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The Impact of Tourism Activities on Carbon Emissions: Evidence Using a Time-Varying Parameter Vector Autoregression Model

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Abstract This article examines the impact of tourism activities, economic growth, and energy demand on environmental degradation in Turkey using Primiceri's (2005) time-varying parameter structural vector autoregression model for the period 1991:Q1 to 2020:Q1. The findings from the linear VAR model indicate that the response of carbon emissions to shocks in tourism activity is negative and significant. However, the time-varying responses show that the impact of tourism activities on environmental degradation varies over time but is not significant for most analysis period. The insignificant impact of tourism on carbon emissions implies that the tourism sector can be supported by policymakers without harming the environment. Furthermore, our findings on the positive and significant time-varying impact of tourism activities on economic growth support the validity of the tourism-led growth hypothesis.

Keywords Tourism · CO2 Emissions · Time-Varying Parameter Vector Autoregression Model

JEL Classification C32 · Q50 · Z30

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The Impact of Tourism Activities on Carbon Emissions: Evidence Using a Time-Varying Parameter Vector Autoregression Model

According to the World Tourism Organisation (UNWTO, 2021), the travel and tourism industry accounted for 4% of the global Gross Domestic Product (GDP) in 2019 while growing at a faster rate than the average global economic activity to provide one in ten jobs worldwide. However, its contribution to GDP declined by 1.8% in 2020.

Turkey's tourism revenues grew from 294 million US dollars in 1990:Q1 to 14,031 million US dollars in 2019:Q3 before falling to 4,101 million US dollars in 2020:Q1[1]. At the same time, Turkey's primary energy consumption rose from 54.989 million tonnes of oil equivalent (mtoe to 158.934 mtoe in 2021, with carbon emissions rising in parallel. Meanwhile, Turkey's real GDP per capita over this period fluctuated widely, as shown in Figure 1. For example, it reversed sharply from 7.38% in 1990 to −6.16% in 1994 due to the financial crisis before returning to positive growth. However, it reversed again to −7.11% in 2001 because of Turkey's banking crisis, followed by another sharp decline in 2009.

Climate change can impact tourism in various ways. It is a climate-sensitive industry, with many destinations attracting tourists because of their favourable weather during vacation seasons (Amelung, Nicholls & Viner 2007). However, many tourist attractions are particularly vulnerable to climate change. For example, ski tourism (Scott, Steiger, Rutty, Pons & Johnson, 2019; Steiger & Abegg, 2018; Steiger, Scott, Abegg, Pons & Aall, 2019), beach tourism (Perch-Nielsen, 2010), and mountain tourism (Steiger & Abegg, 2018). To give two specific examples, under the worst-case scenario, tourist arrivals to the Caribbean could decline by 1% per year due to climate change effects (Moore, 2010), while China's tourism industry has already been damaged by air pollution in tourist destinations (Xu & Dong, 2020).

Therefore, it is critical to examine the dynamic relationship between tourism, CO2 emissions, economic growth, and energy consumption as part of developing a comprehensive approach to implementing policies that increase economic growth, including tourism activities, while minimising their environmental impact. Accordingly, this paper contributes to the existing literature by providing new information on the contribution of tourism-related activities, economic growth, and energy demand to environmental degradation in Turkey. Specifically, we apply the time-varying parameter structural vector autoregression (TVP-VAR) model with stochastic volatility to identify any changes over time in how tourism activities, economic growth, and energy demand have led to environmental degradation. This is a novel approach as most previous studies examining the environmental impacts of tourism activities, specifically their contribution to CO2 emissions, have assumed that the relationships are linear. While the TVP-VAR methodology has been applied to investigate the impact of economic policy uncertainty and geopolitical risk on tourist arrivals in China (Zhang, Jiang, Gao & Yang, 2022), to the best of our knowledge, this is the first study to investigate the impact of tourism activities on CO_2 emissions in Turkey using the TVP-VAR model.

The paper is structured as follows. Section two briefly summarises the literature, focusing on the nexus between tourism, economic growth, and CO2 emissions. Section three introduces the data. Section 4 presents the TVP-VAR methodology, while section five summarises the empirical findings. Section six concludes the paper.

[1]Appendix Figure A1 presents the percentage change in year-over-year GDP, CO2 emissions, tourism revenues, and primary energy consumption.

Literature Review

There is an extensive body of literature investigating the relationship between tourism, economic growth, and environmental degradation (Segarra, Brida & Cárdenas-García, 2024). However, the findings vary due to differences in econometric methodologies, data periods, and variables. This section considers this literature in two parts: (i) the tourism and economic growth nexus; (ii) the tourism and CO2 emissions nexus.

The Tourism and Economic Growth Nexus

The contribution of tourism to economic growth cannot be ignored because of the slowdown in global growth in recent years. Studies addressing the economic effects of the tourism industry mainly focus on the determinants of tourism demand and reveal the determinants of international tourism demand through macroeconomic factors (Gaberli & Akdeniz, 2024). Additionally, there have been several literature surveys of the relationship between tourism and economic growth (Brida, Cortes-Jimenez & Pulina, 2016; Pablo-Romero & Molina, 2013; Gaberli, 2023). Four main hypotheses have been proposed to explain this relationship. The first, tourism-led growth (TLG), suggests that tourism increases economic growth. This has been supported by many studies, such as Balaguer & Cantavella-Jorda (2002) for Spain, Durbarry (2004) for Mauritius; Gunduz & Hatemi-J (2005) for Turkey, Dritsakis (2012) for seven Mediterranean countries, Cortes-Jimenez & Pulina (2010) for Italy, Tang & Abosedra (2014) for Lebanon, Seetanah & Fauzel (2018) for 18 island economies, and Colacchio & Vergori (2023) for Italy.

The second hypothesis, economic-driven tourism, suggests the opposite: that economic growth increases tourism. This is supported by Aslan (2014) for seven Mediterranean countries, including Spain, Italy and Greece.

The third hypothesis suggests a bidirectional relationship between tourism and economic growth. Several studies have provided support for this, such as Demiroz & Ongan (2005) and Balli, Sigeze, Manga, Birdir & Birdir (2019) for Turkey, Cortes-Jimenez & Pulina (2010) for Spain, Massidda & Mattana (2013) for Italy, Ben Jebli & Hadhri (2018) for a sample of the top ten international tourism countries, Işik, Kasımatı & Ongan (2017) for Greece, Akadiri & Akadiri (2021) for 16 island tourism countries, Akadiri, Alola & Uzuner (2020a) for Germany, and Dogru & Bulut (2018) for seven European countries.

The fourth hypothesis suggests that there is no causal relationship between tourism and economic growth. In support of this, neither Ozturk & Acaravci (2009) nor Katircioglu (2009) found any evidence to support the TLG hypothesis in Turkey. Similarly, a number of studies of other countries have reported no causal relationship: Işık, Dogru & Turk (2018) for France and Italy; Sokhanvar, Çiftçioğlu & Javid (2018) for seven of 16 emerging countries; Eyuboglu & Eyuboglu (2020) for nine emerging countries; Gaberli & Can (2020) for 47 high- and 12 low-income countries and Destek & Aydın (2022) for the 10 most visited countries.

Tourism and CO_2 Emissions Nexus

While numerous studies have demonstrated tourism's benefits to economic development, many tourist activities rely on nonrenewable energy sources like oil, which increase environmental degradation through CO2 emissions (Paramati, Shahbaz & Alam, 2017b). Because increased energy consumption due to growing tourism can increase CO2 emissions, many experts have recently focused their attention on patterns of energy usage in the tourism sector (Nepal, 2008). In the Seychelles, for example, Gössling, Hansson, Hörstmeier & Saggel (2002) reported that air travel accounts for almost 90% of the country's ecological footprint, while Gössling, Peeters, Ceron, Dubois, Patterson & Richardson (2005) identified fossil fuel use as tourism's major environmental issue, with air travel accounting for 18% of total energy consumption. Becken & Simmons (2002) found that tourist activities use more energy than tourist attractions in New Zealand.

Scott, Peeters & Gössling (2010) argued that tourism contributes to CO2 emissions because it relies on fossil fuels for transportation and numerous tourist activities. Mishra, Pandita, Bhat, Mishra & Sharma (2022) compressively analysed the relationship between tourism and CO2 emissions over the last three decades.

Most studies conclude that tourism contributes significantly to CO2 emissions. For instance, Katircioglu, Feridun & Kilinc (2014) found that tourism contributes to CO2 emissions in Cyprus. This finding is confirmed by Katircioglu (2014), Saint Akadiri, Alola & Akadiri (2019a), and Uzuner, Akadiri & Lasisi (2020) for Turkey. Solarin (2014) for Malaysia; Algieri, Füg & Lombardo (2022) for Italy; Zaman, Shahbaz, Loganathan & Raza (2016) for 34 developed and developing countries; Pablo-Romero, Sánchez-Braza & Sánchez-Rivas (2021) and Lee & Brahmasrene (2013) for European countries; Dogan (2017) for the top ten most-visited countries; Dogan, Seker & Bulbul (2017) for OECD countries; Akadiri, Lasisi, Uzuner & Akadiri (2020b) for 16 small island developing countries; Gao, Xu & Zhang (2021) for 18 Mediterranean countries; Anser, Yousaf, Nassani, Abro & Zaman (2020) for G-7 countries; Gulistan, Tariq & Bashir (2020) for a panel of 112 countries, and Xu, Jin & Yang (2024) for top tourist destinations.

Other studies, however, provided contrary findings. For example, Dogru, Bulut, Kocak, Işık, Suess & Sirakaya-Turk (2020) found that tourism development reduced CO2 emissions in Turkey. Ravinthirakumaran & Ravinthirakumaran (2022) for the Asia-Pacific Economic Cooperation (APEC) member countries. Furthermore, while tourism activities increase CO2 emissions in eastern EU countries, they reduce them in western EU countries (Paramati et al., 2017b). Paramati, Alam & Chen (2017a) found that tourism reduces CO2 emissions although the magnitude varies between developing and developed countries. Kocak, Ulucak & Ulucak (2020) found that the number of tourist arrivals in the world's top ten most visited countries is associated with increased CO2 emissions, whereas tourism receipts and CO2 emissions are negatively associated.

The tourism-induced Environmental Kuznets Curve (EKC) hypothesis has also been confirmed by a number of studies, including De Vita, Katircioglu, Altinay, Fethi & Mercan (2015) and Sun, Duru, Razzaq & Dinca (2021) for Turkey, Katircioglu, Gokmenoglu, & Eren (2018) for the ten most-visited countries, Gao et al. (2021) for Cyprus, Lebanon, and Libya; Akadiri, Akadiri & Alola (2019) for seven small island countries, and Saint Akadiri, Lasisi, Uzuner & Akadiri (2019b) for 15 tourism destinations.

Overall, these findings suggest that although tourism clearly benefits the overall economy, the contribution of tourism-related emissions to climate change remains a critical threat to the industry's long-term sustainability (Hall, Scott & Gössling, 2013). Besides, CO2 emissions from tourism activities and their contribution to environmental degradation play a vital role in the sustainability of tourism, particularly for Turkey. Therefore, unlike previous papers, this paper contributes to the existing literature utilising a novel approach, the TVP-VAR model, identifying any changes over time in how tourism activities, economic growth, and energy demand have led to an increase in CO2 emissions in Turkey.

Data

This article uses quarterly data from 1991:Q1 to 2020:Q1 to examine the effect of tourism activities, economic growth, and energy demand on carbon emissions. The data were collected from the database of Refinitiv Eikon Datastream (Refinitiv Eikon Datastream, 2021). Vector Y_t', which includes the variables of interest, was expressed as follows:

$$Y_t' = [gdp_t \; co2_t \; tour_t \; en_t], \tag{1}$$

where gdp_t represents GDP per capita in constant US dollars; $co2_t$ is the carbon emissions defined in terms of short tonnes; $tour_t$ is tourism receipts in US dollars; and en_t is primary energy consumption. Table 1 presents the descriptive statistics and the correlation matrix for the series covering 1990:Q1 to 2020:Q1.[2]

Table 1

Descriptive Statistics and the Correlation Matrix

Basic Statistics	gdp_t	$co2_t$	$tour_t$	en_t
Mean	3967.570	16.002	4010.033	95.449
Median	3532.650	14.422	3120.000	87.708
Maximum	7483.490	26.297	14031.000	152.368
Minimum	1782.380	8.608	294.000	52.561
Standard Deviation	1776.043	5.244	3282.689	29.797
Jarque-Bera Statistics	12.190	8.030	20.958	7.814
Probability Value of the Jarque-Bera Statistics	0.002	0.018	0.000	0.020
Correlation Matrix	gdp_t	$co2_t$	$tour_t$	en_t
gdp_t	1	0.986	0.745	0.978
$co2_t$	0.986	1	0.738	0.992
$tour_t$	0.745	0.738	1	0.745
en_t	0.978	0.992	0.745	1

The table indicates that, during the sample period, the average per capita income level was around 4,000 US dollars, while the average tourism income was 14,031 million US dollars. The maximum values of carbon emissions and primary energy demand were 26 and 152 toes, respectively. Carbon emissions and tourism income, which are not seasonally adjusted, had the lowest and highest standard deviations, respectively. Lastly, another important finding is that there is a substantial correlation between primary energy consumption and carbon emissions.

The order of integration of the variables was investigated prior to the TVP-VAR estimation by applying the conventional unit root tests, i.e., augmented Dickey Fuller (ADF; Dickey & Fuller, 1981), and Phillips & Perron (PP; 1988). All variables were stationary at the level with a constant and deterministic trend.[3] This is further corroborated by the Lee & Strazicich (2003) test, which accounts for two structural breaks in the series. All test results are presented in Table 2 with their breakpoints obtained from the break fractions λ_j. Based on the unit root test results in Lee & Strazicich (2003), all variables were stationary at the level. The test results further suggest that, based on the timing of the breaks, the crises that occurred over the study period significantly affected the evolution of the variables.

[2]All series in the study were included in the analysis based on their annual percentage changes. Therefore, the estimation covers 1991:Q1 to 2020:Q1

[3]The results of the ADF and PP tests are not reported in the article to save space, but are available upon request from the corresponding author.

Table 2

Unit Root with Two Structural Break Test Results

Variables	Crash Model			Break Model		
	LM Statistics	Break Points		LM Statistics	Break Points	
gdp_t	-4.945***	1997:Q4	2001:Q4	-5.152***	2007:Q3	2011:Q3
$co2_t$	-6.287***	2006:Q4	2017:Q4	-6.713***	2012:Q2	2017:Q2
$tour_t$	-6.634***	2001:Q1	2010:Q3	-6.767***	1998:Q3	2003:Q1
en_t	-5.239***	2003:Q2	2017:Q3	-5.943***	1998:Q3	2001:Q4

Notes: The general-to-specific approach is employed to determine the optimal lag length, with a maximum of 6 lags allowed. The critical values were obtained from Lee & Strazicich (2003). Only breaks in the intercept are permitted in the Crash Model, whereas breaks in both the intercept and the trend are permitted in the Break Model. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Methodology

This study analysed the impacts of tourism activities, economic growth, and energy demand on carbon emissions through time-varying responses and forecast error decompositions, based on the TVP-VAR model proposed by Primiceri (2005). The TVP-VAR model allows a flexible and robust definition of the parameters to capture the possible time-varying nature of the underlying structure of the data. Time variation emerged from both the slope coefficients and the variance-covariance matrix of the innovations. All parameters in the TVP-VAR model specification enable both a temporary and a permanent shift that is assumed to follow the first-order random walk process (Nakajima, 2011a, b)

The TVP-VAR model consists of a measurement equation and transition equations that allow for changes in the parameters over time. Accordingly, the measurement equation of the model was expressed as follows:

$$y_t = c_t + B_{1,t}\,y_{t-1} + \ldots + B_{p,t}y_{t-p} + u_t \qquad u_t \sim N(0,\Omega_t), \tag{2}$$

where y_t and c_t are an $(n \times 1)$ vector of the observed dependent variables and intercepts, respectively. B_{it} are $(n \times n)$ time-varying coefficient matrices. The independent structural shock in the model specification equation is shown by u_t with $(n \times 1)$ dimensions. u_t is assumed to be normally distributed with the time-varying variance–covariance matrix Ω_t. The time-varying variance-covariance matrix can be decomposed as follows:

$$\Omega_t = A_t^{-1} H_t (A_t^{-1})', \tag{3}$$

where A_t is a lower triangular matrix that employs the evaluation of the simultaneous relationships of all variables. The stochastic volatilities on the diagonals are measured by the H_t matrix. These two matrixes can be written as below:

$$A_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ \alpha_{21,t} & 1 & 0 & 0 & 0 \\ \alpha_{31,t} & \alpha_{32,t} & 1 & 0 & 0 \\ \alpha_{41,t} & \alpha_{42,t} & \alpha_{43,t} & 1 & 0 \\ \alpha_{51,t} & \alpha_{52,t} & \alpha_{53,t} & \alpha_{54,t} & 1 \end{bmatrix} H_t = \begin{bmatrix} h_{1,t} & 0 & 0 & 0 & 0 \\ 0 & h_{2,t} & 0 & 0 & 0 \\ 0 & 0 & h_{3,t} & 0 & 0 \\ 0 & 0 & 0 & h_{4,t} & 0 \\ 0 & 0 & 0 & 0 & h_{5,t} \end{bmatrix}, \tag{4}$$

Based on Primiceri (2005) and Nakajima (2011a, b), the transition equations shown below were used to represent changes in the time-varying parameters in the state-space form:[4]

$$\Theta_t = \Theta_{t-1} + v_t \qquad v_t \sim N(0,Q), \tag{5}$$

[4]Because the random walk model is nonstationary by its structure, following Cogley & Sargent (2005), the stability constraint is imposed on the evolution of the time-varying parameters.

$$\alpha_t = \alpha_{t-1} + \zeta_t \qquad \zeta_t \sim N(0, S), \tag{6}$$

$$\ln h_{(i,)_t} = \ln h_{(i,)_{t-1}} + \sigma_i \eta_{it} \qquad \sigma_i \eta_{it} \sim N(0, 1), \tag{7}$$

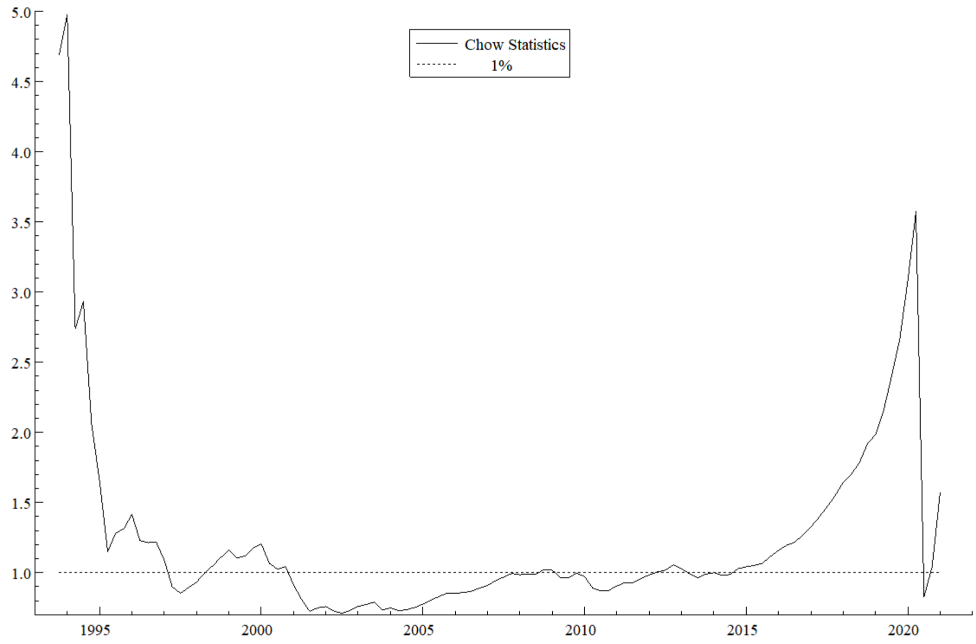
The time-varying parameters of Θ_t and α_t are assumed to follow a random walk process, based inequations 5 and 6, respectively. Stochastic volatility h_t is defined in equation 6, which implies the following independent geometric random walk process. Following Primiceri (2005), the coefficients for the contemporary linkages within the variables are assumed to vary in each equation.

Empirical Findings

Before estimating the TVP-VAR model, we first analysed the parameter stability of the VAR coefficients by estimating the linear VAR model using recursive least squares. Based on this estimate, we calculated the recursive residuals and conducted the Chow breakpoint test. The test result (Figure A2) indicated numerous parameter instabilities in the linear VAR model, which can be linked to the consequences of the economic downturn that occurred during the analysis period. The linear VAR model experienced significant parameter instabilities due to both local and global economic crises at the end of the analysis period. These were indicated by the results of the recursive Chow breakpoint test (Figure 1). This suggested that to appropriately account for nonlinearity in the residual generating mechanism, a time-varying model should be used.

Figure 1

The Chow Statistics Obtained from the Recursive Estimation of the Linear VAR Model



The linear model's instabilities prompted the estimation of the TVP-VAR model using a Bayesian approach, specifically the Markov Chain Monte Carlo (MCMC) technique. This technique allows the estimation of time-varying parameters in relation to unobserved latent variables. The Watanabe & Omori (2004) multi-move sampler was used to generate samples from the exact posterior density of the stochastic volatility, as described by Nakajima, Kasuya & Watanabe (2011). We employed a multi-move sampler to extract a total of 50,000 samples from the posterior distribution. We discarded the initial 5,000 samples as a burn-in sample. Table 3 presents the standard deviations, lower and upper 95% confidence intervals, and posterior averages of the selected parameters derived from the MCMC estimation of the TVP-VAR model.

Table 3

Estimation Results of Selected Parameters of the TVP-VAR model

Parameter	Mean	S.D.	95%L	95%U	CD	Inefficiency
$(\Sigma_\Theta)_1$	0.021	0.003	0.015	0.028	0.768	15.680
$(\Sigma_\Theta)_2$	0.020	0.003	0.016	0.026	0.373	10.500
$(\Sigma_\alpha)_1$	0.069	0.096	0.028	0.307	0.000	8.980
$(\Sigma_\alpha)_2$	0.053	0.033	0.030	0.119	0.024	12.520
$(\Sigma_h)_1$	0.367	0.060	0.269	0.505	0.217	10.200
$(\Sigma_h)_2$	0.503	0.076	0.371	0.669	0.123	48.930

Notes: The TVP-VAR model was calibrated using the following priors in Nakajima (2011a, b): $\Sigma_{\beta}{\sim}IW(25, 0.01I)$, $(\Sigma_\alpha)_i^{-2} \sim G(5, 0.02)$, $(\Sigma_h)_i^{-2} \sim G(5, 0.02)$. The i^{th} diagonal elements of Σ_α and Σ_h matrices are shown in $(\Sigma_\alpha)_i^{-2}$ and $(\Sigma_h)_i^{-2}$, respectively. The TVP-VAR estimation steps are detailed in Nakajima (2011a, b).

The analysis also included convergence diagnostics (CD) and inefficiency statistics. Based on Geweke's (1992) statistics, the null hypothesis of convergence to the posterior distribution was not rejected for the parameters at a significance level of 5%. In addition, the factors of inefficiency were below 100, suggesting that the number of iterations was adequate for a stable estimation of the TVP-VAR model.[5]

Having estimated the TVP-VAR model, the time-varying responses derived from the time-varying variance-covariance matrix in Equation 4 were used to analyse the dynamics of the relationship among economic growth, energy consumption, tourism activities, and CO2 emissions. The responses are plotted in Figures 2 to 5, in which panel (a) presents the accumulated responses of the variables assuming that the model parameters do not change over time. This is achieved by estimating the linear version of the VAR model in Equation (2) using the least squares approach. Panels (b) and (c) present the cumulative time-varying responses. In panel (b), the responses are plotted in a three-dimensional space for the horizons $h = 0, 1, 2, ..., 12$, whereas panel (c) shows the cumulative responses at the horizon $h = 12$. The two standard error bands of the responses are also presented to evaluate the significance of the shocks over the sample period.[6]

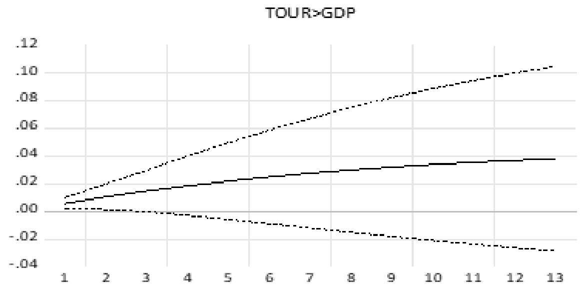
We first conducted an impulse-response analysis to examine the interaction between tourism and economic activity. Figures 2 and 3 display, respectively, the responses of tourism activity shocks to GDP shocks and tourism activity's responses to GDP shocks. The linear responses in Figure 2 indicate that a positive tourism shock leads to an increase in GDP growth, in line with previous studies (Ertugrul & Mangir, 2015; Gokovali, 2010; Gunduz & Hatemi-J, 2005). However, the time-varying responses suggest that the effects of the shocks vary over time. The effects of tourism activity first peaked during the 1994 financial crisis, when the Turkish lira was devalued against foreign currencies after the failure of economic stabilisation efforts. That is, a decline in the national currency's value seems to have created a competitive advantage, increasing tourism revenues at that time. Tourism shocks had the greatest effect between 2007 and 2012, which coincides with the only period of significant time-varying responses.

[5]As shown in Figure A2, the sample autocorrelation functions, sample paths, and posterior densities for the selected parameters indicated that the simulations generated stable and uncorrelated samples.

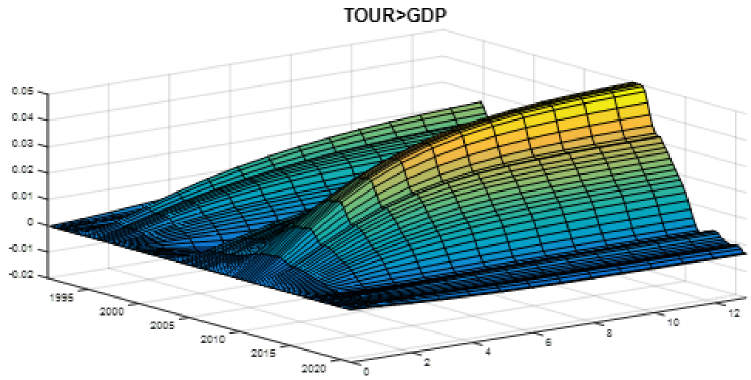
[6]As described in Nakajima (2011a, b), time-varying responses are generated by transforming the shock size into the time-series average of the stochastic volatility over the analysis period.

Figure 2

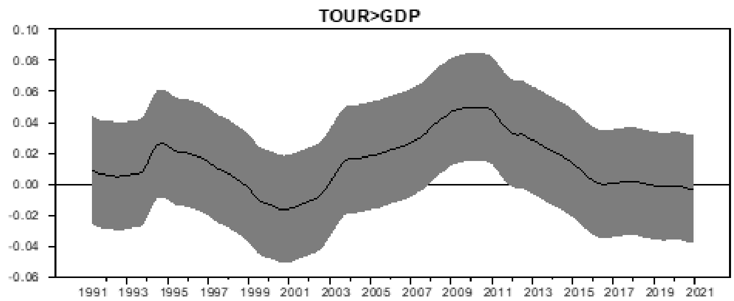
Responses of GDP Growth to Tourism Shocks



(a) Linear responses of tourism receipts to GDP shocks.



(b) Time-varying responses of GDP to tourism receipts in three-dimensional space

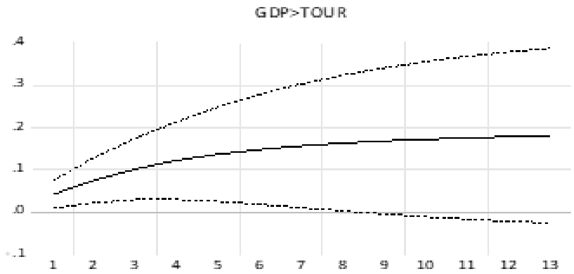


(c) Time-varying responses of GDP to tourism receipts at the 12th horizon

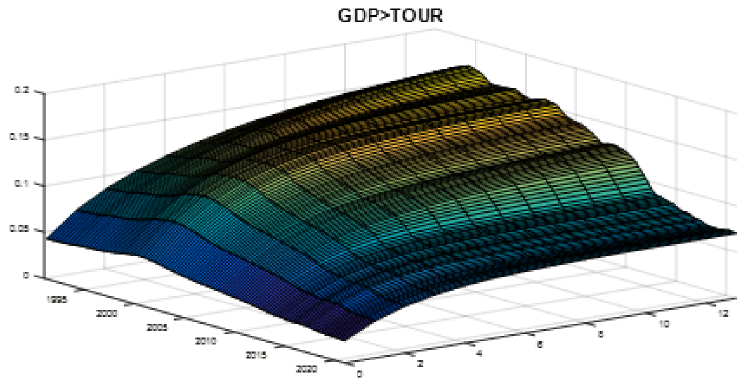
The linear and time-varying responses in Figure 3 also suggest that an increase in GDP leads to a rise in tourism activities in Turkey, in line with Balli et al. (2019). The time-varying responses further indicate that the reaction of tourism to GDP followed a stable path up to 2003. However, it then declined steadily before becoming insignificant.

Figure 3

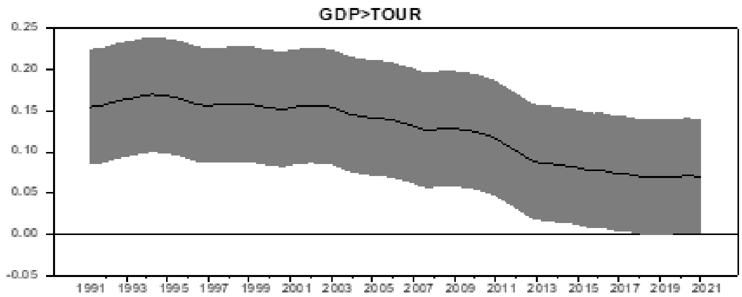
Responses of Tourism to GDP Growth Shocks



(a) Linear responses of tourism receipts to GDP



(b) Time-varying responses of tourism receipts to GDP in three-dimensional space

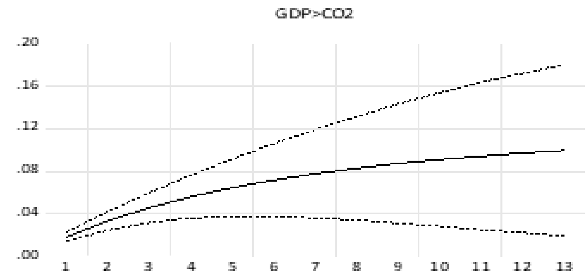


(c) Time-varying responses of tourism receipts to GDP at the 12th horizon

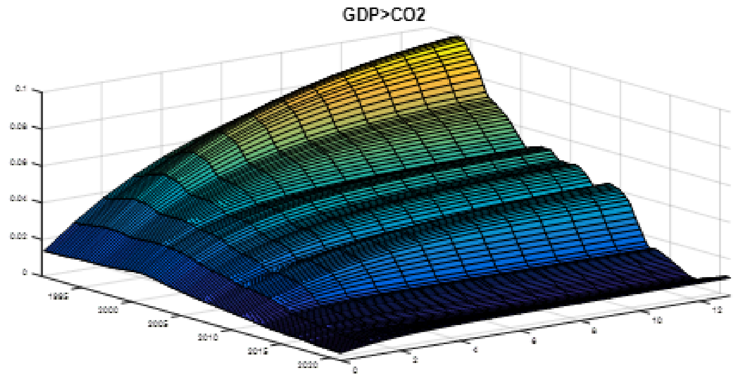
Having examined the interaction between GDP and tourism activities, we then investigated the potential time-varying effects of the variables on CO_2 emissions. Figure 4 shows that the CO_2 emissions derived from the linear VAR model grow as the overall economic activity increases. This is consistent with Eyuboglu & Uzar (2020), Çetin, Aslan & Sarıgül (2022), and Çetin, Sarıgül, Topcu, Alvarado & Karataser (2023). The time-varying responses indicate that the effect of GDP on CO_2 emissions declines over time. The positive effects of GDP shocks became insignificant before the 2001 crisis.

Figure 4

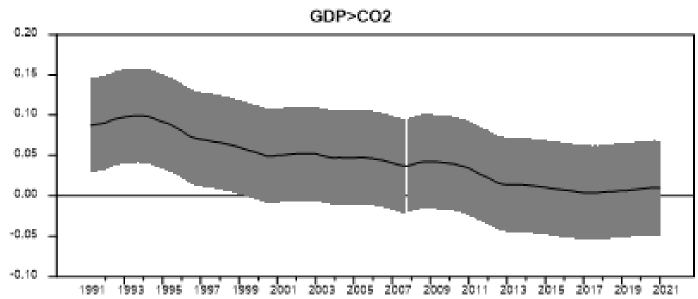
Responses of CO2 to the GDP Shocks



(a) Linear responses of CO2 to GDP



(b) Time-varying responses of CO2 to GDP in three-dimensional space

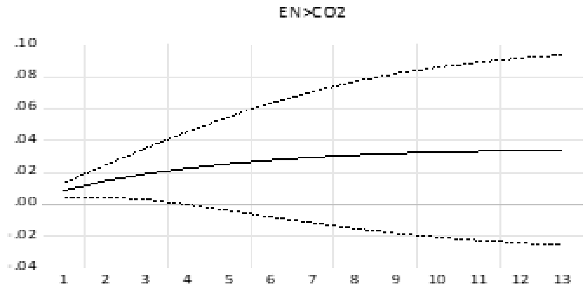


(c) Time-varying responses of CO2 to GDP at the 12th horizon

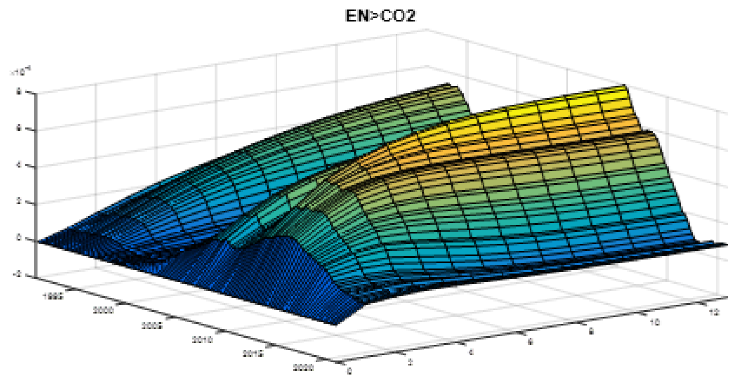
The linear VAR estimates presented in Figure 5 suggest that the accumulated effect of energy consumption shocks on CO2 emissions is positive and significant for a limited time. This finding agrees with the results of Pegkas (2020) for Greece. However, the time-varying responses indicate that the positive impact of energy consumption on emissions varied over the analysis period. The greatest impact of energy consumption was recorded after the 2008 global financial crisis. The responses then became insignificant from 2015 at the end of the investigation period.

Figure 5

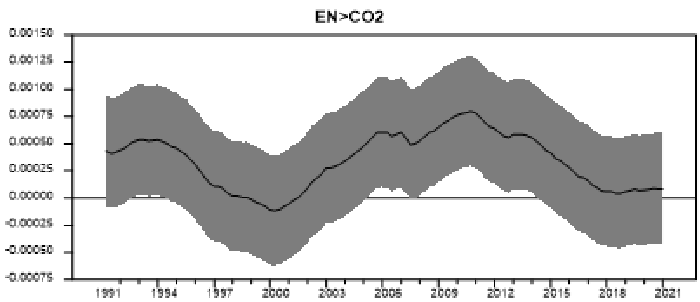
Responses of CO2 to Energy Consumption Shocks



(a) Linear response of CO2 to energy consumption shocks



(b) Time-varying responses of CO2 to energy consumption shocks in three-dimensional space

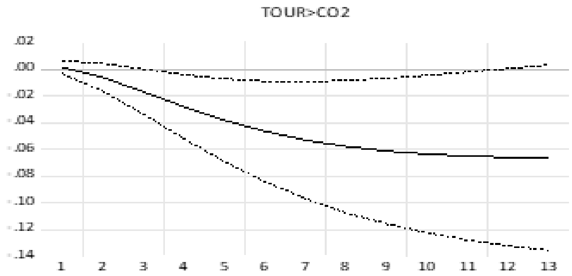


(c) Time-varying responses of CO2 to energy consumption shocks at the 12th horizon

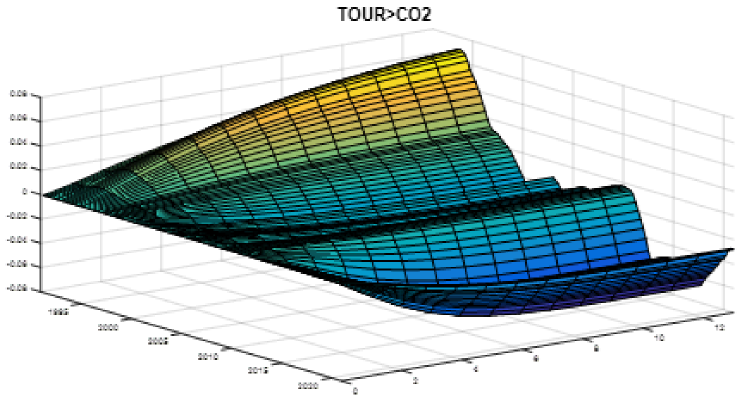
Figure 6 shows the effects of tourism revenue shocks on environmental pollution. The linear responses reported in panel (a) indicate that positive tourism activity shocks reduce CO2 emissions. This finding agrees with Bella (2018) for France and Yıldırım, Yıldırım, Aydın & Erdoğan (2021) for the Mediterranean countries. The time-varying responses indicate that the signs and magnitudes of tourism shocks on CO2 emissions varied over time, but they had an insignificant effect over the entire analysis period. For example, tourism shocks initially had a positive but insignificant effect on CO2. However, the sign of the time-varying response turned negative after the 2001 financial crisis to have its greatest negative effect in 2013. The responses became negative and significant in some periods before becoming insignificant by the end of the analysis period.

Figure 6

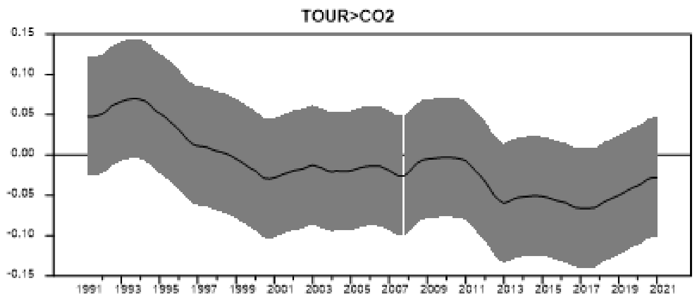
Responses of Carbon Emission to Tourism Activity Shocks



(a) Linear response of CO2 to tourism receipt shocks



(b) Time-varying responses of CO2 to tourism receipt shocks in three-dimensional space



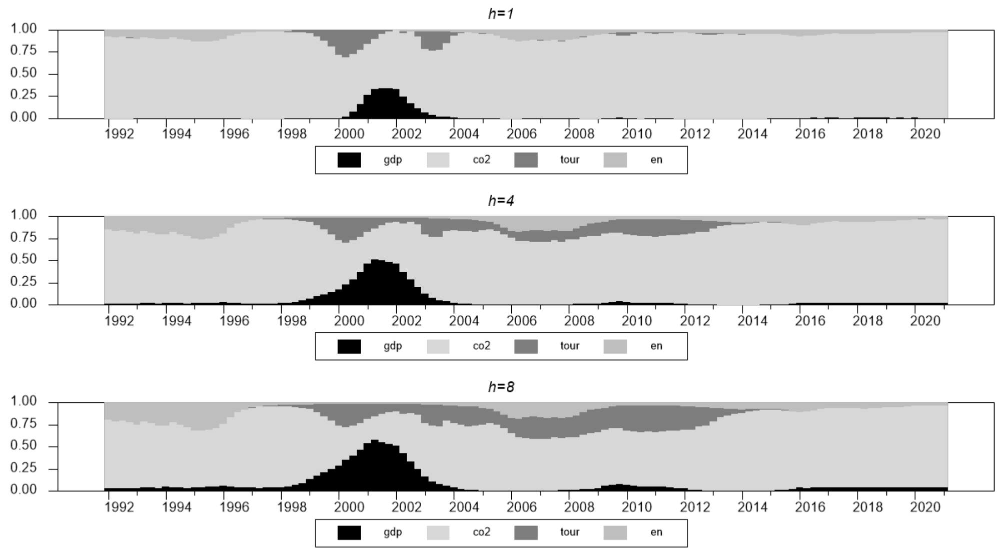
(c) Time-varying responses of CO2 to tourism receipt shocks at the 12th horizon

We next conducted a time-varying forecast error decomposition analysis to assess the relative importance of the factors in explaining CO2 emissions. Figure 7 displays the time-varying decompositions of CO2 at the $h = 1, 4,$ and 8 quarter horizons. The first thing to note is that most fluctuations in CO2 emissions are explained by their own shocks, although the portion explained by the remaining variables varied significantly over time. For example, at $h = 1$, the own shock of the variable explains around 93.1% of the variance in CO2 emissions, whereas energy consumption explains 6.5% of the CO2 shocks at the beginning of the analysis period. At that time, the contribution of GDP and tourism activity was less than 1%.

Extending the forecast horizon to eight quarters significantly increases the influence of these variables. At the eighth quarter forecast horizon, energy consumption after the CO2 shocks at the beginning of the analysis period is the largest contributor for explaining the variations in CO2 emissions. At that time, energy consumption accounted for about 18% of the CO2 changes, whereas GDP accounted for 3.8%, and tourism had a negligible impact. In the first quarter of 1995, which corresponds to the aftermath of the 1994 crisis, energy consumption explained 31% of the variations in CO2 emissions. After that, the explanatory power of energy consumption declined, whereas that of GDP and tourism activities rose. In the first quarter of 2001, the explanatory power of GDP variable shocks to explain CO2 shocks peaked at 58%, while the variable's power to explain its own shocks increased to 27%. The explanatory power of GDP shocks then gradually declined to below 3% in 2004:Q4. GDP shocks accounted for 5.3% of the CO2 change in 2021:Q1, at the end of the study period, when CO2 explained 91.8% of its own shocks. At the end of 1999, tourism shocks, which only explained 4% of the CO2 variation in 1998, became one of the most important variables alongside GDP, explaining 19.3% of the CO2 variations. In 2011:Q1, tourism activity shocks had the highest explanatory power (31%), overtaking GDP as the most significant variable. However, its explanatory power fell to 5.5% in 2013:Q4 before remaining below 1% until the end of the analysis period.

Figure 7

Time-varying decompositions of CO2 emissions obtained from the TVP-VAR at alternative forecast horizons



Conclusion

This article examined the impact of GDP, energy consumption, and tourism activity on environmental degradation in Turkey over time. Our findings indicate numerous parameter instabilities associated with local and global economic crises. The presence of significant multiple parameter instabilities implies that, when compared to other potential candidates, such as Markov regime switching or threshold VAR, the TVP-VAR model is more appropriate for precisely assessing the effects of tourism activities and other potential variables on CO2 emissions.

In general, the time-varying responses and forecast error decompositions obtained from the TVP-VAR confirm prior research that applied linear estimating approaches. Our findings indicate that GDP growth increases CO2 emissions in Turkey. In contrast, tourism activities do not cause significant environmental harm in Turkey, although the influence of shocks on carbon emissions varies over time in terms of sign and size. In particular, economic growth and energy consumption both have positive and time-varying effects on CO2 emissions. However, tourism activities have a negative influence on environmental degradation while tourism shocks have a negligible impact over most analysis period. The results of the time-varying variance decompositions corroborate the results of the impulse-response analysis in that primary energy consumption and economic growth account for more of the variation in emissions over the majority of the study period. However, tourism activity has less explanatory power than the other variables under consideration.

Overall, our empirical results have two important policy implications for the tourism sector in Turkey. First, the evidence that tourism has less impact on CO2 emissions than overall economic activity and energy consumption indicates that the Turkish economy can provide more incentive to expand tourism, given its potential to contribute to economic growth while causing less environmental pollution than other sectors. Second, our findings reveal a downward trend in the expansionary effect of tourism shocks on overall economic activity, which is influenced by local and global economic crises. This suggests that policymakers should implement policies to diversify Turkey's economic structure to avoid becoming overly reliant on tourism revenues. Furthermore, designing policies to account for future tourism shocks would be a rational choice to achieve sustainable growth in Turkey.

Due to its location in the Mediterranean basin, Turkey has significant tourism potential. This study examined only the Turkish economy. Hence, our policy recommendations cannot necessarily be adopted by other countries in the region. Thus, future studies can analyse tourism policies in more detail by including other countries in the Mediterranean basin with important tourism sectors.

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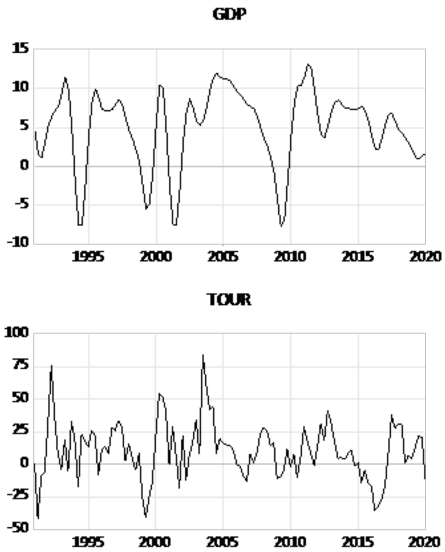
Appendix | Ek

Appendix 1

GDP, Tourism Revenues, Energy Consumption and Carbon Emissions in Turkey



Appendix 2

Diagnostics of the TVP-VAR Model