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From pandemic turbulence to recovery: a dynamic assessment of return and volatility spillovers in tourism finance

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Abstract

This study investigates the return and volatility connectedness among major tourism stock indices and risk-related indices during the pre-COVID-19, COVID-19, and post-COVID-19 periods using a time-varying parameter vector autoregression (TVP-VAR) model. Specifically, a connectedness network is built for each period to compare the nature of connectedness over the three examined periods. The findings reveal significant temporal variations in connectedness, with moderate levels before the pandemic, a sharp surge during COVID-19 driven by increased uncertainty, and partial normalization afterward. While volatility connectedness declines more noticeably in the recovery, return spillovers remain persistently high. Notably, global and American tourism indices are consistent return transmitters, whereas systemic risk measures play a larger role in volatility transmission. Importantly, American tourism stocks are intertwined with global tourism stocks, exhibiting synchronized movement over the periods. These findings highlight how global shocks reshape the transmission of risks in the tourism sector and underscore the need for strategies that address both short-term market reactions and longer-term uncertainty.

Keywords: Tourism, Risk-related indices, Return connectedness, Volatility spillover, TVP-VAR, COVID-19

JEL Classifications: Z30, C22, C53

Introduction

The tourism and travel (T&L) industry is widely regarded as a key driver of the global economy. According to the World Travel and Tourism Council (WTTC), the sector contributes approximately 9.1% to global GDP in 2023, supporting 330 million jobs worldwide. Paramati et al. (2017), using data from 22 developed and developing economies, find that tourism in general has a positive impact on the growth of the economy in the sampled countries. Given its vital economic importance, the dynamics and behavior of the T&L industry have received significant attention from policymakers, practitioners, and researchers.

As a provider of luxury goods, the T&L industry is particularly fragile and economically vulnerable to external shocks, such as natural disasters, geopolitical risks,

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economic policy uncertainty, and oil price shocks (i.e., Ioannides and Apostolopoulos 1999; Kim and Marcouiller 2015; Seraphin 2017; Qin et al. 2021, Kumar 2023; Liu et al. 2024). These shocks impose significant disruptions on travel plans, adversely impacting consumer behavior and potentially exposing T&L firms to higher production and operational costs.

Under conditions of heightened uncertainty regarding expected utility, consumers tend to reallocate their spending from luxury and nonessential goods toward essential goods. From an economic perspective, as a precautionary measure, consumers often reduce discretionary expenditures, including tourism, during periods of elevated uncertainty (see Kim et al. 2012; Wu and Zhao 2022). Indeed, prior research has identified various sources of uncertainty, such as political instability and violence, health crises, and economic volatility, as significant factors contributing to declines in tourism demand (see Gozgor and Ongan 2017; Madanoglu and Ozdemir 2019; Nguyen et al. 2020; Barbhuiya and Chatterjee 2020; Demir et al. 2020; Aharon 2022; Apergis et al. 2023). The common nature of these disruptive events is that they all affect the demand for tourism by increasing uncertainty and fear among consumers. The resultant decline in demand is expected to reduce company revenues and cash flows within the T&L industry, which in turn leads to downward pressure on stock prices. For instance, a shock to oil prices could increase operational expenses, thereby reducing overall cash flow. A reduction in cash flow would subsequently lead to a drop in stock prices and returns for companies within the T&L sector. A second transmission channel is that external uncertainty increases firms' risk profiles and thus raises the required discount rate. Specifically, higher risk perception by investors in the stock market may prompt them to require higher rates of return, which would lower stock prices. According to the DCF framework, if investors require a higher discount rate, *ceteris paribus*, they will pay a lower price for the stock. Last, the behavioral finance literature indicates that changes in investor sentiment represent a separate effect on the stock market. Dragouni et al. (2016) demonstrate that sentiment transmits shocks to tourism demand. Tourism stocks are particularly vulnerable to mispricing by investors (see Narayan and Sharma 2023). In general, higher uncertainty induces fear among investors, making them more pessimistic about business prospects. This leads to increased connectedness with external shocks, regardless of their underlying economic rationale.

As discussed above, the postponement of tourism demand under adverse economic conditions is likely to negatively impact the revenue streams of the tourism industry. Based on the stock valuation framework, increased uncertainty adversely affects a company's cash flow, reducing expected dividends and, consequently, its stock price. Empirical research has extensively investigated the factors influencing the performance of T&L industry stocks. The existing body of evidence highlights the critical role of various sources of uncertainty as key drivers of fluctuations in T&L stock returns. For instance, studies have emphasized the impact of geopolitical risk (Demiralay and Kilincarslan 2019; Jiang et al. 2022), economic policy uncertainty (Demir and Ersan 2018; Bashir and Kumar 2022), oil price shocks (Qin et al. 2021), and health crises such as the SARS outbreak (Chen et al. 2007) and the COVID-19 pandemic (Wang et al. 2023).

In light of the above discussion, the T&L industry is highly susceptible to various external shocks. However, a review of the literature reveals several gaps and underexplored

areas. Building on the current evidence, this study contributes to the literature by examining the connectedness between regional T&L stock indices and a more comprehensive set of risk-related indicators. Specifically, we investigate the interactions between four regional T&L stock indices, STOXX T&L Global, STOXX North America, STOXX Europe, and STOXX Asia Pacific, and their responses to shocks from oil prices, geopolitical risk, economic policy uncertainty, infectious disease equity market volatility, and financial stress. While some of these shocks, such as oil price volatility, geopolitical risk, and economic policy uncertainty, have been examined individually in previous empirical studies, the evidence from a broader perspective is ignored. To the best of our knowledge, this is the first study to comprehensively analyze the effects of risk and uncertainty on regional T&L stock indices using an extensive set of risk-related indices that consider both return and volatility.

The outbreak of the COVID-19 pandemic has had a profound impact on the tourism industry (Baker et al. 2020; Ozdemir et al. 2022; Liu et al. 2023). A critical aspect of this impact lies in the heightened exposure of the T&L sector to various uncertainties (Bashir and Kumar 2022; Hadi et al. 2022). Empirical studies such as those by Hadi et al. (2022), Shahzad et al. (2022), and Liu et al. (2023) have demonstrated the significant influence of the COVID-19 pandemic on the connectedness structure of tourism stocks. These studies reveal that connectedness within the tourism industry becomes particularly pronounced during the COVID-19 crisis period. Building on this evidence, this study compares the relationships across three distinct periods: pre-COVID-19, during COVID-19, and post-COVID-19. For estimating connectedness across a set of variables, the time-varying parameter vector autoregression (TVP-VAR) framework is employed as a robust method.¹

Our findings demonstrate significant temporal variations in connectedness across the analyzed periods. In the pre-COVID-19 period, connectedness is moderate, and the global and American tourism indices act as dominant transmitters of return. However, the risk-related indices are positioned on the side of the net senders of volatility spillovers. During the COVID-19 period, connectedness peaks for both return and volatility, reflecting extreme market uncertainty. In this phase, the Global and American tourism indices play a pivotal role in transmitting return spillovers, while risk-related indices such as the US Economic Policy Uncertainty (US-EPU), the Financial Stress Index (FSI) and the Infectious Disease Equity Market Volatility Index (IDEMV) critically amplify systemic volatility spillovers. In the post-COVID-19 period, connectedness declines from its peak but remains elevated compared to prepandemic levels. Notably, volatility connectedness declines more considerably in the postcrisis period, whereas return connectedness remains persistently high in this phase. Furthermore, the interconnectivity between American and global tourism stocks becomes particularly evident, as they exhibit synchronized movements across all periods.

These findings underscore the dynamic interdependencies among markets during periods of crisis and subsequent recovery, highlighting the evolving nature of return and volatility transmission and the pivotal role of systemic risks in shaping market behavior.

¹ The TVP-VAR connectedness measure addresses key limitations of the Diebold and Yilmaz (2012) rolling-window VAR model, such as the arbitrary choice of window size, loss of observations, and sensitivity to outliers.

Overall, this study shows that global shocks such as COVID-19 reshape not only the immediate comovement patterns in returns but also the longer-term dynamics of volatility spillovers. The T&L sector's resilience will increasingly depend on its ability to adapt to an environment where high interconnectedness (especially in returns) may persist long after the crisis subsides.

The remainder of the paper is structured as follows: Sect. "[Literature review](#)" provides a comprehensive review of the relevant literature. Sect. "[Methodology](#)" details the methodology employed in the study, while Sect. "[Data and preliminary analysis](#)" describes the data sources and examines preliminary data characteristics. Sect. "[Empirical results](#)" presents the empirical findings, and Sect. "[Summary and conclusion](#)" summarizes and concludes the study with a discussion of key insights and implications.

Literature review

Tourism is generally regarded as a luxury good (Kim et al. 2012), making its demand relatively inelastic and highly sensitive to shocks in discretionary income and purchasing power (Smeral 2003; Kim et al. 2012). Therefore, the tourism industry is inherently fragile and vulnerable to external shocks, including natural disasters, geopolitical risks, economic policy uncertainty, and oil price fluctuations. A substantial body of research confirms the sensitivity of tourism demand to both economic and noneconomic uncertainties. Evidence suggests that tourism demand is cyclical and subject to structural breaks influenced by business cycles and the occurrence of crises (Guizzardi and Mazzocchi 2010; Cró and Martins 2017).

Shocks arising from natural disasters, pandemics, and political turmoil have received considerable attention in the literature. For instance, studies by Kim and Marcouiller (2015), Barbhuiya and Chatterjee (2020), and Rosselló et al. (2020) highlight the devastating effects of natural disasters on tourism demand. Similarly, Polyzos et al. (2021) and Jaipuria et al. (2021) demonstrate that health-related threats, such as pandemics, have a negative impact on global tourist flows. Political troubles and conflicts also exert severe recessionary pressures on the tourism industry. Empirical evidence by Bac et al. (2015), Lanouar and Goaied (2019), and Fourie et al. (2020) underscores the detrimental impact of terrorism and political instability on tourism demand. Recently, the geopolitical risk index (GPR) developed by Caldara and Iacoviello (2022) has been widely utilized to investigate the effects of geopolitical risks on international tourism. Studies such as Tiwari et al. (2019), Akadiri et al. (2020), Demir et al. (2020), and Parray et al. (2024) report a significant negative impact of GPR on tourism demand. Under conditions of heightened geopolitical risk, tourists tend to postpone travel plans, as their sense of security and expected utility is threatened.

Economic policy uncertainty (EPU) also plays a critical role in influencing consumer purchasing power. Research indicates that heightened EPU reduces household consumption (Wu and Zhao 2022). Thus, another strand of the literature has examined how economic uncertainty affects tourism demand. Balli et al. (2018), Demir and Gozgor (2018), and Tiwari et al. (2019) provide evidence that increases in EPU are associated with declines in tourism demand. These findings suggest that heightened economic uncertainty undermines consumer confidence, leading to reduced discretionary spending on tourism. Similarly, oil price volatility has been identified as a determinant of

tourism activity. Studies by Yeoman et al. (2007) and Becken and Lennox (2012) report that increases in oil prices significantly reduce tourism arrivals, underscoring the sensitivity of the sector to changes in energy costs.

The adverse impacts on tourism demand are likely to transmit to the stock market. During periods of heightened uncertainty, firms and households often delay spending and investment, with the T&L industry being a producer of luxury goods among the first and most severely affected sectors. This leads to a decline in expected cash flows for tourism companies, which consequently results in a reduction in their market value (Baker et al. 2016; Dragouni et al. 2016). A body of research has investigated the effects of various uncertainties on the returns of T&L stocks. Several studies have focused on the role of geopolitical risk (GPR) as a determinant of T&L stock performance. For instance, Demiralay and Kilincarslan (2019), Hasan et al. (2020), Jiang et al. (2022), and Raheem and le Roux (2023) analyze the relationship between GPR and T&L stock returns. Demiralay and Kilincarslan (2019) examine the impact of GPR on four regional T&L stock indices: Global, Asia–Pacific, Europe, and North America. Using quantile regression, they find that GPR negatively affects T&L indices at lower quantiles, particularly when the industry underperforms, with the exception of the Asia–Pacific region. Similarly, Jiang et al. (2022) document a negative relationship between GPR and T&L stock returns in the Chinese market, observing a stronger association at lower quantiles. Employing the nonparametric causality-in-quantiles (CiQ) approach, Hasan et al. (2020) and Raheem and le Roux (2023) investigate the impact of GPR on emerging market T&L stocks. Their findings indicate that GPR is a significant predictor of T&L stock returns; however, the effect is not consistent across all countries.

The impact of economic policy uncertainty (EPU) on tourism demand has further extended to the stock market. Empirical evidence demonstrates that shocks to EPU prompt consumers to postpone consumption (Al-Thaqeb et al. 2022; Wu and Zhao 2022). Dragouni et al. (2016) argue that increases in EPU weaken consumers' economic confidence, leading to reduced consumption, particularly for nonessential goods such as tourism. Consistent with this projection, several studies provide robust evidence of the negative effects of EPU on travel and leisure (T&L) stock performance (Demir and Ersan 2018; Ersan et al. 2019; Qin et al. 2021; Bashir and Kumar 2022; Jiang et al. 2022; Hadi et al. 2023). For instance, Demir and Ersan (2018) report a negative association between EPU and Turkish T&L stocks. Similarly, Ersan et al. (2019) examine the STOXX Europe 600 T&L price index and demonstrate that EPU exerts a negative effect on its returns, with the impact being stronger in the lower quantiles. Extending this evidence, Bashir and Kumar (2022) investigate the global effect of EPU on T&L stocks across the Asia–Pacific region, North America, and Europe, reporting a negative association that was further exacerbated by the COVID-19 pandemic. Considering the dynamic nature of this relationship, Hadi et al. (2023) employ a time-varying parameter vector autoregressive (TVP-VAR) model to analyze U.S. tourism stocks, confirming a persistent negative relationship with EPU.

In the context of the Chinese market, the findings are less conclusive. Qin et al. (2021) utilize a TVP-VAR framework to examine Chinese T&L stocks and find that the effect of EPU fluctuates between positive and negative. Jiang et al. (2022), using quantile regression, also confirm the dual nature of EPU's impact on Chinese T&L stocks, with both

positive and negative effects observed depending on market conditions. Moreover, health-based uncertainty has been shown to significantly affect T&L stock performance. Empirical studies by Shahzad et al. (2022), Lee and Chen (2022), and Wang et al. (2023) consistently report the negative impact of the COVID-19 crisis on T&L stocks. Liu et al. (2023) analyze the connectedness among tourism and hospitality stock indices across 40 countries or regions, highlighting intensified connectedness during the COVID-19 crisis. Pandemics, such as COVID-19, are also expected to amplify the influence of various uncertainties on T&L stock performance (e.g., Bashir and Kumar 2022).

In summary, the T&L industry remains particularly vulnerable to a wide range of external shocks. However, the literature still leaves important gaps, particularly in capturing its interplay with diverse sources of risk. Addressing this shortfall, the present study advances the literature by analyzing the connectedness between regional T&L stock indices and a more comprehensive set of risk-related indices from the perspective of both return and volatility.

Methodology

TVP-VAR-based connectedness approach

In this study, we employ the time-varying parameter vector autoregression (TVP-VAR) framework to estimate connectedness measures across both positive and negative components of the data. The TVP-VAR approach, as outlined by Koop and Korobilis (2014), addresses key limitations of the rolling-window VAR model, such as the arbitrary choice of window size, loss of observations, and sensitivity to outliers (Antonakakis et al. 2020). Based on the Bayesian Information Criterion (BIC), a first-order TVP-VAR model is specified as follows:

$$x_t = A_t x_{t-1} + \epsilon_t, \epsilon_t \sim N(0, \Sigma_t), \quad (1)$$

$$\text{vec}(A_t) = \text{vec}(A_{t-1}) + v_t, v_t \sim N(0, R_t), \quad (2)$$

where x_t and x_{t-1} are $N \times 1$ vectors representing observations at times t and $t - 1$, respectively, and ϵ_t denotes the error term. The matrices A_t and Σ_t represent time-varying coefficients and variance–covariance structures, respectively, while R_t is the dimensional matrix for the coefficients.

The generalized forecast error variance decomposition (GFEVD), as introduced by Pesaran and Shin (1998), is applied to quantify the influence of shocks from one variable on the forecast error variance of another. Unlike orthogonalized variance decompositions, GFEVD provides invariant results with respect to the ordering of variables, making it particularly suitable for analyzing interconnected systems (Diebold and Yilmaz 2012). Using the Wold representation theorem, the TVP-VAR model is transformed into a time-varying moving average (TVP-VMA) process:

$$x_t = \sum_{i=1}^p A_{it} x_{t-i} + \epsilon_t = \sum_{j=0}^{\infty} \psi_{jt} \epsilon_{t-j}. \quad (3)$$

The GFEVD is then computed as:

$$\theta_{ij}(H) = \frac{(\Sigma_t)_{jj}^{-1} \sum_{h=0}^H \left((\psi_h \Sigma_t)_{ij} \right)^2}{\sum_{h=0}^H (\psi_h \Sigma_t \psi_h')_{ii}}, \quad (4)$$

where $\theta_{ij}(H)$ captures the contribution of shocks in variable j to the forecast error variance of variable i over a forecast horizon H . To ensure comparability across variables, the values are normalized so that each row sums to unity:

$$\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{k=1}^N \theta_{ik}(H)}. \quad (5)$$

From the normalized GFEVD, directional connectedness metrics are derived, including net pairwise connectedness (NPDC):

$$NDPC_{ij}(H) = \tilde{\theta}_{ij}(H) - \tilde{\theta}_{ji}(H), \quad (6)$$

where $NDPC_{ij}(H) > 0$ indicates that variable j influences i more than the reverse. Total directional connectedness measures the cumulative influence transmitted to or received from other variables:

$$TO_i(H) = \sum_{j \neq i} \tilde{\theta}_{ji}(H), \quad FROM_i(H) = \sum_{j \neq i} \tilde{\theta}_{ij}(H). \quad (7)$$

The net total directional connectedness is expressed as:

$$NET_i(H) = TO_i(H) - FROM_i(H), \quad (8)$$

with $NET_i(H) > 0$ indicating that variable i is a net transmitter of shocks.

The total connectedness index (TCI) quantifies the overall level of interdependence within the network (Chatziantoniou et al. 2021):

$$TCI_t(H) = \frac{N}{N-1} \sum_{i=1}^N TO_i(H) = \frac{N}{N-1} \sum_{i=1}^N FROM_i(H). \quad (9)$$

The TCI illustrates the mean impact a shock in one index has on all the others. Therefore, higher TCI values suggest greater network interconnectedness and systemic risk.

Data and preliminary analysis

Our dataset spans the period from January 3, 2017, to June 19, 2025, and comprises daily returns for a diverse selection of financial and risk-related indices, as outlined in Table 1. The data were sourced from Bloomberg Terminal and Refinitiv Workspace to ensure consistency and reliability in the analysis. These indices capture sectoral and asset-class variations, with a particular focus on travel and leisure, energy markets, global risk and uncertainty factors. Specifically, the dataset includes regional and global equity indices, crude oil prices, and indices quantifying financial stress, geopolitical tensions, economic policy uncertainty, and infectious disease-induced market volatility. To conduct the return and volatility connectedness analyses, we first compute the logarithmic daily returns from closing prices using $r_{i,t} = 100 \times \ln \left(P_{i,t} / P_{i,t-1} \right)$, where $r_{i,t}$ denotes the daily return of asset i at time t , and $P_{i,t}$ is its closing price. For the volatility connectedness

Table 1 Symbols and descriptions of selected variables

Symbol	Description
Europe	STOXX Europe 600 Travel & Leisure
Asia/Pacific	STOXX Asia/Pacific 600 Travel & Leisure
Global	STOXX Global 3000 Travel & Leisure
America	STOXX North America 600 Travel & Leisure
Oil	Crude Oil (WTI)
FSI ¹	Financial stress index
GPRD ²	Geopolitical Risk Index
US-EPU ³	Economic Policy Uncertainty Index (USA)
IDEMV ⁴	Infectious Disease Equity Market Volatility

¹ <https://www.financialresearch.gov/financial-stress-index/>

² <https://www.policyuncertainty.com/gpr.html>

³ https://www.policyuncertainty.com/us_monthly.html

⁴ https://www.policyuncertainty.com/infectious_EMV.html

analysis, we follow the widely accepted approach in the connectedness literature (Diebold & Yilmaz 2012; Antonakakis et al. 2020) and use the squared daily returns as a proxy for daily volatility. This method is particularly suitable when high-frequency intra-day data are not available and ensures consistency between the return and volatility spillover frameworks.

To ensure a meaningful analysis and to account for potential structural breaks and changing relationships among variables during the COVID-19 outbreak, we divide the entire sample period into three subperiods: pre-COVID-19, COVID-19, and post-COVID-19. The pre-COVID-19 period, spanning from January 3, 2017, to January 30, 2020, consists of 768 daily observations and reflects a relatively stable economic environment prior to the onset of the pandemic. The COVID-19 period, from January 31, 2020, to May 04, 2023, includes 813 daily observations and captures the initial market shock and heightened volatility following the World Health Organization's declaration of the coronavirus pandemic. Last, the post-COVID-19 period, covering May 5, 2023, to June 19, 2025, comprises 544 daily observations and represents the normalization and structural adjustment phase, during which markets adapted to the new economic realities shaped by the pandemic. This is in line with the studies of Nazlioglu et al. (2015) and Hung and Vo (2021), which analyze structural breaks during periods of crisis.

Table 2 presents summary statistics for the included variables across these periods. Pre-COVID-19, average returns for most indices are marginally positive, with relatively low variances, reflecting stable market conditions. However, Oil exhibits negative mean returns (-0.00084) and the highest variance (0.0297), indicative of heightened market uncertainty in the energy sector even before the pandemic. Skewness and kurtosis metrics reveal significant departures from normality, with negative skewness dominating equity indices and positive skewness observed in IDEMV and FSI. The Jarque–Bera (JB) test confirms nonnormality for all variables, and the ERS unit root test verifies stationarity, supporting the use of models based on stationary processes.

During the COVID-19 outbreak, mean returns decline across all T&L indices, with the exception of oil, which shows a large positive mean (0.0478). Variance increases substantially, particularly for the financial stress index, highlighting the heightened uncertainty

Table 2 Summary statistics

	Europe	Asia/Pacific	Global	America	Oil	FSI	GRPD	US-EPU	IDEMV
<i>Panel A. Pre-COVID-19 period</i>									
Mean	0.000086	0.000213	0.000286	0.000432	−0.000839	−2.6804466	4.656637	4.436435	0.355169
Variance	0.0003	0.0003	0.0003	0.0003	0.0297	0.0309	0.0143	0.0164	0.0247
Skewness	−0.122	−0.178**	−0.473***	−0.580***	−0.235***	0.741***	−0.562***	−0.268***	3.754***
	(0.166)	(0.044)	(0.000)	(0.000)	(0.008)	(0.000)	(0.000)	(0.003)	(0.000)
Ex.Kurtosis	1.103***	0.741***	1.792***	3.365***	4.938***	0.627***	2.503***	0.775***	20.528***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.001)	(0.000)
JB	40.819***	21.631***	131.377***	405.349***	787.186***	82.924***	241.006***	284.28***	15,288.557***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ERS	−8.908***	−5.275***	−3.504***	−9.730***	−4.695***	−2.384**	−7.393***	−8.096***	−9.240***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.017)	(0.000)	(0.000)	(0.000)
Q(10)	2.004	7.593	5.905	3.970	8.093	3449.140***	163.406***	229.717***	21.468***
	(0.937)	(0.200)	(0.378)	(0.670)	(0.163)	(0.000)	(0.000)	(0.000)	(0.000)
Q2(10)	24.109***	18.935***	35.012***	79.238***	12.005**	3455.910***	180.200***	233.149***	2.599
	(0.000)	(0.001)	(0.000)	(0.000)	(0.027)	(0.000)	(0.000)	(0.000)	(−0.874)
<i>Panel B. COVID-19 period</i>									
Mean	−0.000170	−0.000136	−0.000020	−0.000024	0.047795	−0.780393	4.628800	5.044026	14.226860
Variance	0.0008	0.0005	0.0006	0.0007	0.0601	0.0945	0.0174	0.0191	0.3544
Skewness	−0.374***	0.204**	−0.686***	−0.671***	0.014	0.968***	0.024	0.413***	1.801***
	(0.000)	(0.018)	(0.000)	(0.000)	(0.866)	(0.000)	(0.777)	(0.000)	(0.000)
Ex.Kurtosis	4.739***	1.935***	7.311***	10.569***	18.956***	1.274***	0.441**	−0.189	4.531***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.023)	(0.271)	(0.000)
JB	779.621***	132.481***	1874.643***	3844.810***	12,171.896***	181.843***	6.660**	24.326***	11,345.94***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.036)	(0.000)	(0.000)
ERS	−9.938***	−11.663***	−5.362***	−6.103***	−6.584***	−1.822*	−3.754***	−3.611***	−4.227***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.069)	(0.000)	(0.000)	(0.000)

Table 2 (continued)

	Europe	Asia/Pacific	Global	America	Oil	FSI	GRPD	US-EPU	IDEMV
Q(10)	27.011*** (0.000)	4.566 (0.574)	29.915*** (0.000)	43.767*** (0.000)	19.826*** (0.000)	4133.326*** (0.000)	1323.873*** (0.000)	1720.623*** (0.000)	1312.797*** (0.000)
Q2(10)	382.726*** (0.000)	44.961*** (0.000)	347.032*** (0.000)	454.786*** (0.000)	277.278*** (0.000)	3347.851*** (0.000)	1509.023*** (0.000)	1888.059*** (0.000)	1406.824*** (0.000)
<i>Panel C. Post-COVID-19 period</i>									
Mean	0.010843	0.010717	0.010970	0.011057	0.011039	-1.270715	4.894772	4.866851	7.046195
Variance	0.010848	0.006786	0.003602	0.004002	0.030050	0.032477	0.035187	0.036956	0.346538
Skewness	-0.056 (0.587)	0.101 (0.331)	1.119*** (0.000)	0.734*** (0.000)	-0.194* (0.064)	1.278*** (0.000)	-1.644*** (0.000)	-1.265*** (0.000)	3.500*** (0.000)
Ex.Kurtosis	67.446*** (0.000)	25.204*** (0.000)	72.486*** (0.000)	40.142*** (0.000)	13.480*** (0.000)	2.818*** (0.000)	3.879*** (0.000)	2.349*** (0.000)	16.282*** (0.000)
JB	103,109.374*** (0.000)	14,400.046*** (0.000)	119,209.297*** (0.000)	36,573.236*** (0.000)	4121.928*** (0.000)	327.973*** (0.000)	586.287*** (0.000)	270.096*** (0.000)	7119.395*** (0.000)
ERS	-11.410*** (0.000)	-9.528*** (0.000)	-7.754*** (0.000)	-8.649*** (0.000)	-2.382** (0.018)	-1.676* (0.094)	-1.880* (0.061)	-2.104** (0.036)	-6.765*** (0.000)
Q(10)	161.251*** (0.000)	97.736*** (0.000)	174.756*** (0.000)	58.086*** (0.000)	50.837*** (0.000)	2005.408*** (0.000)	2024.831*** (0.000)	1919.041*** (0.000)	88.230*** (0.000)
Q2(10)	190.298*** (0.000)	126.126*** (0.000)	290.470*** (0.000)	137.584*** (0.000)	181.087*** (0.000)	2062.635*** (0.000)	2098.867*** (0.000)	1996.441*** (0.000)	59.604*** (0.000)

***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively. Values in parentheses correspond to *p* values. Skewness is tested using the method of D'agostino (1970), kurtosis is assessed following Anscombe and Glynn (1983), and normality is evaluated with the Jarque-Bera (1980) test. The ERS refers to the unit root test proposed by Elliott et al. (1996), while Q(20) and Q2(20) utilize the weighted portmanteau test introduced by Fisher and Gallagher (2012)

and volatility during the pandemic. Skewness varies across indices, and while some equity markets display persistent negative skewness, risk indices exhibit heightened positive skewness and extreme kurtosis. These dynamics show the heavy-tailed nature of asset returns during the pandemic. The Q(10) and Q2(10) tests confirm significant autocorrelation and conditional heteroskedasticity, particularly for risk indices such as FSI and IDEMV.

In the post-COVID-19 period, average returns recover across all equity indices and commodities. While variances decrease from the pandemic peak, they remain higher than pre-COVID-19 levels, reflecting a gradual normalization of market conditions. Skewness becomes less pronounced, although negative skewness persists for major equity indices. Leptokurtic distributions continue to characterize return series, as confirmed by significant kurtosis values. Across all periods, stationarity of the return series is verified by the ERS test ($p < 0.05$), justifying the application of models that assume stationary processes, such as TVP-VAR.

Table A1 in the appendices provides an overview of the unconditional (Pearson's) correlations across three selected periods. During the pre-COVID-19 period, correlations between regional indices, such as Europe and Global (0.5416) and Europe and America (0.3795), suggest moderate interconnectedness among these markets, reflecting relatively stable economic conditions. The strong correlation between Global and America (0.8243) highlights the influence of U.S. markets on global performance. Commodity markets, represented by Oil, exhibit weak correlations with regional indices, such as Europe (0.0419) and Asia/Pacific (0.0351), suggesting limited direct influence during this period. Risk-related variables, including the FSI, GPRD, and IDEMV, display weak or near-zero correlations with most financial indices, reflecting their limited influence on asset prices during noncrisis periods.

The outbreak of COVID-19 marks a dramatic shift in correlation patterns, driven by heightened uncertainty and market volatility. Correlations among regional indices increase significantly, indicating stronger interconnectedness. For instance, Europe-Global (0.7010) and Global-America (0.9488) exhibit much higher correlations than in the pre-COVID-19 period. Interestingly, correlations involving Oil turn negative, such as Oil-America (-0.0354), indicative of the adverse impact of the pandemic on energy markets due to collapsing demand and supply chain disruptions.

In the post-COVID-19 phase, correlations begin to moderate, reflecting a gradual normalization of market dynamics. Correlations between risk indices and equity markets decline substantially (i.e., GPRD-Global: -0.2923), indicating decoupling as markets adjust to postpandemic dynamics and risk sentiment normalizes. IDEMV retains some correlation with other uncertainty indices (i.e., IDEMV-FSI: 0.2877), but its links to equity markets weaken, suggesting that its influence may be more episodic in nature. Overall, this pattern is consistent with a transition from crisis-driven integration to more differentiated market behavior across sectors and regions.

Empirical results

This section presents the return and volatility connectedness results among major tourism stock indices and risk-related indices across three distinct subperiods. Specifically, a separate volatility connectedness network is constructed for each period to facilitate comparison of the evolving nature of interconnectedness over time.

Return connectedness

Figure 1 displays the dynamic total connectedness graphs of return series across three identified subperiods, namely, the pre-COVID-19, COVID-19, and post-COVID-19 periods. The dynamic total connectedness index (TCI) shows distinct shifts across the

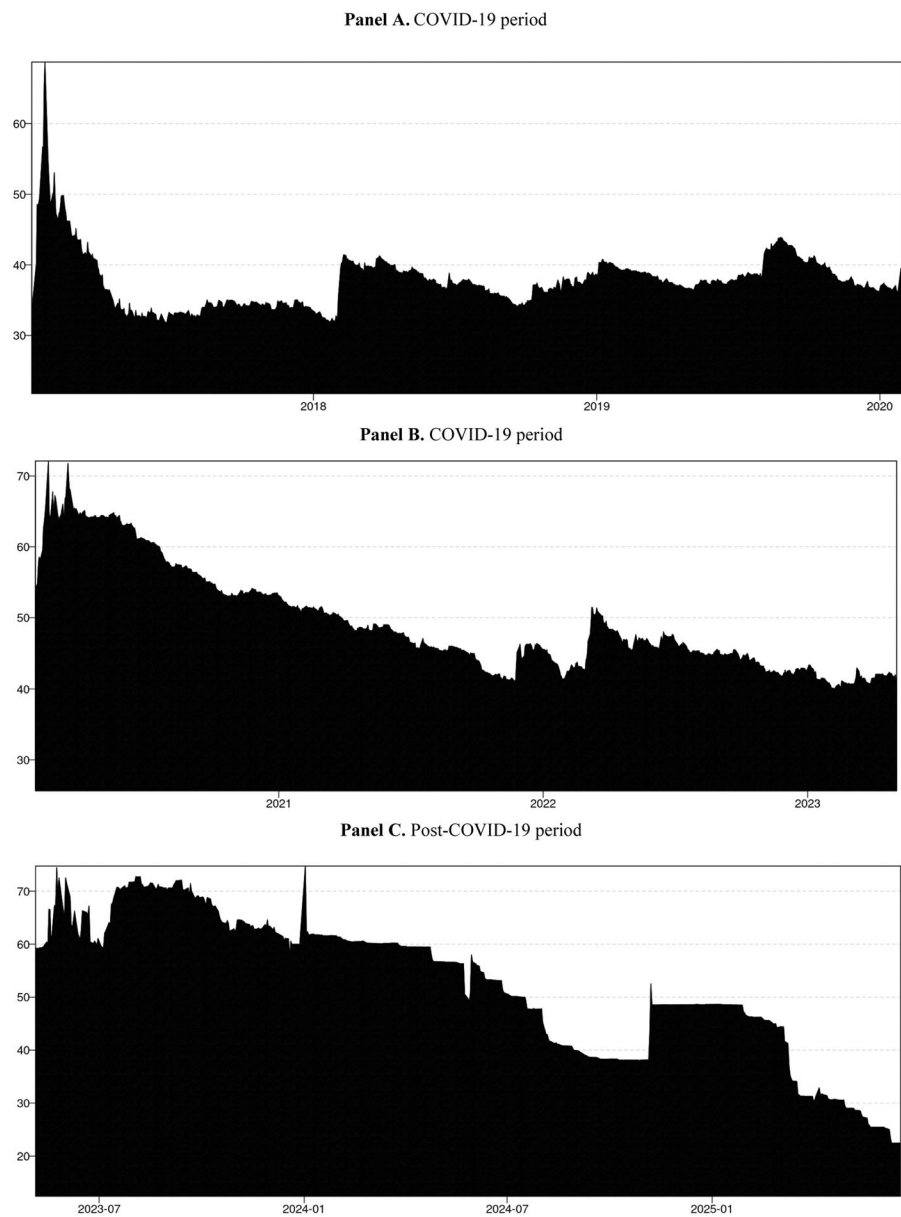


Fig. 1 Dynamic total connectedness graphs for return series

three periods. Before COVID-19 (Panel A), connectedness starts high in early 2017 and then declines sharply. Afterwards, it stabilized at moderate levels with brief upticks approximately 2018 and 2019. During the pandemic (Panel B), TCI spikes sharply to its highest levels, reflecting intense global market comovements driven by heightened uncertainty, before gradually declining yet experiencing brief surges during later pandemic waves and geopolitical events. In the post-COVID-19 period (Panel C), connectedness starts high but steadily decreases, indicating a gradual return to more normal market conditions, although occasional jumps highlight persistent sensitivity to new shocks.

Table 3 presents the return connectedness among major tourism stock indices and risk-related indices, as estimated by the time-varying parameter vector autoregression (TVP-VAR) model for three distinct time periods: pre-COVID-19, COVID-19, and post-COVID-19. Diagonal values give the proportion of each index's return attributed to its own past innovations, while off-diagonal values indicate the extent of return spillovers between indices. A high "FROM" value for an index suggests that its return is significantly influenced by other indices, whereas a high "TO" value indicates that the index has a substantial impact on the return of others. The difference between the "TO" and "FROM" values represents "NET" spillovers: negative values denote a net receiver of return, while positive values indicate a net transmitter.

Broadly, the analysis of total connectedness (TCI) across the three periods reveals significant variations in return spillovers. In the pre-COVID-19 period, total return connectedness remains relatively low. However, during and after the COVID-19 periods, total return connectedness surges significantly, driven by increased financial stress, extreme uncertainty, and widespread contagion across global markets. Notably, the return spillover level in the postpandemic period remains slightly higher than the pandemic level. This indicates that while markets have recovered to some extent compared to the prepandemic period, a degree of interconnectedness continues to persist in the postcrisis landscape. This persistence in return connectedness suggests that the pandemic has generated lasting changes in investor expectations and cross-market dependence within the tourism sector. Even as volatility pressures ease, tourism equity returns continue to comove due to delayed adjustments in cash-flow expectations, uneven recovery in international travel demand, and structural reallocation across regions. As a result, return spillovers reflect longer-term expectation-driven transmission rather than short-lived crisis reactions.

Before the pandemic, return spillovers exhibit moderate interconnectedness, with a total connectedness index (TCI) of 33.53%. As shown in Fig. 2 (Panel A), the Global and American tourism indices are the dominant net transmitters, while the Asia/Pacific, US-EPU, and FSI serve as key net receivers. The return transmission is primarily concentrated within the tourism indices, reflecting standard market influence patterns under normal conditions.

During the pandemic, total return connectedness rises by approximately 10 percentage points, indicating rising systemic risk. Figure 2 (Panel B) reveals that the Global Tourism Index remains the strongest net transmitter, followed by America and Oil, highlighting the highly contagious nature of tourism shocks during crises. Conversely, Asia/Pacific, IDEMV, US-EPU, GPRD, and FSI emerge as major receivers for return spillover,

Table 3 Return connectedness table

	Europe	Asia/Pacific	Global	America	Oil	FSI	GRPD	US-EPU	IDEMV	From
<i>Panel A Pre-COVID-19 period</i>										
Europe	53.36	3.37	18.10	10.92	1.22	10.66	0.97	0.89	0.50	46.64
Asia/Pacific	7.92	58.16	18.00	7.30	0.99	4.45	1.46	0.96	0.77	41.84
Global	12.85	8.45	39.59	25.60	0.73	11.30	0.41	0.58	0.51	60.41
America	7.53	0.71	28.63	44.65	1.02	15.96	0.47	0.58	0.45	55.35
Oil	1.72	0.84	1.46	1.75	90.18	1.02	1.73	0.68	0.62	9.82
FSI	10.26	0.62	14.78	21.86	3.04	46.86	1.32	0.79	0.45	53.14
GRPD	1.40	1.05	0.91	0.98	1.93	1.43	90.28	1.04	0.99	9.72
US-EPU	1.90	0.99	2.04	2.17	2.26	3.48	1.39	84.02	1.74	15.98
IDEMV	1.18	1.34	1.58	0.89	0.76	1.18	1.15	0.74	91.18	8.82
TO	44.77	17.36	85.50	71.47	11.96	49.48	8.91	6.25	6.03	301.73
IncOwn	98.13	75.52	125.09	116.11	102.14	96.34	99.19	90.27	97.21	cTCI/TCI
NET	-1.87	-24.48	25.09	16.11	2.14	-3.66	-0.81	-9.73	-2.79	37.72/33.53
NPT	5.00	2.00	8.00	7.00	5.00	5.00	3.00	0.00	1.00	
<i>Panel B, COVID-19 period</i>										
Europe	39.34	2.53	20.62	17.97	3.38	13.36	1.11	0.78	0.92	60.66
Asia/Pacific	9.05	49.67	15.83	11.56	2.89	7.74	1.13	1.43	0.72	50.33
Global	16.03	4.34	32.70	29.10	3.26	12.85	0.52	0.60	0.59	67.30
America	14.57	1.36	30.64	34.53	3.25	13.79	0.61	0.66	0.60	65.47
Oil	1.46	1.00	2.12	2.42	87.12	1.45	1.02	1.82	1.60	12.88
FSI	13.84	2.74	19.78	19.99	3.93	34.71	1.04	2.18	1.78	65.29
GRPD	1.92	0.75	2.35	2.71	0.76	2.60	81.06	6.41	1.42	18.94
US-EPU	1.98	1.42	2.92	2.51	0.93	4.08	6.41	73.58	6.17	26.42
IDEMV	3.28	1.52	4.52	4.04	1.68	6.13	1.88	4.61	72.35	27.65
TO	62.14	15.66	98.77	90.32	20.06	61.99	13.71	18.49	13.80	394.94
IncOwn	101.47	65.33	131.47	124.85	107.18	96.70	94.77	92.07	86.15	cTCI/TCI
NET	1.47	-34.67	31.47	24.85	7.18	-3.30	-5.23	-7.93	-13.85	49.37/43.88

Table 3 (continued)

	Europe	Asia/Pacific	Global	America	Oil	FSI	GPRD	US-EPU	IDEMV	From
NPT	5.00	1.00	7.00	6.00	6.00	4.00	3.00	3.00	1.00	
<i>Panel C. Post-COVID-19 period</i>										
Europe	39.18	13.14	14.51	17.15	0.78	0.75	8.74	4.87	0.89	60.82
Asia/Pacific	14.00	45.51	13.93	14.74	0.46	0.60	6.84	3.40	0.53	54.49
Global	15.89	13.78	37.27	18.09	0.79	1.34	7.82	4.62	0.40	62.73
America	17.28	13.24	16.88	37.19	0.77	0.72	8.05	5.33	0.53	62.81
Oil	1.71	0.87	1.52	1.93	89.34	0.33	1.75	1.49	1.06	10.66
FSI	5.41	4.55	4.58	5.41	0.35	75.36	2.89	0.97	0.48	24.64
GPRD	11.66	8.52	10.45	12.29	0.55	0.50	34.51	20.91	0.60	65.49
US-EPU	10.29	7.26	9.12	11.21	0.50	0.58	19.95	40.37	0.71	59.63
IDEMV	2.73	1.89	1.83	2.17	0.90	3.44	2.41	1.31	83.32	16.68
TO	78.97	63.24	72.83	83.00	5.09	8.25	58.46	42.90	5.21	417.93
IncOwn	118.15	108.75	110.10	120.19	94.43	83.61	92.98	83.27	88.52	cTCI/TCI
NET	18.15	8.75	10.10	20.19	-5.57	-16.39	-7.02	-16.73	-11.48	52.24/46.44
NPT	8.00	5.00	6.00	7.00	1.00	1.00	3.00	4.00	1.00	

Results are based on a TVP-VAR (0.99) model with lag length of order 1 (BIC) and a 10-step-ahead forecast. We re-estimated the TVP-VAR model using lag lengths of 2 and 3, as well as alternative information criteria (AIC, HQIC), to ensure that the results are not sensitive to the BIC-selected lag order of 1. While minor quantitative differences were observed, the qualitative patterns of net transmitters/receivers and period-specific connectedness dynamics remained unchanged

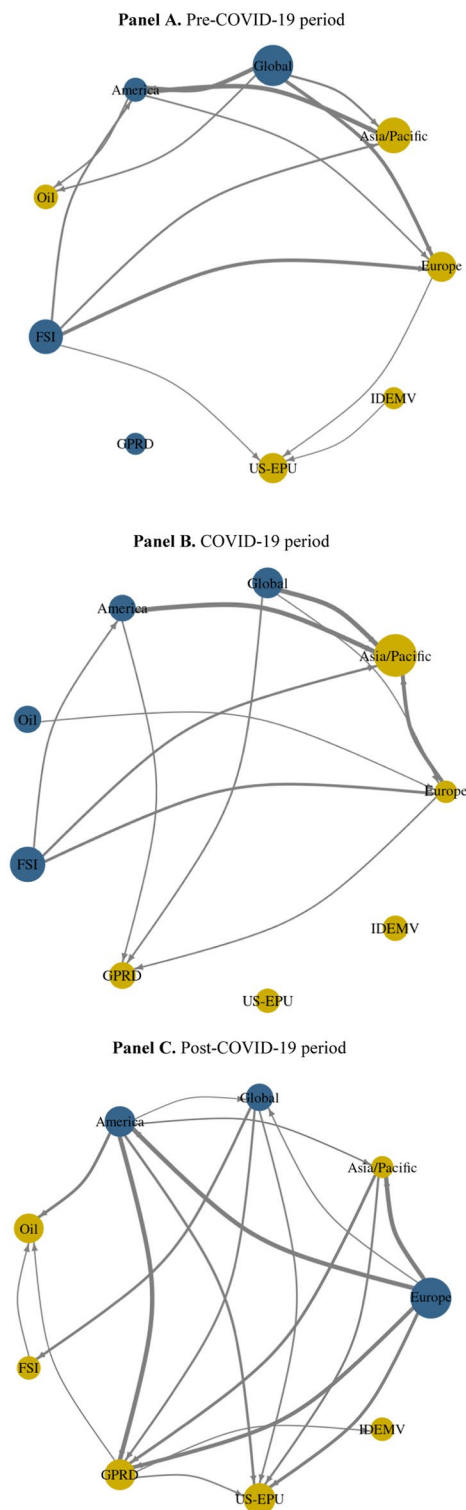


Fig. 2 Network plots for returns. Note Blue nodes represent shock transmitters, while receivers are symbolized by yellow nodes

suggesting that uncertainty and fear-related indices become more sensitive and reactive amid global disruptions.

In the postpandemic period, return connectedness remains elevated relative to the precrisis phase. As shown in Fig. 2 (Panel C), a notable shift occurs. For instance, America and Europe become the leading net transmitters of return spillovers, while US-EPU, FSI, and IDEMV continue to absorb shocks. This indicates that Western tourism sectors regain dominance in driving return spillovers, whereas risk-related indices persist as net receivers amid ongoing geopolitical and economic uncertainty.

Volatility connectedness

Figure 3 presents the dynamic total connectedness graphs of volatility series across the subperiods. Compared to the return TCI graphs, volatility connectedness generally exhibits lower levels in the prepandemic phase (Panel A), with occasional short-lived spikes. During the COVID-19 period (Panel B), both returns and volatility show sharp increases in connectedness. However, volatility TCI remains more persistent at higher levels than that of returns, peaking above 60% in early 2020 and staying high through mid-2022. In the post-COVID-19 period (Panel C), volatility connectedness starts relatively high and then drops sharply by mid-2024. Notably, while return spillovers remain high after the pandemic, volatility spillovers ease more significantly as market uncertainty subsides. This suggests that volatility connectedness undergoes a more significant normalization compared to return connectedness. This pattern reflects the fact that volatility spillovers are primarily driven by uncertainty shocks, risk aversion, and precautionary behavior, which tend to dissipate as macroeconomic conditions stabilize. Once systemic stress subsides, volatility transmission weakens, even though return spillovers may persist due to continued cross-market integration and slower adjustment in tourism fundamentals.

Table 4 and the associated network graphs present the structure of volatility spillovers. Overall, volatility connectedness is found to be generally higher and more responsive to systemic shocks compared to return spillovers, particularly during the COVID-19 period. However, in the prepandemic phase, volatility linkages are notably weaker than return spillovers. Panel A of Fig. 4 shows that tourism indices such as Europe, Asia/Pacific, and America act as net volatility receivers, while risk-related indicators, including for instance, US-EPU, IDEMV, and GPRD, emerge as dominant volatility transmitters.

During the pandemic period, volatility spillovers rise sharply, surpassing return connectedness. As shown in Panel B of Table 4, US-EPU becomes the largest net transmitter of volatility (84.20%), underlining its pivotal role in the transmission of uncertainty. In contrast, tourism indices in Asia/Pacific, Europe, and America are the main net receivers, indicating rising vulnerability to volatility shocks. This reflects a notable shift from the return spillover network, where tourism indices previously played a dominant transmitting role.

In the post-COVID-19 period, volatility interconnectedness moderates compared to the peak levels observed during the pandemic but remains elevated relative to the prepandemic phase. Interestingly, Panel C of Fig. 4 shows that Europe transitions into a net volatility transmitter, reversing its earlier role. Meanwhile, the Asia/Pacific and America

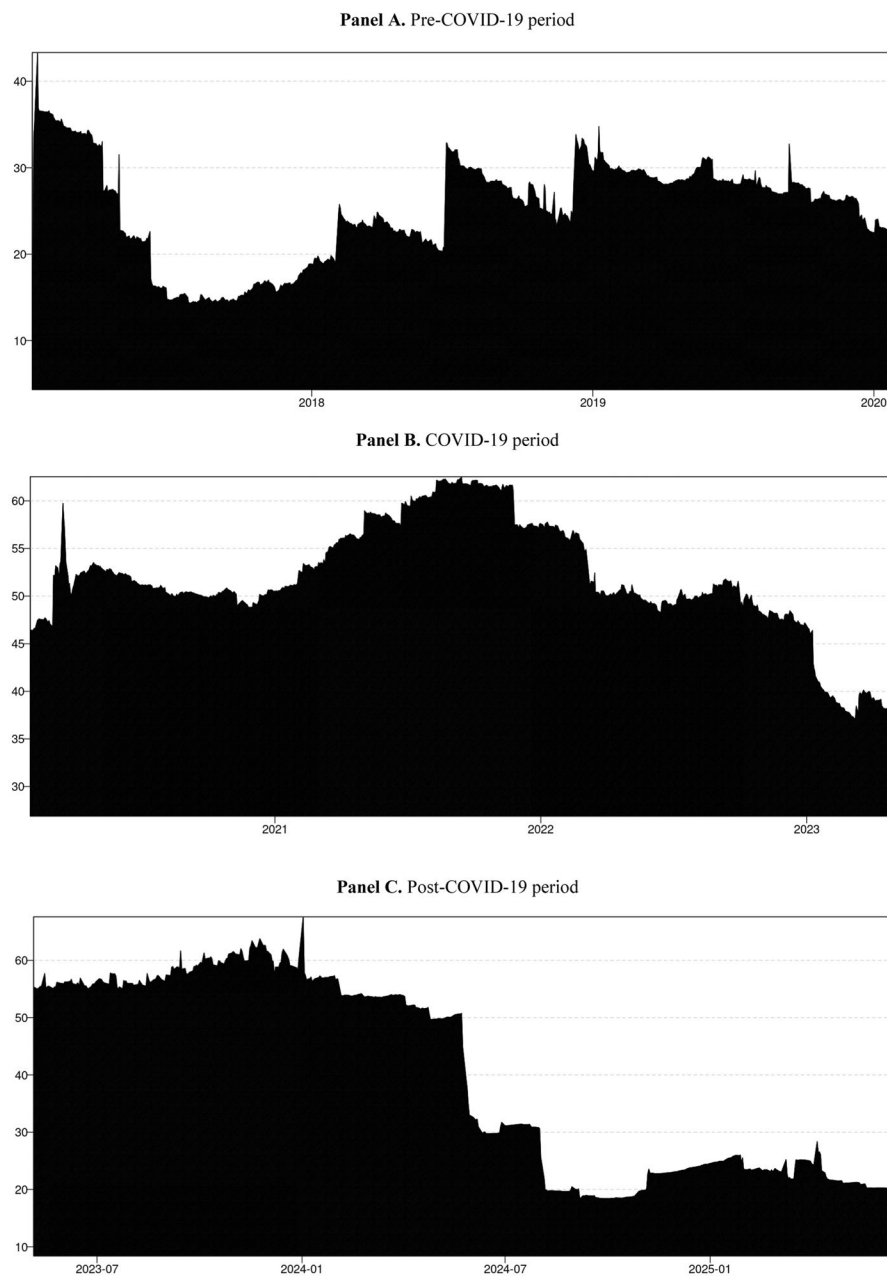


Fig. 3 Dynamic total connectedness graphs for volatility series

indices return to being net receivers. Additionally, oil shifts from a volatility sender to a receiver, and indicators such as US-EPU, FSI, and IDEMV also become net receivers after being key transmitters in earlier periods.

These dynamics suggest that while volatility spillovers begin to normalize post-COVID-19, return spillovers remain persistently high. This divergence reflects the difference in what each measure captures: return spillovers tend to reflect immediate market reactions to news and shocks, whereas volatility spillovers represent the slower-moving transmission of uncertainty and risk perceptions.

Table 4 Volatility connectedness table

	Europe	Asia/Pacific	Global	America	Oil	FSI	GPRD	US-EPU	IDEMV	From
<i>Panel A: Pre-COVID-19 period</i>										
Europe	63.43	6.13	6.76	6.12	1.73	5.28	1.44	6.25	2.87	36.57
Asia/Pacific	6.90	64.77	2.98	7.61	2.68	2.73	2.19	7.81	2.33	35.23
Global	6.01	2.38	54.75	15.54	4.10	4.38	4.68	3.17	4.99	45.25
America	5.45	7.45	15.99	56.49	1.59	5.23	2.20	3.35	2.25	43.51
Oil	1.13	0.32	0.73	0.93	93.70	1.13	0.81	0.98	0.27	6.30
FSI	0.71	1.28	3.06	4.27	2.80	84.34	2.06	1.02	0.46	15.66
GPRD	0.38	0.59	0.38	0.88	0.99	0.82	94.75	0.90	0.31	5.25
US-EPU	1.15	0.75	0.42	0.37	0.59	3.37	1.73	90.42	1.20	9.58
IDEMV	0.85	0.44	0.19	0.10	0.35	0.46	0.67	0.36	96.59	3.41
TO	22.59	19.34	30.50	35.81	14.83	23.40	15.77	23.84	14.68	200.77
IncOwn	86.02	84.11	85.26	92.31	108.53	107.75	110.52	114.26	111.26	cTCI/TCI
NET	-13.98	-15.89	-14.74	-7.69	8.53	7.75	10.52	14.26	11.26	25.10/22.31
NPT	1.00	0.00	3.00	2.00	7.00	6.00	7.00	5.00	5.00	
<i>Panel B: COVID-19 period</i>										
Europe	35.50	5.20	12.67	9.77	2.55	4.58	10.11	17.34	2.28	64.50
Asia/Pacific	5.15	40.97	4.27	2.24	4.40	1.12	7.66	32.41	1.79	59.03
Global	10.77	3.64	28.45	25.76	3.20	8.45	3.63	9.88	6.22	71.55
America	8.80	2.26	27.30	29.53	2.41	9.86	3.62	8.48	7.75	70.47
Oil	0.56	0.99	2.02	2.53	81.27	3.75	1.82	4.60	2.46	18.73
FSI	3.21	0.36	5.73	4.08	3.70	73.48	1.07	2.37	5.99	26.52
GPRD	3.65	4.65	1.73	1.55	1.35	0.30	57.61	27.10	2.06	42.39
US-EPU	2.64	5.43	1.27	0.96	3.03	1.10	8.62	74.33	2.63	25.67
IDEMV	1.78	1.04	5.16	5.73	3.06	10.53	1.02	7.68	64.01	35.99
TO	36.55	23.57	60.15	52.61	23.70	39.68	37.55	109.87	31.17	414.85
IncOwn	72.05	64.54	88.60	82.15	104.97	113.16	95.16	184.20	95.19	cTCI/TCI

Table 4 (continued)

	Europe	Asia/Pacific	Global	America	Oil	FSI	GPRD	US-EPU	IDMV	From
NET	-27.95	-35.46	-11.40	-17.85	4.97	13.16	-4.84	84.20	-4.81	51.86/46.09
NPT	0.00	2.00	3.00	2.00	4.00	6.00	6.00	8.00	5.00	
<i>Panel C: Post-COVID-19 period</i>										
Europe	54.61	17.02	10.13	8.04	0.37	1.95	5.08	2.36	0.42	45.39
Asia/Pacific	11.56	61.35	9.92	9.11	0.32	1.04	4.37	1.73	0.60	38.65
Global	7.45	11.18	52.30	12.62	0.33	1.38	7.32	6.29	1.13	47.70
America	4.37	9.76	13.83	56.46	0.48	1.68	7.13	5.73	0.57	43.54
Oil	0.30	0.25	0.49	0.28	90.40	2.39	2.58	2.53	0.78	9.60
FSI	4.58	4.96	3.71	2.77	0.74	78.47	1.93	2.00	0.84	21.53
GPRD	1.76	4.36	9.99	8.58	1.16	2.63	49.14	21.94	0.43	50.86
US-EPU	1.32	3.12	8.97	7.02	1.59	3.24	23.87	49.56	1.32	50.44
IDMV	0.62	0.64	1.33	0.63	0.70	1.55	1.04	2.37	91.11	8.89
TO	31.96	51.30	58.37	49.05	5.70	15.87	53.32	44.95	6.09	316.60
IncOwn	86.57	112.65	110.67	105.51	96.10	94.34	102.46	94.51	97.20	cTCI/TCI
NET	-13.43	12.65	10.67	5.51	-3.90	-5.66	2.46	-5.49	-2.80	39.58/35.18
NPT	2.00	6.00	7.00	5.00	3.00	4.00	5.00	3.00	1.00	

Results are based on a TVP-VAR (0.99) model with lag length of order 1 (BIC) and a 10-step-ahead forecast. We re-estimated the TVP-VAR model using lag lengths of 2 and 3, as well as alternative information criteria (AIC, HQIC), to ensure that the results are not sensitive to the BIC-selected lag order of 1. While minor quantitative differences were observed, the qualitative patterns of net transmitters/receivers and period-specific connectedness dynamics remained unchanged

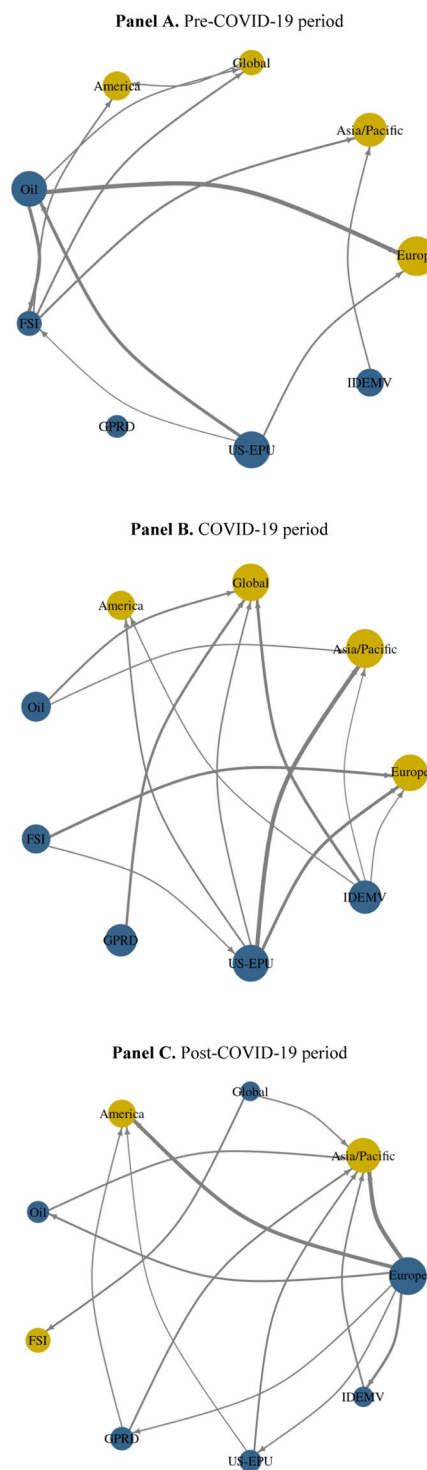


Fig. 4 Network plots for volatilities. Note Blue nodes represent volatility transmitters, while volatility receivers are symbolized by yellow nodes

Discussions and implications

The results show that before COVID-19, both return and volatility connectedness are relatively moderate, with spillovers in returns largely concentrated among tourism

indices and volatility linkages relatively weaker. This reflects a market environment where geographic segmentation and stable demand patterns are limited to the transmission of shocks. During the pandemic, both measures spike sharply but with distinct characteristics: return connectedness rises due to immediate and intense comovements driven by uncertainty, while volatility connectedness not only surges but also remains persistently high until mid-2022, signaling consistent risk transmission even as returns begin to ease. This divergence underscores that returns tend to capture the short-term fast-moving impact of news and crises, whereas volatility captures slower-moving uncertainty effects. Accordingly, changes in connectedness across phases are driven by shifts in dominant transmission channels, from uncertainty-led volatility spillovers during crisis periods to expectation-driven return spillovers during the recovery phase.

In the post-COVID-19 period, partial normalization is observed. Volatility connectedness declines more sharply, suggesting a subsiding of prolonged uncertainty, while return connectedness remains elevated relative to prepandemic levels. This persistence indicates that the pandemic has left a lasting imprint on market integration, particularly within tourism sectors in America and Europe, which have regained leading transmitter roles in returns. In contrast, risk-related indices such as US-EPU and IDEMV have shifted from being dominant transmitters during the pandemic to fading transmitters. This asymmetric adjustment implies that declining volatility alone should not be interpreted as a full normalization of cross-market dependence.

These findings carry several implications. First, the persistent elevation in return connectedness in the postcrisis period indicates that tourism equity markets now operate under a higher baseline level of integration. For investors and portfolio managers, this suggests that diversification strategies based solely on volatility reduction may be insufficient and that portfolio rebalancing should explicitly account for sustained return comovements across regions. Second, the tightening of volatility linkages during the crisis highlights the critical role of systemic risk indices in shaping market behavior. For financial institutions and risk managers, incorporating uncertainty-sensitive indicators such as US-EPU into stress testing and early-warning frameworks can support more timely adjustments in risk exposure during periods of heightened systemic stress. Third, the distinct behavior of return and volatility spillovers implies that risk management tools should address both dimensions, capturing short-term market shocks as well as longer-term uncertainty transmission.

From a practical perspective, tourism and leisure firms, investors, and policymakers should adopt adaptive, phase-dependent strategies that explicitly account for evolving cross-market linkages. For investors, diversification across regions and subsectors remains important but should be complemented by dynamic hedging during crisis periods when volatility spillovers dominate. For policymakers, the persistence of return connectedness in the postcrisis phase suggests that policy support for tourism-dependent economies should not be withdrawn solely on the basis of declining volatility or headline recovery indicators but rather informed by continued monitoring of return spillovers and cross-market dependence. Targeted, region-specific interventions and coordinated crisis-preparedness measures can help mitigate prolonged financial interdependence and reduce vulnerability to renewed shocks.

Summary and conclusion

This study investigates the time-varying return and volatility connectedness among major tourism stock indices and systemic risk indicators across the pre-COVID-19, COVID-19, and post-COVID-19 periods using a TVP-VAR framework. By constructing dynamic networks for each period, we capture how the intensity and direction of spillovers evolve over time. This provides new insights into the transmission of shocks within the global tourism and leisure (T&L) sector.

The results reveal clear structural shifts across the three periods. Before the pandemic, both return and volatility connectedness are moderate, with spillovers in returns concentrated primarily among tourism indices, led by Global and America as net transmitters. Volatility linkages, in contrast, are relatively weaker, with tourism indices (e.g., Europe, Asia/Pacific, and America) acting mainly as net receivers and systemic risk indicators playing a limited role. This reflects a relatively segmented and stable market environment.

The COVID-19 period is characterized by a sharp escalation in both return and volatility connectedness, reflecting severe disruptions to global markets. While return connectedness increases due to rapid comovements and expectation revisions, volatility connectedness is driven predominantly by uncertainty and systemic risk, with indicators such as US-EPU emerging as major transmitters of volatility shocks to tourism equities. This divergence highlights how crises propagate through distinct transmission channels, with volatility capturing prolonged uncertainty effects and returns reflecting faster information assimilation.

Overall, the findings underscore that global crises can fundamentally reshape both short-term and longer-term interconnectedness in the T&L sector. Notably, return connectedness remains elevated in the postcrisis period, whereas volatility connectedness normalizes more rapidly as uncertainty fades. These asymmetric dynamics have important practical implications: investors and risk managers should jointly monitor return and volatility spillovers to capture both immediate and persistent channels of risk transmission, while policymakers should account for lingering return interdependence when designing recovery and stabilization policies. The results further suggest that enhanced cross-border coordination and the integration of connectedness measures into risk monitoring frameworks can improve resilience against future shocks.

Future research could extend this analysis by exploring additional regional indices and incorporating high-frequency data to capture intraday dynamics. Additionally, examining the impact of emerging uncertainties, such as those associated with specific geopolitical tensions (e.g., the Russia-Ukraine war, Israel-Iran conflict) or prolonged public health challenges (e.g., different COVID-19 variants), would provide valuable insights into the evolving risk landscape.

Appendix

See Table [A1](#).

Table A1 Unconditional correlations

	Europe	Asia/Pacific	Global	America	Oil	FSI	GPRD	US-EPU	IDEMV
<i>Panel A. Pre-COVID-19 period</i>									
Europe	1.0000								
Asia/Pacific	0.2434	1.0000							
Global	0.5416	0.4723	1.0000						
America	0.3795	0.0822	0.8243	1.0000					
Oil	0.0419	0.0351	0.0482	0.0572	1.0000				
FSI	−0.0288	−0.0259	−0.0459	−0.0569	−0.0196	1.0000			
GPRD	0.0379	−0.0368	0.0241	0.0360	−0.0479	−0.0399	1.0000		
US-EPU	0.0738	0.0058	0.0457	0.0762	0.0172	0.2134	0.0635	1.0000	
IDEMV	0.0674	0.0264	0.0296	0.0183	0.0105	0.0398	−0.0378	0.0116	1.0000
<i>Panel B. COVID-19 period</i>									
Europe	1.0000								
Asia/Pacific	0.2639	1.0000							
Global	0.7010	0.3403	1.0000						
America	0.6562	0.1755	0.9488	1.0000					
Oil	0.0016	0.0116	−0.0178	−0.0354	1.0000				
FSI	−0.0666	−0.0167	−0.0607	−0.0614	−0.0104	1.0000			
GPRD	0.0309	0.0282	0.0546	0.0355	−0.0218	0.2503	1.0000		
US-EPU	0.0333	0.0426	0.0612	0.0669	0.0647	0.3069	−0.2303	1.0000	
IDEMV	−0.0041	0.0153	−0.0024	−0.0108	0.0430	0.3388	−0.1599	0.4870	1.0000
<i>Panel C. Post-COVID-19 period</i>									
Europe	1.0000								
Asia/Pacific	0.1002	1.0000							
Global	0.0769	0.1037	1.0000						
America	−0.0999	0.0844	0.2127	1.0000					
Oil	0.0226	0.0131	0.0296	−0.0103	1.0000				
FSI	−0.0144	−0.0230	0.0196	−0.0354	−0.0131	1.0000			
GPRD	−0.0990	−0.1789	−0.2923	−0.2672	−0.0132	0.1055	1.0000		
US-EPU	−0.0910	−0.1448	−0.2689	−0.2470	−0.0500	0.0726	0.8640	1.0000	
IDEMV	0.0377	0.0493	−0.0229	0.0006	−0.0324	0.2877	0.0766	0.1302	1.0000

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Author contributions

MS: conceptualization, methodology, software, data curation, writing-original draft preparation, visualization, investigation, supervision, software, validation, writing-reviewing and editing. MK: conceptualization, data curation, writing-original draft preparation, writing-reviewing and editing. BK: data curation, methodology, writing-original draft preparation, writing-reviewing and editing. All authors read and approved the final manuscript.

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