S., Abedin, M.Z., Lucey, B., 2024. Volatility spillover and hedging strategies among Chinese carbon, energy, and electricity markets. J. Int. Financ. Mark. Inst. Money 91, 101938.

Yadav, M.P., Sharif, T., Ashok, S., Dhingra, D., Abedin, M.Z., 2023. Investigating volatility spillover of energy commodities in the context of the Chinese and European stock markets. Res. Int. Bus. Financ. 65, 101948.

Yoon, S.M., 2022. On the interdependence among biofuel, fossil fuel and agricultural food prices: evidence from quantile tests. Renew. Energy 199, 536–545.

Yousaf, I., Abrar, A., Goodell, J.W., 2023. Connectedness among travel & tourism tokens, tourism equity, and other assets. Financ. Res. Lett. 53, 103595.

Zeng, H., 2024. Risk transmission and diversification strategies between US real estate investment trusts (REITs) and green finance indices. Kybernetes.

Zeng, H., Abedin, M.Z., Ahmed, A.D., 2024. Quartile risk dependence between clean energy markets and the US travel and leisure index. Curr. Issues Tour. 1–25.

Zeng, H., Abedin, M.Z., Zhou, X., Lu, R., 2024. Measuring the extreme linkages and time-frequency co-movements among artificial intelligence and clean energy indices. Int. Rev. Financ. Anal. 92, 103073.

Zeng, H., Ahmed, A.D., Lu, R., Dai, N., 2022. Dependence and spillover among oil market, China's stock market and exchange rate: new evidence from the Vine-Copula-CoVaR and VAR-BEKK-GARCH frameworks. Heliyon 8 (11).

Zeng, H., Ahmed, A.D., 2023. Market integration and volatility spillover across major East Asian stock and bitcoin markets: an empirical assessment. Int. J. Manag. Financ. 19 (4), 772–802.

Zeng, H., Huang, Q., Abedin, M.Z., Ahmed, A.D., Lucey, B., 2025. Connectedness and frequency connection among green bond, cryptocurrency and green energy-related metals around the COVID-19 outbreak. Res. Int. Bus. Financ. 73, 102547.

Zeng, H., Lu, R., Ahmed, A.D., 2023. Return connectedness and multiscale spillovers across clean energy indices and grain commodity markets around COVID-19 crisis. J. Environ. Manag. 340, 117912.

Zhao, X., Meo, M.S., Ibrahim, T.O., Aziz, N., Nathaniel, S.P., 2023. Impact of economic policy uncertainty and pandemic uncertainty on international tourism: what do we learn from COVID-19? Eval. Rev. 47 (2), 320–349.