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Do Energy Transition and International Tourism Mitigate Environmental Emissions? The Case of SCO Economies

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ABSTRACT

This study examines the role of energy transition and international tourism in alleviating environmental emissions in the case of selected Shanghai Cooperation Organization (SCO) countries for 1992–2022. Ecological footprint has been taken as a proxy for environmental emissions. Along with energy transition and international tourism, GDP per capita is also incorporated as an independent variable to check the validity of the Environmental Kuznets Curve (EKC) hypothesis. To find the cross-sectional dependency among selected economies, the cross-sectional dependence (CD) test was used. Due to geographical reasons, cross-country spillover special effects are possible among the eight SCO economies. After testing the unit-roots of the variables, two empirical approaches have been used for the empirical findings: fixed effect regression with Driscoll-Kraay (DK) standard errors and the method of moment's quintile regression (MMQR). The empirical results indicate that the EKC hypothesis is not valid in the case of the eight selected SCO countries. Though energy transition has reduced environmental emissions in the economies under consideration, the impact of international tourism on the population is statistically insignificant. We can conclude and propose for countries in this region to focus on renewable energy sources.

Keywords: Shanghai Cooperation Organization, Ecological footprint, Energy transition, Environmental degradation, international tourism

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INTRODUCTION

Energy and environmental problems are interconnected, as energy production and consumption significantly affect our environment, including air pollution, water contamination, climate change, and heat pollution (Dinçer, 1998). Addressing these issues requires the transition to cleaner and more sustainable forms of energy. Various factors are involved in environmental destruction, such as using fossil fuel energy, high levels of emissions of CO2 and sulfur dioxide, pollution in the air, and the greenhouse effect (Omer, 2008). The energy transition discusses the change in the international energy sector from traditional fossil fuels to renewable energy sources. It is a well-known fact that as we move toward an energy transition, the quality of the ecosystem undergoes improvement (Saidi & Omri, 2021). Renewable energy uses strategies that can help achieve sustainable development goals set by the United Nations Organization (UNO) so that climate change may be mitigated. In this context, modern technology reduces the destruction of ecosystems through energy transition.

Tourism has become an important industry worldwide, but conversely, it has a meaningfully undesirable impact on our environment (Scott et al., 2012). The major problem in this regard is the depletion of natural resources due to overconsumption. Tourists often consume more resources than residents can provide, leading to a resource shortage (Satrovic & Adedoyin, 2023). This puts pressure on the environmental quality, and leads to soil erosion, water scarcity, and damage to natural habitats (Ahmad et al., 2019a). Tourism also contributes to pollution and waste problems, as many destinations need more infrastructure to handle the waste generated by large numbers of visitors (Apergis et al., 2010). Tourism can also harm wildlife and endanger the species as tourism activities destroy or disturb their habitats (Balsalobre-Lorente et al., 2020; Teng et al., 2021).

According to the key messages of the Intergovernmental Panel on Climate Change Working Groups (IPCC, 2023), "mitigation" in the context of climate change refers to human actions aimed at reducing the emission of greenhouse gases (GHG) to reduce the harshness of climate change. The effect of unrestrained climate change on human and natural ecosystems is becoming increasingly visible. In the past two decades, numerous manuscripts have been written about the environmental sways in the growing economies. The authors generally accept the Environmental Kuznets Curve (EKC) hypothesis, which examines how the quality of the environment declines in countries having low-income levels and improves in nations with high-income levels (Gill et al., 2018).

Energy is a well-known and essential driver for the growth and development of an economy and a source of economic well-being (Lamb & Steinberger, 2017). In 2015, an international agreement was signed during a climate-related conference in Paris, France. The international forces agreed to set up the goal of keeping global warming below two °C as compared to the pre-industrial era by the end of this century. In 2021, the World leaders again met in Glasgow and committed to reducing the temperatures by 1.5°C. They reiterated their commitment to become carbon neutral by 2050 (Weisser & Müller-Mahn, 2016).

From a historical perspective, energy transition is not a new phenomenon. There have been significant revolutionary changes in the past; for example, the transition from wood to coal in the 19th century to obtain energy for daily use and from coal to oil during the Industrial Revolution in the 20th century. In just ten years (2010–2019), the cost of renewable energy technologies has decreased by 80% for solar energy and 60% for onshore wind energy (Elia et al., 2021). The energy transition is not just about phasing out coal-fired power generation and developing clean energy; it is a system-wide paradigm shift. The energy transition must be inclusive and leave no one behind. Climate change and energy policy will affect the world's energy system in the next decade. The rapid fall in the prices of renewable energy technologies around the world is opening unprecedented opportunities. Sustainable development in many countries shows good prospects for security, inclusion, and sustainability in a changing energy sector (Strielkowski et al., 2017). Environmental recovery relies on quick fixes and upgrades for the future using all available technologies.

Significant changes are needed in the energy sector of all countries, to improve energy efficiency and productivity (Finman & Laitner, 2001). In this regard, changes must be adopted in consumption patterns and lifestyles. With the ever-expanded use of renewable energy for electricity distribution and direct use in all regions of the world, the energy transition is spreading. So, there is a need to reorganize and develop the energy sector's infrastructure to utilize abundant resources better. An upgraded system for electrification of new services mainly used in transport is also required. The transition is ongoing and widespread in some countries and regions, including SCO countries (Hamid et al., 2021). However, it is well known that the speed and extent of the transition varies from country to country. Innovations in technology, business models, and market solutions are also needed so that existing capabilities can continuously improve until 2050. Many countries are closing the gap between carbon-neutral energy systems, considering national conditions (Elavarasan et al., 2022).

The current research will be an important addition to the literature concerning the EKC hypothesis and economic growth impact, by employing the prominent variables that are pointers of environmental degradation (ecological footprint). Here, we have considered the cross-sectional dependency among the eight SCO economies before examining the influence of energy transition and international tourism on environmental emissions.

LITERATURE REVIEW

Developing an inclusive policy outline for sustainable development is a challenge confronted by the majority of countries around the globe, including developed countries that have already created an environment-oriented policy for success (Schubert & Sedlacek, 2005). Moreover, researchers around the globe have a keen interest in studying climate change, environmental security, and energy transition (Markard et al., 2012). Renewable energy or energy transition is one of the critical factors of the 2030 agenda regarding sustainable development (Androniceanu & Sabie, 2022).

Energy Transition Impact on Environmental Degradation

The term ‘‘sustainability’’ has been discussed, by multiple scholars and stakeholders. Several researchers have focused on environmental sustainability by employing the key pillars of energy transition namely energy access, energy efficiency, and energy security. In this regard, researchers have focused on CO2 emissions (Ahmad et al., 2019b; Alola et al., 2022; Hamid et al., 2021; Murshed et al. 2022; Nathaniel et al., 2021; Rehman et al., 2021; Saidi & Omri 2020). By employing the carbon productivity variable, other researchers have tried to explore the impact on environmental degradation (Long et al., 2020; Alam et al., 2022). Moreover, by using the ecological footprint as a proxy for environmental alleviation, some researchers have found that in developed economies, the energy transition has significantly affected environmental degradation (Sharma et al., 2021; Pata, 2021; Huang et al., 2022).

Several studies suggest that the energy transition has helped reduce environmental degradation (Scott et al., 2012; Gill et al., 2018) In this regard, researchers have used different variables to assess the transition impact. Foreign direct investment (FDI) affects the environmental quality. The analysis of historical data from many countries proves that renewable energy positively impacts economic growth (Huang et al., 2022). Various studies show a bidirectional causal relationship between CO2 emissions, renewable energy sources, education, and other factors. Empirical evidence supports the fact that there is a need to invest in both renewable energy and the education sector (Zafar et al., 2021; Lamb & Steinberger, 2017).

Moreover, for the sake of comprehensive outcomes of the environmental effect of the energy transition, a research study conducted by Li and colleagues (2021) examined structural changes in the energy sector, such as renewable energy, industrial development, and urbanization. They also used trade openness at both baseline and intermediate levels. Data was collected from 1995-2014 in the middle and high-income countries. The results showed an inverted U-shaped relationship between renewable energy and environmental footprint. The energy transition and international tourism play an imperative role in reducing environmental degradation. Satrovic and Adedoyin, (2023) examined the Environmental Kuznets Curve from 1997 to 2018. Using ecological footprint as the indicator of environmental degradation, the OLS and panel quintile regressions were applied. Empirical results suggest that energy dynamics and global travel are essential in moderating environmental degradation (Saidi & Omri, 2021).

Apergis and colleagues (2010) explain that energy security and climate change are becoming increasingly essential challenges for numerous countries worldwide. They use a panel error correction model to examine the relationships among variables such as CO2 emissions, nuclear energy consumption, and economic growth in a mixed panel of nineteen developed and developing countries from 1984-2007. The empirical results confirmed that the role of nuclear power in reducing CO2 emissions is essential. Nuclear power consumption exerts a negative and statistically significant impact on carbon emissions. A two-way causality was observed between renewable energy consumption and economic growth. The authors believe that renewable energy development reduces import-dependent economies' dependence on foreign energy sources and oil-related energy consumption.

Using the data ranging from 1980-2014, Dogan and Ozturk (2017) tested the EKC model. The primary variables used were CO2 emissions, real income, and real income squared. The Autoregressive Distributed Lag Stationarity (ARDL) model showed that increased use of renewable energy may help reduce environmental degradation. Conversely, the increasing use of non-renewable energy contributes to environmental degradation and CO2 emissions. Moreover, the EKC assumptions are reported as wrong. Using time series econometric methods by structural differences in the data, the results of the research study were robust, consistent, and precise. The governments should focus more on renewable energy and cleaner technologies. While similar findings obtained by Wang and colleagues (2022) stated that energy transition alleviates environmental degradation in the case of upper and lower-middle economies.

Tourism's Impact on Environmental Degradation

Nowadays, tourism is regarded as a critical sector in the world economy that is experiencing significant growth in developing countries and is cited as an essential indicator of development and poverty reduction in the world's developing countries (Teng et al., 2021). The tourism industry is considered a highly complex sector for climate change, which implies that both environmental and socio-economic changes result from international travel activities, with an increasing contribution to climate change.

A complex relationship between climate change and numerous components of the international tourism system has been studied while following five focus themes. Such themes are recognized in literature, focusing on the influence of climate variations on tourism. The five thematic areas include (i) climate, (ii) temporal, (iii) geographical changes in travel demand, (iv) climate-induced ecological deviations, and (v) destination competition in three main market segments (Scott et al., 2012).

Similarly, an empirical analysis presented by Balsalobre-Lorente and colleagues (2020) shows that climate change is amplified by energy consumption and tourism along with economic growth. There is also an inverse U-shaped relationship between international tourism and CO2 emissions. Therefore, the role of worldwide tourism in climate change at an initial growth stage has been reduced internationally. Moreover, the carbon footprint and climate change on the global tourism business, mainly the aviation industry, have been studied by Leal Filho and colleagues (2023). By exploring the nexus of tourism and environmental degradation, Shahbaz and colleagues (2021) stated that tourism is one of the most critical indicators that significantly affect environmental degradation.

Furthermore, Raza and colleagues (2021) found a non-linear association between tourism and environmental degradation. By using the Panel smooth transition regression (PSTR) model, findings suggested that non-linearity between these two variables is mainly regime dependent. There was a negative and significant relationship between underlying variables above the threshold level. However, this relationship was positive and statistically significant while below the threshold level. Similarly, Ahmad and colleagues (2019a) found that the relationship between tourism and environmental degradation is non-linear. This relationship varies for different economies in the same region because of the country's different demographic and environmental characteristics.

Moreover, utilizing the top ten worldwide spots, Jebli and Hadhri (2018) found a negative correlation between tourism and environmental degradation as the emissions declined. In the case of the Organization for Economic Co-operation and Development (OECD) economies, Dogan and colleagues (2017) endorse that tourism tends towards higher carbon emissions, and trade is positively correlated with environmental quality. Furthermore, increased tourism leads to a higher quantity of solid waste. Using panel data from EU economies, Arbulú (2015) suggests a strong association between tourists' arrival and waste generation. The study highlights the need for further efforts to address environmental concerns related to tourism and aviation. They found that while the industry has adopted some sustainable practices, top airlines need a coherent strategy to reduce carbon emissions.

Empirical Model

In the current section of the study, we will discuss the study's theoretical background and a model specified in the case of eight SCO economies for the period 1992-2022. We are taking the Environmental Kuznets Curve (EKC) hypothesis as the theoretical background of our study. A famous environmental economist, Simon Kuznets, first proposed this hypothesis in the 1950s and 1960s. The inverted U-shaped curve is known as the Kuznets curve. The theory recommends that as a country starts achieving higher growth rates through industrialization, the country's economy will undoubtedly become a metropolis, which will have a deteriorating impact on the environment (Gill et al., 2018). Based on the fundamental theoretical background of the EKC hypothesis, the functional form of the model is written empirically in the following way:

$$\mathrm{EP_{it}} = \mathrm{f(GDP_{it}, GDP_{it}^2, POP_{it}, ET_{it}, IT_{it})} \quad \ldots\ldots (1)$$

Equation (1) given EP above denotes the environmental pollution will be measured in terms of ecological footprint (EP) through carbon dioxide emissions, while GDP represents the gross domestic product (GDP) of a country. The terms $GDP\ and\ GDP^2$ indicate the economic growth and its quadratic form, respectively. Squared terms indicate the environmental Kuznets hypothesis. The negative coefficient value will justify the validity of the EKC hypothesis. The notation POP illustrates the population, ET shows the energy transition, and IT indicates international tourism. The subscripts i and t represent the cross-section and time, respectively. All the variables mentioned above are converted to the logarithmic form as below:

$$L(EP_{it}) = \beta_o + \beta_1 L(GDP_{it}) + \beta_2 L(GDP_{it}^2) + \beta_3 L(POP_{it}) + \beta_4 L(ET_{it}) + \beta_5 L(IT_{it}) + \varepsilon_{it} \ldots (2)$$

METHODOLOGY

This section comprises of information about the selected data and empirical techniques that explore the role of energy transition, economic growth, international tourism, and population in alleviating environmental degradation.

The Data

The annual data for 1992-2022 has been collected on the selected variables for a panel of eight Shanghai Cooperation Organization (SCO) economies consisting of the Republic of China, India, Kazakhstan, Kyrgyzstan, Russia, Pakistan, Tajikistan, and Uzbekistan. Data on ecological footprints, used in this study, has been collected by the Global Footprint Network (GFN). Data on GDP per capita, population growth rate, energy transition, and international tourism have been acquired from the World Bank's World Development Indicators (WDI) database. We have summarised the overall description of the selected variables in Table 1.

Table 1
Description of underlying variables

Acronyms	Variables	Description	Source
EP	Ecological Footprint	Ecological footprint taken as global hectares per capita	GFN
GDP	GDP per capita	Gross domestic product per capita at constant 2015 USD	WDI
POP	Population	Population employed (employment-to-population ratio, 15+, total), %	WDI
ET	Energy Transition	Renewable energy consumption, % of total final energy consumption	WDI
IT	International Tourism	Expenditures for passenger transport items	WDI

Source: https://www.footprintnetwork.org/; https://databank.worldbank.org/source/world-development-indicators

Table 2 comprises the descriptive statistics of the selected variables. The average value of the GDP per capita is about 3292.995 in the case of the SCO region. Whereas Kazakhstan stated the maximum GDP per capita, which is 7665.494 (Constant USD), Tajikistan reported a minimum value of 753.35. Moreover, 2.414 is the average value for SCO nations. However, a more significant total ecological footprint was reported in Russia (5.708); 0.772 is the minimum value in the case of Pakistan. If we look at the energy transition, the reported average value is 24.546.

Table 2
Descriptive statistics

Variable	Mean	Std.Dev.	Min.	Max.	Skewness	Kurtosis
EP	2.414	1.837	0.686	9.539	1.09	3.242
GDP	3292.995	3319.458	371.831	11402.76	1.168	2.891
POP	55.863	9.706	37.398	76.849	-.124	2.417
ET	24.546	20.837	0.720	64.58	.279	1.655
IT	8.61	1.24	1	6.051	2.049	6.678

Source: Authors' Estimation

The correlation matrix has been reported in Table 3, which illustrates a positive correlation among our variables including- ecological footprint, population growth, economic prosperity, as well as international tourism.

Table 3
Correlation Matrix

Variables	EP	GDP	POP	ET	IT
EP	1.000				
GDP	0.818*	1.000			
POP	0.494*	0.476*	1.000		
ET	-0.768*	-0.650*	-0.607*	1.000	
IT	0.305*	0.265*	-0.029*	-0.125*	1.000

Source: Authors' Estimation, while *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Estimation Methodology

To examine the important role of our variables i.e. energy transition and international tourism in alleviating environmental degradation in the case of eight SCO countries, we initially observed the existence of cross-sectional dependence through the targeted economies. The cross-sectional dependence (CD), being an effective test employed in this study was proposed by Pesaran (2004). Due to geographical reasons, cross-country spillover special effects are possible among the eight SCO economies. Furthermore, this study employed the Pesaran and Yamagata (2008) test to check the potential slope of heterogeneity. To check the stationarity of data, the cross-sectional augmented Dickey-Fuller test (CADF) and second-generation Pesaran test (CIPS) by Pesaran (2007) are used. The functional form of CADF and CIPS may expressed in the following way:

$$\mathrm{CIPS} = \mathrm{N}^{-1} \sum_{i=1}^{n} \mathrm{CADF} \ldots \ldots \ldots \ldots (3)$$

In the above equation (3) CADF shows the cross-sectional Augmented Dickey-Fuller test. Further formulation of this equation can be expressed as:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \delta_{0i}\Delta\bar{y}_t + \delta_{1i}\Delta\bar{y}_{t-1} + \varepsilon_{it} \dots \dots . (4)$$

The null hypothesis is that $H_o: \beta_i = 0$ for all selected SCO countries, and the alternative hypothesis is that $H_1: \beta_i < 0$.

To test whether the selected variables correlated in the long term, the co-integration test proposed by Westerlund (2007) was used. The tests conducted with no co-integration assumed that the examined variables do not have a dynamic long-run relationship. The OLS regression with Driscoll-Kraay (DK) standard errors can used to measure long-run estimates once the long-term relationship has been verified. The mentioned regression (OLS) with DK standard errors may also have some drawbacks: It only yields mean estimates and is unable to reveal the differences among inspected individuals at different levels of quantiles. Our focus in this research is to use the panel Method of Moments Quantile Regression (MMQR) with fixed effects to fill up these gaps (Machado & Silva, 2019). Utilizing the following formula, the MMQR can be estimated:

$$Q_{LECFP}(\tau|X_{it}) = \beta_{1\tau}LGDP_{it} + \beta_{2\tau}LGDP_{it}^2 + \beta_{3\tau}LET_{it} + \beta_{4\tau}LIT_{it} + \beta_5 LPOP_{it} + \alpha_i \dots \dots \dots (5)$$

Equation 5 represents the LEP as a dependent variable, while α_i shows the unnoticed discrete effects.

In the primary stage, while performing analysis, we conducted the cross-sectional dependence test as well as heterogeneity analysis by obtaining the log values of the fundamental variables to assess the legitimacy of the EKC hypothesis in the mentioned SCO nations (Table 4).

Table 4
Results of cross-sectional dependence (CD) tests based on Pesaran's test (2004)

Model 1				
Variable	CD-test	p-value	Corr.	abs(Corr)
LEP	2.100	0.035	0.071	0.332
LGDP	27.600	0.000	0.937	0.937
$LGDP^2$	27.670	0.000	0.939	0.939
LPOP	5.340	0.000	0.181	0.443
LET	7.370	0.000	0.250	0.344
LIT	2.480	0.013	0.084	0.396

Pesaran's test of cross-sectional dependence = 2.044, Pr. = 0.0410

The values are taken in average absolute terms of the off-diagonal elements = 0.405

Source: Authors' Estimation

At the 1% significance level, the CD test outcomes demonstrate that our null hypothesis about cross-sectional independence has been rejected. Hence, cross-sectional independence for our models is refuted by Pearson's cross-sectional dependence tests. The unit root tests for panel data outperform first-generation tests since the null hypothesis on slope uniformity is also rejected (Table 5).

Table 5
Unit root tests overlook the cross-sectional dependence.

Variables	At level	At 1st difference
LEP	-2.4216	-2.2762
	(0.0002)	(0.0114)
LGDP	-2.1875	-2.5647
	(0.0038)	(0.0004)
$LGDP^2$	-3.4522	-2.0520
	(0.0014)	(0.0201)
LPOP	-4.4607	-3.6733
	(0.000)	(0.0001)
LET	-2.4307	-1.1336
	(0.0075)	(0.0128)
LIT	-1.8022	-2.9716
	(0.2067)	(0.0004)

Note: P-values are given in parenthesis

The insights derived from the CIPS test show that international tourism has unit root only at the level but becomes stationary as we take the first differences. The results confirm that total variables become stationary at the first difference. In the following step, the co-integration method suggested by Westerlund (2007) is applied to examine the long-term association among the variables. The obtained results are reported in Table 6. Westerlund co-integration test statistics show the presence of co-integration amid the variables, so we can reject the null hypothesis of no co-integration in most cases. Therefore, a long-lasting relationship exists amid ecological footprint and all other variables such as GDP, population growth, etc.

Table 6

Co-integration Test (Westerlund, 2007)

	LEP as a dependent variable	
Statistic	Value	P-value
Gt	-3.557	0.048
Ga	-11.200	0.993
Pt	-11.938	0.000
Pa	-12.146	0.086

Source: Authors' Estimation

The DK-OLS and MMQR approaches have been used to assess the long-run elasticities. The findings are presented in Tables 7 and 8, respectively. The fixed effects Regression results with Driscoll-Krray standard errors have been reported in Table 7. Our results pointed out that the coefficient on GDP is negative as well as statistically significant at a 1 percent level of significance. In comparison, its squared term is positive and significant at a 5 percent level. It indicates that no validity of the EKC hypothesis is proved for the selected eight SCO economies in the period ranging from 1992 to 2022. It has also been found that economic growth has a significantly undesirable (negative) influence on the ecological footprint suggesting that the energy transition hurts the ecological footprint. The transition towards the usage of renewable energy technologies is proven to be environmentally friendly, which reduces carbon emissions. The effect of universal tourism has been reported to be uncertainly significant at a 10 percent level. These findings are consistent with Damrah and colleagues (2022).

This study also used quantile regression. Findings of MMQR estimators illustrate that energy transition in all the quantiles has a negative and significant impact on the carbon intensity at a 1% level of significance, and these results are in line with Niu and colleagues (2022). At the same time, other variables have insignificant impact. The regression results of MMQR estimators are reported in Table 8. The obtained results demonstrate that in most cases, GDP coefficients are found to be negative and significant, while its squared terms are positive and significant. It is again proved that the EKC hypothesis is invalid in the SCO countries under consideration (Andreichyk & Tsvetkov).

Table 7
Driscoll-Krray Fixed Effects Model Results

Dependent variable: LEP Regression	Coefficients	DK standard errors
LGDP	-1.0019*	-3.26
$LGDP^2$	0.0489**	2.41
LPOP	0.4155	0.651
LET	-0.6587*	-6.670
LIT	-0.0234***	-1.94
Constant	6.3235**	2.02
No. of obs.	248	
No. of groups	8	
R^2 (within)	0.49	

*The notation * ' ** and *** show the significance at 1 %, 5 %, and 10 % respectively.*

Table 8
Method of Moments Quintile Regression Model Results; Dependent variable: LEP

Variable	0.1 QR	0.2 QR	0.3 QR	0.4 QR	0.5 QR	0.6 QR	0.7 QR	0. 8 QR	0.9 QR
LGDP	-1.07**	-1.053*	-1.039*	-1.025*	-1.014*	-0.999**	-0.972**	-0.944	-0.911
	(0.467)	(0.377)	(0.329)	(0.306)	(0.313)	(0.354)	(0.354)	(0.670)	(0.899)
LGDP^2	0.052***	0.052**	0.051*	0.050**	0.049**	0.049**	0.049**	0.046	0.044
	(0.029)	(0.024)	(0.021)	(0.019)	(0.019)	(0.022)	(0.022)	(0.042)	(0.056)
LPOP	0.021	0.122	0.197	0.281	0.345	0.428	0.428	0.747	0.937
	(0.486)	(0.392)	(0.342)	(0.318)	(0.327)	(0.370)	(0.370)	(0.697)	(0.935)
LET	-0.639*	-0.645*	-0.648*	-0.652*	-0.655*	-0.659*	-0.659*	-0.675*	-0.684*
	(0.139)	(0.113)	(0.098	(0.091)	(0.094)	(0.106)	(0.106)	(0.200)	(0.269)
LIT	0.012	-0.003	-0.004	-0.011	-0.017	-0.025	-0.025	-0.053	-0.070
	(0.027)	(0.021)	(0.019)	(0.0175)	(0.018)	(0.021)	(0.021)	(0.038)	(0.051)

*Note: The standard errors are given in parentheses. The notations * ' ** and *** show significance at 1 %, 5 %, and 10 % respectively.*

DISCUSSION

This study examines the effect of energy transition and international tourism on environmental emissions in the eight Shanghai Cooperation Organization (SCO) countries using annual data for the period 1992 -2022. Ecological footprint has been taken as a proxy for environmental degradation. Along with energy transition and international tourism, GDP per capita is also incorporated as an independent variable to check out the validity of the environmental Kuznets curve (EKC) hypothesis. The unit root test, the fixed effect regression with Driscoll-Kraay (DK) standard errors, and the method of moments quintile regression (MMQR) approaches are used for estimation.

The obtained results demonstrate that in most cases, GDP coefficients are found to be negative and significant, while its squared terms are positive and significant. The empirical results indicate that the EKC hypothesis is invalid in the selected eight SCO economies. The energy transition harms the ecological footprint as we estimated by using the underlying model. The transition towards using renewable energy technologies is proven to be environmentally friendly, reducing carbon emissions. The energy transition and green innovations have led to using renewable energy technologies, significantly reducing the carbon footprint. These outcomes are in line with Satrovic and Adedoyin (2023) who stated that energy transitions in most cases are very effective. The impact of population and international tourism is found to be insignificant in the regression in the case of all the quintiles. So, the population and international tourism are only some contributors to the environmental emissions in the countries under consideration. Dinçer (1998) argued that population and international tourism are not the fundamental reasons for enhancing the emissions, but they mainly correlate with the environment.

We found that the energy transition exerts a significantly negative influence on the ecological footprint and that the energy transition and green innovations pave the path for renewable energy sources. Thus, using renewable and cleaner energy technologies significantly reduces the carbon footprint. Renewable energy consumption causes a decline in CO2, thus reducing the carbon intensity in the atmosphere. Renewable energy consumption causes a decline in intensity and negatively impacts carbon intensity at a 1% significance level. These results are in line with Yan and Huang (2022). These outcomes are also supported by Gill and colleagues (2018) who stated that energy transition is the prominent variable that causes a decline in environmental emissions. Therefore, concerned authorities should focus on energy transition technologies and partly on tourism.

CONCLUSION

We conclude in this study that the EKC hypothesis is not valid in the case of the eight selected SCO countries- consisting of the Republic of China, India, Kazakhstan, Kyrgyzstan, Russia, Pakistan, Tajikistan, and Uzbekistan. Though energy transition has reduced environmental emissions in the economies under consideration, the impact of international tourism on the population is statistically insignificant. Thus, the governments of the eight Shanghai Cooperation Organization economies need to focus on this dilemma because environmental emissions are specifically a concern for sustainable economic development. Based on the results of this study, the essential recommendations are that states and stakeholders should focus on renewable energy sources. Renewable and cleaner energy technologies may help mitigate the environmental deterioration. Wind power may be produced in the coastal areas. Most importantly, the transition towards solar energy may be a game changer for these countries due to the availability of substantial sunshine. Government support in the form of subsidies on solar energy-producing materials would also greatly reduce environmental emissions.

DECLARATION STATEMENTS

Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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Ethics and permission

Ethical Approval is not applicable here, as secondary data has been used.

Authors' contributions

MSA was responsible for conceptualization, formal analysis, investigation, resources, and writing the original draft**. FA** was responsible for resources, writing the original draft, and formal analysis**. MAR** was responsible for data curation, software, resources, review & editing. All authors have given explicit consent to submit and publish this work.

Data Availability Statement

Data will be available upon request from the corresponding.

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