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Article

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The Role of Tourism, Technological Innovation, and Globalization in Driving Energy Demand in Major Tourist Regions

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ABSTRACT

This extensive study explores the complex relationship between tourism, technological innovation, globalization, and energy use in leading tourist region consist of UK, USA, Mexico, Austria, France, Germany, Greece, Italy, and Spain from 1990 to 2019. The research examines the effects of key factors on energy consumption dynamics using the Marshallian Demand Function. The study utilized the Panel Autoregressive Distributive Lag Model (ARDL) in addition to Quantile Regression techniques to explore the intricate connections between the explanatory and dependent variables. The results highlight that increase in economic growth, technological innovation, and globalization increased energy consumption in the prominent tourist region. On the other hand, tourism and trade openness were discovered to have an inverse correlation with energy consumption. This study provides valuable insights into the intricate dynamics that influence energy consumption patterns in prominent tourist regions. Policymakers should focus on sustainable economic growth by investing more on green technology through domestic investment and as well as attracting cleaner technologies from international trade activities.

Keywords: Energy Use, Tourism, Technological Innovation, Globalization, Marshalian Demand Function
JEL Classifications: Q43, L83, O33, F60, D11

1. INTRODUCTION

Due to the consequences of rapid growth in population, urbanization, and industrialization, energy which is regarded as the key element for economic and social development is becoming more and more vital daily (Çil and Baygin, 2023). Castro et al. (2024) indicated that in advanced economies, resources and energy possess a greater impact in the fields of economic sustainability and the future of the general population. According to Zhang et al. (2023) United States, the Czech Republic, and Australia have more energy consumption. On the other hand, Koc et al. (2023) revealed that in Italy, Japan, the UK, and the USA using green energy improves the quality of the environment. The group's total energy use accounts for around 42% of global energy consumption. The World Bank estimates that although China's energy consumption climbed by an average of 1.04% in 2015, global energy consumption increased by around 1.43% (World Bank, 2017). To address their growing energy demands, a substantial number of countries use mostly on nonrenewable energy sources, which has certainly caused environmental issues demonstrated by Yusoff et al. (2023). Reducing the percentage of non-renewable resources in energy consumption and increasing the balance of green energy is one of the prerequisites for ensuring environmental sustainability. Moreover, environmental quality is improved when the use of energy is decreased since fewer pollutants are released into the atmosphere (Voumik et al., 2023). Ensuring that energy is readily available, affordable, reliable, and sustainable is the purpose of the energy goal (SDG 7). Nonetheless, according to projected trends, 679 million people will lack access to energy in 2030. Despite numerous efforts around the world, the percentage of green energy in total energy consumption was just 17.7% in 2019; the yearly energy intensity improvement rate for the 2010-2019 periods was only 1.9% (UN SDG, 2023). The targets for this goal are to double the global rate of improvement in energy efficiency by 2030 using the energy intensity which is calculated using the main energy source and the GDP (gross domestic product) as an indicator and to ensure that energy services are universally accessible, affordable, and reliable. Additionally, there is a goal to significantly increase the share of green energy. The rise of globalization advancements in technology and sustainable tourism all have the potential needed for minimizing damage to the environment. The hazards associated with global warming have worsened over the past few decades for several reasons, including (1) expanding industrialization, (2) population growth across the globe, (3) changes in lifestyle, and (4) rising use of energy (Ming-Tsai and Pao, 2010). Since energy is an essential component for sustaining all developmental processes, an adequate amount of energy is required to provide the greatest possible amount of output (Dobnik et al., 2011; Shaari et al., 2023). The environment is adversely affected by rising use of energy brought on by rapid economic growth (Hossain, 2012).

Global foreign tourist arrivals are expected to rise from 1.0 billion in 2012 to 1.8 billion in 2030, according to projections made by the United Nations World Tourism Organization (UNWTO) (UNWTO, 2013). As travel and tourism continue to rise globally, there are significant concerns that the travel and tourism sector's influence on CO_2 emissions is a major factor in climate change (Telfer and Sarfley, 2014). According to Yakut et al. (2015), outgoing and arriving transportation accounts for 90% of energy use (43% by air, 42% by land, 15% by sea, and 15% by railroads). If appropriate measures are implemented, these effects might potentially be mitigated. Ahmad et al. (2020) demonstrated that tourism adversely impacts Greece's environment. Certain countries are starting to gain prominence as important travel destinations; in 2018, Turkey and Greece were the two most popular travel destinations, respectively. Due to the region's tourist industry's rapid expansion and rising energy consumption, there is a good chance that the sector is negatively affecting the natural world (Adedoyin and Satrovic, 2023). Economic growth is a significant factor that directly affects energy consumption and, in turn, the travel and tourist industry. Thus, there is a significant connection between the growth in tourism and the rise in energy consumption. Energy and tourism are seen as essential elements in the contemporary economy. Sarpong et al.(2020) revealed that energy is necessary for both sustainable development and high living standards. The overall effect of travel and tourism on the world's gross domestic product (GDP) increased from USD 8.811 trillion in 2018 to USD 9.25 trillion in 2019. This represents 10.4% of GDP. Additionally, it is anticipated to increase to USD 13.085 trillion in 2029, or around 11.5% of the GDP. Additionally, according to the World Travel and Tourism Council (WTTC, 2019), it accounted for around 319 million jobs (10% of all employment) in 2018 and is projected to increase to nearly 421 million jobs (11.7% of all employment) in 2029. Moreover, travel and tourism stimulated USD 940.9 billion in capital investment in 2018. It is anticipated that increase at an average of 4.2% per year to reach USD 1.489 trillion in 2029. World Travel and Tourism Council (WTTC, 2019). Ekanayake and Long (2012), Bibi et al. (2020), Damnjanović et al. (2017) demonstrated the significance of tourist development for the GDP, investment, and employment creation. All of them agree that more tourism has an advantageous impact on economic growth.

Chemisana et al. (2022) stated that technological innovation stimulates the use of renewable energy. Besides according to the views by Alam and Murshed (2021) higher efficiency in energy use driven by technological innovations reduces the demand for non-renewable energy. Moreover, they claimed, demand for NRE resources declined as energy-efficient technology advancements were made. The detrimental effect of counterfeiting on non-renewable energy (NRE) has been demonstrated by technological innovation (Batueva et al., 2021). The number of tourists exploring Europe's highly developed nations has been demonstrated to have increased despite the COVID-19 pandemic. Specifically, in 2020, 86.9 million tourists traveled to France, 81.8 million to Spain, 58.3 million to Italy, 37.7 million to the UK, 37.5 million to Germany, 29.5 million to Austria, 27.2 million to Greece, and 21.2 million to Portugal. It was rendered possible by popular companies associated with these nations' regions and the adoption of cutting-edge, interactive technological innovations to attract tourists and offer tourism-related services explained by Shevchuk et al. (Buntova et al., 2023).

Ren et al. (2020) expressed that globalization is another factor contributing to the rise in carbon emissions. This term is used to describe the economic, social, and political interdependence of nations. A particular component that is either directly or indirectly related to people and how they interact in social, political, and economic situations is globalization. The global economy is expanding along with its integration throughout time, which causes industrialization and urbanization, both of which worsen the state of the environment (Deng et al., 2021; Sheraz et al.2021). The increasing globalization has the potential, for several reasons, to both accelerate the transition to renewable energy (RE) technologies and increase economic activity. This will help to achieve UN Sustainable Development Goal No. 7, which is to provide affordable and clean energy (Ahmad et al., 2023). Globalization of the economy and CO_2 emissions were found to be positively associated in turkey (Bilgili et al., 2023). The IEA (IEA, 2021) estimates that Mt. 33621.5 of CO_2 was emitted globally in 2019. About 1.1% of the world's total CO_2 emissions in 2019, or 366.11 million tons, was produced in Turkey. Since 1990, Turkey's CO_2 emissions have increased by 184%. The world's energy use has dropped recently as a result of industrialized nations' advancements in energy consumption technologies. From 7.3 Megajoule (MJ) in 1995 to 5.0 MJ in 2017 (US$ constant 2011, PPP), there has been an average annual fall of 1.4% (Liu et al., 2022). Indeed, BP (BP, 2021) explained with 251.1 million tons in 2020, France is among the leading emitters throughout Europe. However, France's GHG emissions dropped by just 19% between 1990 and 2018, which remains considerably short of the challenging target of 40% between 1990 and 2030. Furthermore, trade liberalization might have a negative impact on the environment, including higher energy use, pollution, and resource exploitation (Chang et al., 2016). Over time, a 1% increase in trade openness resulted to about 0.21% increase in energy intensity (Kavaz et al., 2024). The amount of renewable energy is adversely affected by trade openness (Laila et al., 2023). But over time, trade openness lowers the amount of energy consumed. Because trade has made it easier to get more advanced technology that increases the use of energy, the process's effect frequently results in a decrease in energy intensity (Khan et al., 2023).

In this work, we have concentrated on discovering the relationship that drives the use of energy in major tourist areas (such as Austria, France, Germany, Greece, Italy, Mexico, Spain, Turkey, the UK, and the US) between tourism, technological innovation, and globalization. The goals of the investigation were established by the research questions that were put forward after extensive discussion on the topic at hand: First, what impact can trade openness and the number of tourists has on the amount of energy consumed in the selected tourist regions? Secondly, in what ways do the significant effects of globalization and the adoption of technological advancements influence the energy demands of major tourist destinations? Lastly, what is the impact of policy interventions aimed at encouraging energy efficiency measures and sustainable tourism practices on the dynamics of the use of energy in selected tourist destinations? This is especially important since usage of energy can have the power to slow environmental deterioration. The contribution of the current research to the overall condition of the environment in the selected major tourist areas, however, needs a more thorough explanation involving further relevant variables. Within this context, the primary objective of this research is to carefully examine how tourism, technological innovation, and globalization interplay to generate energy demand in a popular tourist destination. By exploring this association, the study intends to provide significant insights into the effectiveness of stakeholder engagement in promoting sustainable energy practices in major tourism areas. This exploration is especially important because it will help to determine whether bringing together these sustainable solutions can effectively counterbalance the environmental impact of energy use in the chosen countries, thereby providing a roadmap for developing policies and making strategic decisions related to environmental sustainability.

To provide an overview of the main concepts, ideas, and frameworks supporting the connections between trade openness, tourism, globalization, technological advancements, and energy consumption in the chosen travel areas (Austria, France, Germany, Greece, Mexico, Italy, Spain, Turkey, the UK, and the US), the current study assesses the relevant research. Through an extensive review of the literature, it aims to provide an overall overview of the present level of knowledge by bringing out significant gaps and areas that would benefit from more research. In contrast to most other studies, this study uses energy demand as a measure of energy usage. It explores how globalization, technological innovation, and tourism all work together towards fuel energy demand in popular travel destinations. The present research aims to make a significant contribution by examining how several factors, including globalization, trade openness, tourism, technological innovation, and economic expansion, have contributed to the use of energy in popular tourist destinations over time. A more comprehensive awareness of the interactions between policy interventions and socioeconomic and technological drivers in the context of environmental conservation is offered by this dynamic view on the association between all of these factors and environmental sustainability. This empirical finding validates the idea that shifting to more environmentally friendly energy sources is an essential strategy for maintaining environmental sustainability. The second addition is the study's emphasis on how trade openness and tourist arrival volume affect energy usage in major travel destinations. While different findings (Adebayo and Alola, 2022; Faggian et al., 2022; Borgi et al., 2022) have recognized the significance of technological advancement in protecting the environment. This highlights the critical role innovation plays in mitigating the harmful effects of economic activity and expands our understanding of the useful applications of technology in environmental sustainability initiatives. This study applies sophisticated econometric techniques to analyze the dataset's characteristics to offer a greater comprehension of the relationship between the variables. It accomplishes this by utilizing the Panel ARDL framework and quantile regression. In summary, this study incorporates the body of literature by presenting empirical data on how globalization, tourism, and technological innovation affect energy demand in the chosen tourist regions. It also does so by dynamically analyzing socioeconomic aspects within the framework of environmental sustainability. The above-mentioned contributions improve our knowledge of the intricate interplay of diverse socioeconomic and technological factors and environmental consequences, hence offering significant conclusions for policymakers and stakeholders attempting to foster sustainable practices in these countries.

The paper is structured as follows: Section 2 presents an in-depth analysis of the literature; Section 3 explores the methodology for selecting and analyzing variables and models; Section 4 explains the research findings; and Section 5 gathers the key findings, conclusions, and their implications for the field of study.

2. LITERATURE REVIEW

Numerous empirical studies have investigated how technological innovation, globalization, and economic growth have affected energy use. Most research examined the role of trade openness and tourism in explaining energy consumption, while many studies examined the Panel ARDL and quantile regression models. Others have concentrated on examining the relationship among tourism, trade openness, globalization, and economic expansion. Because this is a relatively new area, previous research on the idea of energy demand in the context of emerging countries has not yet been conducted in depth. Nonetheless, the study was able to draw on some previous research to assist with its methodology and variable selection. Several of these investigations will be discussed in this section.

2.1. Economic Growth-Energy Use Nexus

The long-term cointegrating relationship between financial development gross domestic product and energy consumption is studied by Rahman et al. (2021) research. Numerous diagnostic tests, including the Augmented Dickey-Fuller, Phillips-Perron, Autoregressive distributed lag (ARDL) bound tests, Johansen and Juselius, and Bayer-Hanck cointegration test, have been carried out to evaluate the connection. The estimated findings revealed a considerable long-run cointegrating link between energy use and gross domestic product. In a research done in Pakistan; Raza et al., (2021) investigated the effects of economic growth and coal intensity on the country's energy use. They discovered that an increase in economic growth is associated with an increase in coal consumption by using the Laspeyres index of decomposition approach for annual data covering the years 2001-2020. Sánchez-Braza et al., (2019) explored the EKC hypothesis to examine the link between residence consumption of energy and economic growth in 12 transition economies between 1995 and 2013. The EKC hypothesis corresponds with the estimated results. The findings also suggest that economic growth has been reducing domestic energy consumption in low-income nations, which may be connected to improvements in efficiency. Several studies like Chen et al. (2012) have begun to use Granger causality tests to evaluate the relationship between economic growth and energy consumption. They employed meta-analysis utilizing a multinomial logit model to survey 174 research studies and investigated the association between consumption of energy and economic growth. They have shown how these contested results are greatly affected by time periods, topic choices (such as GDP and energy consumption), econometric models, and instruments related to specific aspects of greenhouse gas emission reduction. This suggests that it is necessary to look at energy usage, economic growth, and greenhouse gas emissions all at the same time. Boateng et al. (2021) examined the relationship between economic growth and energy consumption in a panel of 23 emerging nations, examining the effects of social, political, and economic globalization from 1970 to 2015. The findings from the method of moment model with an instrumental variable implied that economic growth and energy use are interdependent. All over the world, sustainable economic growth and energy efficiency are two of the most significant problems. The shared economy may have mathematical methods as well as potential effects for sustainable economic growth and energy consumption. Moub et al. (2021) and (Galindo-Martín et al., 2021) addressed the regulatory, privacy, and trust problems associated with a sharing economy that promotes improvements in energy use. Top Asian nations that prioritize energy savings include Thailand, Saudi Arabia, Taiwan, South Korea, Indonesia, Japan, Turkey, India, and China. Pérez et al. (2020) and Chien et al. (2021) explored the areas within a sharing economy where companies and consumers generate disturbances to governance and energy consumption changes. Excessive consumption of energy has an adverse effect on conventional business operations as well as the environment and human lives. Economic systems are highly dependent on the environment, which is related to the use of energy and how they meet consumer demand. The use of energy is essential since less consumption of energy could have a positive impact on economic growth.

2.2. Tourism-Energy Use Nexus

The study conducted by Feridun et al. (2014) assessed the long-term equilibrium relationship between energy consumption, carbon dioxide emissions (CO_2), and international tourism. It also examines the direction of causality between these variables. The study focuses on Cyprus, a small island that hosts over 2 million foreign tourists annually and the findings from "tourism-induced models" showed that there is a long-term equilibrium between energy consumption and international tourism. Using a multivariate approach, Gokmenoglu and Eren (2020) analyzed the impact of foreign tourists on Turkey's energy use between 1960 and 2015. Asymptotic and bootstrap distribution tests for causality between integrated variables: theory and practice. The empirical evidence supporting the significance of the tourist industry on the consumption of energy for the studied sample is provided by the bootstrap causality tests. The long-term cointegrating link between international tourist arrivals and Australia's primary energy consumption is examined by Rahman et al. (2021). The study used data from the last 40 years (1976-2018), and several key diagnostic tests, including the Johansen and Juselius, Phillips–Perron, Autoregressive distributed lag (ARDL) limit tests, and the Augmented Dickey–Fuller cointegration test, were performed to evaluate the connection. The displayed results show a considerable long-run cointegrating link between energy consumption and the number of tourists. Udemba, (2019) performed an investigation in China and concluded that there is a bi-directional (feedback) causal link between tourist arrivals and the use of energy. The author used Granger causality techniques and ARDL-bound testing to account for both short- and long-run effects. The study done by Katircioglu et al.(2019) addressed how the expansion of tourism contributes to increased energy consumption in key tourist destinations. Thus, panel data covering the years 1995-2014 was obtained and the findings showed that tourism had an inelastic but positive substantial impact on overall energy consumption. Using the Autoregressive Distributed Lag (ARDL) approach, research by Voumik et al. (2023) seeks to investigate the long-term link between Malaysian tourism, energy consumption, and their association with economic growth, as well as financial development. The study's conclusions, which are based on yearly data from 1990 to 2020, demonstrate that rising tourism raises the energy demands for transportation, accommodation, and recreation.

2.3. Technological Innovation-Energy use Nexus

Tang and Tan (2013) investigation analyzed the connections between Malaysia's economic growth, energy pricing, technological innovation, and consumption of energy between 1970 and 2009. The study's findings suggest a cointegration between the factors that influence electricity consumption and its consumption. The Granger causality results demonstrate that Malaysian energy use is Granger-caused by technological advancement. To evaluate the impact of technological innovation (TI) on energy use in Malaysia, Begum et al. (2015) expanded the Marshallian demand framework. Over the sample period of 1985-2012, this study employs an ARDL (autoregressive distributed lag) bounds testing technique and finds that technological innovation leads to increased efficiency in energy use over time. Sinha et al. (2021) addressed the nations of the Middle East and North Africa (MENA) from 1990 to 2016. The results show that technological innovation has a positive effect on energy use in the selected nations, and second-generation methodological techniques have been utilized. In a sample of 28 OECD nations, (Shahzad et al., 2022) evaluated the impact of environmentally friendly innovations on energy demand and energy efficiency. They utilized panel estimate approaches, and by employing yearly data for the years 1990-2014, they revealed that environmental technology contributes significantly to energy efficiency increases by lowering the use of energy while simultaneously having a significant detrimental impact on energy consumption. These data imply that environmental technology enhances overall energy efficiency in each of the OECD economies while additionally helping in the reduction of overall energy consumption. Khan et al.(2023) analyzed the effect of technological innovation on technically derived energy use utilizing panel data covering the years 2002-2019. By the application of a system generalized method of moments (GMM) methodology, the results of the system GMM shown that technological innovation is significantly contributing to the improvement of South Asia's agriculture sector's energy consumption. In the top ten green innovator economies (Switzerland, Sweden, Germany, USA, Denmark, Finland, UK, Netherlands, Japan, and Norway), a study by Rasool et al. (2024) investigates the asymmetric relationship between innovation in environmentally friendly technologies and energy consumption. According to their estimates, energy efficiency increases with green technology innovation at certain quantiles in most economies. Husain et al. (2024) look at the influence of green innovation technologies on energy demand in the G-7 nations for the period of 1990-2020. Using panel cointegration and panel regressions (FMOLS, DOLS), the findings demonstrate that green technologies reduce overall energy use. Using the GMM panel VAR framework, Ganda (2024) analyzes the relationship between financial development, innovation in technology, and energy consumption in the BRICS countries on a yearly basis between 1990 and 2020. The findings demonstrated a positive and significant relationship between technological innovation and energy usage.

2.4. Globalization-Energy Use Nexus

Lahiani et al. (2018) used QARDL modeling to look at how globalization affects energy usage in the Netherlands and Ireland between 1970Q1 and 2015Q4. They discovered a positive, long-term connection between globalization and energy usage. However, there is no obvious short-term effect of globalization on energy use, and globalization and energy consumption have a quantile-dependent link. Huang et al. (2020) used a panel error correction model with cross-sectional dependency to study how globalization affects energy consumption. The empirical findings show that, over time, there is an inverse U-shaped relationship between globalization and energy consumption; that is, energy consumption will continue to increase until a particular point in globalization is reached, after which it will start to decline. Dogan and Deger (2016) evaluated the cointegration and causality connections between the BRIC (Brazil, Russia, India, and China) nations' economic growth, globalization, and total energy consumption over the 2000-2012 periods. The Granger causality analysis panel, unit root, and Pedroni and Kao cointegration tests were employed. The results show that there is no causal relationship between globalization and energy consumption. Shahzad et al. (2018) employed both time series and panel data methodologies to investigate the causal link between globalization, economic growth, and energy consumption for 25 developed economies during the 1970-2014 periods. The empirical findings demonstrated that globalization increases the consumption of energy in a wide variety of countries. Globalization and energy consumption are negatively connected in the United States and the United Kingdom, and the empirical study provides policymakers with beneficial recommendations for using globalization as an economic instrument to use energy effectively for long-term sustainable economic growth. Jannat et al. (2018) covered pertinent data in Bangladesh for 36 years, from 1980 to 2015 and their investigation revealed that there was no long-term causal relationship between the use of energy and globalization. Balcilar et al. (2018) assessed the dynamic causal link between globalization and energy consumption using Granger causality methods for 20 top and bottom globalized economies, utilizing quarterly data covering the period 1970Q1-2017Q4. The empirical findings indicated that there is a time-varying, dynamic causal link between energy usage and globalization. Using panel data from 60 countries between 1995 and 2018, Huo et al. (2023) utilized the spatial econometric model to find out how globalization has affected the usage of renewable energy. The empirical findings support the spatial dependence of renewable energy consumption across nations and reveal that globalization has a positive effect on renewable energy consumption overall, suggesting that globalization is a key factor in driving the use of renewable energy.

2.5. Trade Openness-Energy Use Nexus

Ramaharo,, & Razanajatovo, (2024) utilized yearly data from 1990 to 2021 and the ARDL bounds testing method to examine the macroeconomic factors influencing Madagascar's consumption of renewable energy. The results of their research demonstrate that trade openness has a major and positive long-term influence on the use of renewable energy. Khan et al. (2023) investigated how trade openness, financial development, and urbanization influenced the consumption of energy in 12 newly industrialized countries (NICs) using data from the World Bank for the years 2000 to 2020. They discovered that trade openness lowers energy consumption over the long term but not in the short term using panel autoregressive distributed lag/pooled mean group (ARDL/PMG) and cross-sectional ARDL (CS-ARDL). The Marshallian demand framework has been expanded extensively by Begum et al., (2015) to investigate the impact of technological innovation (TI) on the use of energy in Malaysia. Using the application of an ARDL (autoregressive distributed lag) bounds testing methodology for the period of 1985-2012, this research confirms that trade openness ultimately increases energy consumption. Osabuohien-Irabor and Drapkin (2022) investigated the relationship between innovation and energy in 24 OECD countries from 1996 to 2015, using the CS-ARDL, AMG, and System Generalized Methods of Moments (SYS-GMM) approaches. The findings illustrate that trade openness and technological advancement has a combined negative and statistically significant influence on energy demand over the short and long terms. In research accomplished in the G-7 nations between 1990 and 2020, Husain et al. (2024) used panel cointegration and panel regressions (FMOLS, DOLS). Their findings indicate that trade leads to an increase in energy consumption. From 2005 to 2018, Zhang et al. (2022) assessed the energy consumption in thirty provinces and regions on the Chinese mainland. They found that trade openness reduces their level of energy. Additionally, the import route has less impact on energy intensity than the export route, which is the principal way foreign trade influences energy intensity. Urbanization and trade openness's effects on China's use of renewable and non-renewable energy during the 1990-2018 periods were examined by Zeeshan et al. (2022). Their analysis revealed that trade activities, including the manufacture and export of commodities; significantly depend on sources of energy that are not renewable, as compared to renewable energy sources. They suggested that to reduce the negative impacts of non-renewable energy usage, the government should promote trade.

2.6. Literature Gap

To the best of our knowledge, no research has been done on how economic growth, trade openness, tourism, globalization, and energy demand interact with each other in the chosen top tourist destinations, including the UK, USA, Mexico, Austria, France, Germany, Greece, Italy, and Spain. A small number of researchers have conducted a few studies in various fields, but they have not combined their findings. Our study utilizes a novel mixed methodology that combines panel data analysis with qualitative methods, establishing it apart from the existing literature and offering a more comprehensive understanding of the dynamic relationships between economic growth, trade openness, tourism, globalization, and the demand for energy in certain tourist areas. This current study contributes to a nuanced and context-specific understanding of sustainable development by filling in these gaps in the literature and providing empirical evidence. This helps stakeholders and policymakers develop strategies that are specifically tailored to the unique socioeconomic and environmental dynamics of energy demand in the selected countries.

3. DATA AND VARIABLES

The present research examined data from the World Development Indicator and KOF Globalization Index to assess the impact of trade openness, tourism, technological innovation, globalization, and economic growth on fueling energy demand in popular tourist regions from 1990 to 2019. Austria, France, Germany, Greece, Italy, Mexico, Spain, Turkey, the UK, and the USA are the countries that have been selected. These ten countries were our first choice for the study since their data has significance and is readily available for our current research needs. We use energy demand as an endogenous variable in this case. Data on energy demand, expressed in kilograms of oil equivalent per capita, were sourced from the World Development Indicator (WDI). The World Development Indicator (WDI) data enables us to calculate the GDP per capita in US dollars in 2015. Furthermore, information on technological innovation and tourism is collected from the World Development Indicator (WDI) equivalent. The policy variable in our analysis is globalization, which we extracted from (Dreher, 2006) KOF globalization index. This index offers useful and instructive results for understanding how globalization affects energy consumption. Table 1 presents a clear and concise description of the variable.

3.1. Theoretical and Econometric Framework

Theoretical discussion clarifies the complex relationship that exists between a country's energy consumption, economic growth, and related energy costs. The Marshallian demand function, which provides insights into the dynamics of energy demand at a specific moment in time and reflects the equilibrium state in the energy market, is a useful framework for modeling this relationship (Friedman, 1949). This model captures how consumer behavior and market forces interact to shape patterns of energy consumption by equating energy demand with energy utilization. Increasing our knowledge of these dynamics is essential for developing sustainable energy management plans and well-informed policy.

$$E_{Dt} = f(Y_t, P_{et}) \quad (1)$$

In equation (1), E_{Dt}, Y_t, and P_{et} stand for, respectively, energy demand, income, and the cost of energy at time t.

Tourism, technological innovation, globalization, and trade openness are interrelated factors that have a substantial impact on global energy consumption. To begin with, tourism stimulates energy consumption through various means, such as transportation, lodging, and leisure activities (Shah et al., 2023; Voumik et al., 2023). The surge in global travel has resulted in escalated fuel consumption in the aviation and transportation industries, thereby contributing to heightened energy requirements. In addition, the construction of high-end resorts and hotels requires a substantial amount of energy for heating, cooling, and lighting, which worsens the already high energy requirements (Tahrim et al., 2023). Furthermore, technological innovation serves a twofold purpose in relation to energy demand. Technological advancements, such as electric vehicles and energy-efficient appliances, decrease energy consumption per unit, thereby reducing the growth in demand (Edziah et al., 2021; Voumik et al., 2023). On the other hand, the widespread adoption of technology-driven lifestyles, which involve constant connectivity and dependence on electronic devices, results in increased energy usage as a whole (Rahman et al., 2024). Globalization increases energy demand by enabling the growth of trade networks and supply chains. The growing international trade requires the use of transportation, storage, and manufacturing methods, all of which require substantial energy consumption (Ridwan, 2023). Furthermore, globalization and urbanization promotes the growth of cities and industries, resulting in an increased need for energy to support the development of infrastructure and industrial processes (Ridwan, 2023). Increased trade openness, which involves the reduction of trade barriers and the expansion of international commerce, leads to a greater demand

Table 1: Variables source and description

Variables	Description	Logarithmic form	Unit of Measurement	Source
END	Energy Demand	LEND	Energy use (kg of oil equivalent per capita)	WDI
GDP	Gross Domestic Product	LGDP	GDP per capita (current US$)	WDI
TOR	Tourism	LTOR	International tourism, number of arrivals	WDI
TNI	Technological Innovation	LTNI	Patent applications, residents	WDI
GOB	Globalization	LGOB	Globalization Index	KOF
TO	Trade openness	LTO	Trade (% of GDP)	WDI

for energy (Raihan et al., 2024). When countries participate in international trade, they frequently focus on industries that require a lot of energy in order to take advantage of their comparative strengths, which leads to increased energy usage. In addition, the openness of trade promotes economic growth, resulting in higher living standards and an increase in per capita energy consumption. Thus, this investigation considers Eq (2).

$$END = f(Y, EP, TOR, TNI, GOB, TO) \quad (2)$$

The income elasticity of energy is positive $\frac{\partial E_t/\partial Y_t}{E_t/Y_t} = \varepsilon_{Ye} > 0,$, while price elasticity is negative $\frac{\partial E_t/\partial P_t}{E_t/P_t} = \varepsilon_{Pe} < 0,$, according to the conventional Marshallian demand function. However, since energy costs are subsidized in leading tourist region, this research does not take into account energy prices as independent determinants.

Equation (3) is the econometric format of the Equation mentioned above.

$$END_t = \gamma_0 + \gamma_1 GDP_t + \gamma_2 TOR_t + \gamma_3 TNI_t + \gamma_4 GOB_t + \gamma_5 LTO_t + €_t \quad (3)$$

Here, TO represents trade openness, and URBA shows urbanization at time t

$$END_t = \gamma_0 + \gamma_1 LGDP_t + \gamma_2 LTOR_t + \gamma_3 LTNI_t + \gamma_4 LGOB_t + \gamma_5 LTO_t + €_t \quad (4)$$

In Eq. (4, all variables utilized in this study are expressed in logarithmic form.

3.1.1. Panel ARDL model

Pooled Mean Group (PMG) approach was developed by Shin et al. (2012) to estimate the non-stationary dynamic panel data model. The PMG-ARDL was utilized in this study to examine the short- and long-term impacts of Economic Growth, Tourism, Technological Innovation, Globalization and Trade openness on Fueling Energy Demand. Based on the ARDL model, the PMG estimator assumes that each group has unique short-term coefficients, intercepts, and error parameters, while the panel as a whole has the same long-run coefficients. When selecting lag orders, the PMG estimator performs admirably in the period between. By including short-term factors, the PMG panel ARDL estimate technique considers cross-sectional heterogeneity. This makes it possible to analyze causal relationships that are both long- and short-term, regardless of whether the variables being used are integrated of order zero I(0) or one I(1). Unfortunately, when working with second-order I(2) integrated variables, this approach is not suitable. Moreover, Zhang et al. (2021) Have shown, this model has the benefit of successfully handling autocorrelation, heteroscedasticity, and multicollinearity difficulties in models. The long-term association models for PMG are presented in Equation 5 below:

$$\Delta Y_{1,it} = \beta_{1i} + \gamma_{1i} Y_{1,it-1} + \sum_{l=2}^{k} \gamma_{1i} X_{1,it-1} + \sum_{j=1}^{p-1} \lambda_{1ij} \Delta Y_{1,it-j} + \sum_{j=0}^{q-1} \sum_{l=2}^{k} \lambda_{lij} \Delta X_{1,it-j} + \varepsilon_{1i,t} \quad (5)$$

Here, refers the dependent variable and are independent variables where l = 1,2,3,4. ε_{it} and Δ are residual and first difference operator respectively.

We obtain the following long-term ARDL model for END as the dependent variable (Equation 6):

$$\begin{aligned} \Delta LEND_{it} = {} & \beta_{1i} + \gamma_{1i} LEND_{i,t-1} + \gamma_{2i} LGDP_{i,t-1} + \gamma_{3i} LTOR_{i,t-1} \\ & + \gamma_{4i} LTIN_{i,t-1} + \gamma_{5i} LGOB_{i,t-1} + \gamma_{6i} LTO_{i,t-1} \\ & + \sum_{j=1}^{p} \lambda_{1i} \Delta LEND_{i,t-j} + \sum_{i=0}^{q} \lambda_{2i} \Delta LGDP_{i,t-j} \\ & + \sum_{i=0}^{q} \lambda_{3i} \Delta LTOR_{i,t-j} + \sum_{i=0}^{q} \lambda_{4i} \Delta LTIN_{i,t-j} + \\ & \sum_{i=0}^{q} \lambda_{5i} \Delta LGOB_{i,t-j} + \sum_{i=0}^{q} \lambda_{6i} \Delta LTO_{i,t-j} + \varepsilon_{1i,t} \end{aligned} \quad (6)$$

Where, μ_i, i and t represent fixed effect, countries and time respectively.

Furthermore, the following is the short-run relationship (Equation 7) that takes error correction models into account:

$$\begin{aligned} \Delta LEND_{it} = {} & \sum_{j=1}^{p-1} \alpha_{1ij} \Delta LEND_{i,t-j} + \sum_{i=0}^{q-1} \alpha_{2ij} \Delta LGDP_{i,t-j} \\ & + \sum_{i=0}^{q-1} \alpha_{3i} j \Delta LTOR_{i,t-j} + \sum_{i=0}^{q-1} \alpha_{4i} j \Delta LTIN_{i,t-j} \\ & + \sum_{i=0}^{q-1} \alpha_{5ij} \Delta LGOB_{i,t-j} + \sum_{i=0}^{q-1} \alpha_{6ij} \Delta LTO_{i,t-j} \\ & + \mu_{1i} ECT_{1,it-1} + \varepsilon_{1i,t} \end{aligned} \quad (7)$$

Additionally, we have to take into account the PMG approach's assumption, which states that the coefficients for long-run associations are equivalent for every country.

3.1.2. Quantile regression model

The panel quantile regression approach was employed to investigate the sectoral impacts and heterogeneity between quantiles. Rather than using the quantile method of Powell (Powell, 2022) and simultaneous (Bassett and Koenker, 1978) quantile approach, we employed method of moment quantile regression (MM-QR) (Santos Silva and Machado, 2019) as a panel quantile.

The following equation (Equation 8) illustrates this MM-QR regression:

$$Q_{LEND_{it}}\left(\tau \mid \delta_0, x_{it}, \ \mu_i\right) = \delta_0 + \mu_{it} + \delta_{1\tau}\mathrm{LGDP}_{it} + \delta_{2\tau}LTOR_{it} + \delta_{3\tau}LTIN_{it} + \delta_{4\tau}\mathrm{LGOB}_{it} + \delta_{5\tau}\mathrm{LTO}_{it} + \epsilon_{it} \quad (8)$$

Here, $(\tau|\delta_0, x_{it}, \mu_i)$ is the τ th conditional quantile. τ and X_{it} refers the quantile measure and independent variables respectively.

4. FINDINGS

To assess the complex relationships between fueling energy demand in the top tourist areas and economic growth, tourism, technological innovation, globalization, and trade openness, we employed a wide range of statistical methods in this study. In this part, we offer an in-depth assessment of these statistical investigations' findings, emphasizing their significance for advancing the main objectives of our study. The outcomes of our statistical analysis offer crucial new insights into the complicated procedures at work.

4.1. Summary Statistics

The findings of the summary statistics are displayed in Table 2. This investigation is an initial step towards looking at variables and fully understanding their characteristics, including mean, skewness, minimum and maximum values, standard deviation, etc. Out of all the variables, the mean value for LTOR is 17.76618, making it the highest value. Conversely, the lowest average value belongs to LRSP. In the same way, the median values with the greatest (17.69822) and lowest (4.073846) were revealed by the LTOR and LTO, respectively. Variable LTOR has the highest value, whereas LTO has the lowest value. While LTOR and LTNI demonstrate a positive or left skewness, the variables LEND, LGDP, LGOB, and LTO indicate an inverse skewness. This indicates that there is a greater concentration of values on the right side of the mean for LTOR and LTNI. The values of Kurtosis of all variables are more than 3 except LEND, LTOR, and LTNI. The Jarque–Bera test shows that the data set for all variables are not normally distributed. The observations for all variables are the same, and it is valued at 230.

4.2. Cross-Sectional Dependence test

The initial procedure for evaluating econometric panel data is to do a cross-sectional dependency test. The Pesaran CD test findings are displayed in Table 3, where all CSD statistics values are highly significant at the 1% significance level. According to the results, the null hypothesis—which asserts that there is no cross-sectional dependency across nations, is rejected for all of the variables. This suggests that a shock in one of the sample countries may also have an impact on the remaining nations.

4.3 Slope Homogeneity test

Table 4 displays the findings of the Pesaran and Yamagata slope heterogeneity tests. The P-values allow for the rejection of the assumption, which leads to the rejection of the null hypothesis, which states that slope coefficients are homogeneous. This suggests that multiple variables have different coefficients.

4.4. Panel Unit Root Test

To find out if the variables are stationary or not, it is often recommended performing thorough unit root testing before using cointegration. In Table 5 the unit root tests outcome are presented. The first-generation unit root tests in the present research were LLC, whereas the second-generation unit root tests were CIPS and CADF. The LLC test deficits results show that each variable, except LEND, LTNI, and LGOB, is stationary at first difference. The remaining variables are stationary at the first difference, while LGDP, LTOR, and LTO are stationary in both orders. LTOR and LGOB are stationary in both levels, according to the CIPS test results, whereas the remaining variables (LEND, LGDP, LTNI, and LTO) are stationary at I(1). Similarly, the CADF unit root test shows that all variables are stationary at first difference only.

4.5. Panel Cointegration Test

The pedroni panel cointegration test result in two dimension (within-dimension and between dimension) are displayed in Table 6. Since the P-values of the Panel v-Statistic and Panel rho-Statistic are higher (0.5272 and 0.8000) than the conventional significance level, they indicate that there is no evidence of cointegration. However, because their P-values are below conventional significance thresholds, the Panel PP-Statistic and Panel ADF-Statistic offer evidence to reject the null hypothesis that there is no cointegration. These statistics therefore suggest that there is cointegration. The Group rho-Statistic shows a very high

Table 2: Summary statistics of the variables

Statistic	LEND	LGDP	LTOR	LTNI	LGOB	LTO
Mean	4.067	10.190	17.766	8.773	4.383	4.067
Median	8.030	10.388	17.698	8.986	4.410	4.073
Maximum	8.994	11.242	19.199	12.595	4.493	4.817
Minimum	6.984	8.039	15.817	5.624	4.051	3.103
Std. Dev.	0.444	0.643	0.835	1.842	0.104	0.346
Skewness	−0.016	−0.977	0.037	0.359	−1.324	−0.688
Kurtosis	2.901	3.129	1.869	2.396	3.996	3.830
Jarque-Bera	0.103	36.791	12.300	8.441	76.715	24.762
Probability	0.949	0	0.002	0.014	0	0.000
Sum	1846.875	2343.913	4086.222	2017.916	1008.21	935.461
Sum Sq. Dev.	45.197	94.831	159.947	777.289	2.506	27.414
Observations	230	230	230	230	230	230

P-value of 0.9835 in the between-dimension analysis, suggesting insufficient evidence for cointegration in any of the panels. However, there appears to be some evidence for cointegration across the panels according to the Group PP-Statistic (P-value: 0.0225) and the Group ADF-Statistic (P-value: 0.0075).

4.6. Panel ARDL Model

The findings derived from the Panel ARDL model as depicted in Table 7, shed light on the complex dynamics shaping fuelling energy demand in major tourist areas. Beginning with LGDP, the long-run coefficient exhibits a positive value of 0.376742, which is statistically significant at conventional levels. This suggests that GDP exert a significant influence on energy demand in the selected region. The significant correlation among GDP and Energy demand (END) indicates that mere economic expansion may be a major driver of energy demand in the top selected tourist areas context. Similar outcome was also demonstrated by Raza et al. (2021) and Raghutla et al. (2023), they demonstrated that economic growth has positive impact on energy consumption. In contrast, the presence of tourist arrivals (LTOR) appears to negatively impact energy demand in the chosen areas over the long run and similar to LGDP, this coefficient is statistically significant as the P = 0.0003. This implies that a 1% rise in LTOR will result in a corresponding decrease of 0.319961% in LEND, and vice versa. The negative correlation among tourism and energy demand underscores the need for policymakers to carefully consider the environmental implications in the tourism sector.

Furthermore, the coefficient linked to technological innovation displays a positive correlation with energy demand, signifying that an increase of 1% in LTNI could potentially result in a increase of 0.170335% in LEND. Ahmad et al., (2023) also revealed that innovations in technology have had an advantageous effect on Jordan's energy consumption, which is important for reaching the SDGs. Similarly, globalization (LGOB) demonstrates a positive association among energy demand, with a statistically significant coefficient suggesting that a 1% rise in globalization could result in a 2.113358% increase in energy demand over the long term. On the other hand, Ghazouani (Ghazouani, 2022) discovered that there are several ways in which globalization affects the consumption of renewable energy.

In case of trade openness (LTO) exhibit negative relationships with energy demand in the long run, the coefficients lack statistical significance. However, the non-significant coefficients of trade openness propose the efficacy of given policy measures in reducing energy demand may vary. Therefore, the findings underscore the importance of adopting a multi-dimensional approach to address energy demand in the selected top tourist destinations.

Table 7 provides a comprehensive overview of the short-run estimates derived from the Panel ARDL model, offering further insights into the dynamics among key variables and energy demand in the selected region. Initially, the analysis unveils a significant positive correlation among economic growth and energy demand. In the short term, a mere 1% increase in LGDP results in a corresponding surge of LEND by 0.019348%, underscoring the immediate environmental consequences of economic growth.

In contrast to its long-term counterpart, this estimate reveals a negative yet statistically insignificant correlation among tourism and energy demand. Similarly, like the long term analysis, the short-term analysis unveils a positive link among technological innovation and demand of energy, indicating that a 1% increase in LTNI results in a modest 0.030827% increase in energy demand. But it is not statistically significant at the conventional level. On the other hand, surprisingly the short-run results shows the negative link among globalization and LEND. A 1% increase in LGOB is associated with a substantial short-term reduction of 0.25003% in demand of energy, emphasizing the immediate benefits of sustainable globalization measures in mitigating energy consumption. Regarding trade openness, while the short-run estimate suggests an increase in energy demand and it is statistically significant at conventional level. On the other hand, Loganathan et al. (2015) revealed that trade openness leads to affluence and hence increases energy consumption in Malaysia.

4.7. Quantile Regression Model

Table 8 presents the results of quantile regression. The coefficient in the first quantile of the LGDP is 0.519 while the fifth quantile has

Table 3: Cross-sectional dependence test

Variables	CD Statistics	P-value
LEND	10.84***	0.000
LGDP	26.31***	0.000
LTOR	19.17***	0.000
LTNI	3.86***	0.000
LGOB	29.88***	0.000
LTO	24.74***	0.000

*** Represent significant at 1% level

Table 4: Slope Homogeneity test

Slope homogeneity tests	Δ statistic	P-value
$\breve{\Delta}$ test	9.063***	0.000
$\breve{\Delta}_{adj}$ test	10.866**	0.000

*** , ** Represent significant at 1% and 5% level

Table 5: Panel unit root test

Variables	Levin chu		CIPS		CADF	
	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
LEND	−2.521	−3.102***	−1.815	−5.320***	0.182	−2.303**
LGDP	−4.687***	−5.210 ***	−1.644	−3.926***	0.145	−2.151**
LTOR	−2.327***	−4.124***	−2.274***	−3.413***	−0.339	−2.576**
LTNI	−0.136	−4.319***	−1.618	−4.403***	0.775	−1.640*
LGOB	−0.327	−10.593***	−2.307*	−5.187***	0.579	−3.596***
LTO	−3.057***	−5.124***	−1.596	−3.853***	1.163	−2.304**

*** , **, * Represent significant at 1% ,5% and 10% level a value of 0.193. Empirically, it shows that the LEND will increase by 0.519% in the first quantile and 0.193% in the final quantile, respectively, for every 1% increase in economic growth. Each of the coefficients of LGDP in the subsequent table is significant at the 1% level and indicates a positive correlation between LGDP and LEND. The LTOR coefficient estimates show the impact of tourism on energy demand across all quantiles. At first, the coefficients of LTOR exhibit a positive increase until the second quantile, and then further quantile they commenced to decline. According to the first quantile, a 1% increase in LTOR results in a 0.420% increase in LEND; this value decreases to 0.0729% in the final quantile.

Table 6: Result of panel cointegration test

Alternative hypothesis: Common AR coefs. (within-dimension)				
Variables	**Statistic**	**Prob.**	**Weighted Statistics**	**Prob.**
Panel v-Statistic	−0.695	0.527	−0.053	0.521
Panel rho-Statistic	0.841	0.800	0.958	0.831
Panel PP-Statistic	−2.393***	0.008	−2.195**	0.014
Panel ADF-Statistic	−2.669***	0.003	−2.489***	0.006
Alternative hypothesis: individual AR coefs. (between-dimension)				
Variables	**Statistic**	**Prob.**		
Group rho-Statistic	2.131	0.983		
Group PP-Statistic	−2.005**	0.022		
Group ADF-Statistic	−2.432***	0.007		

*** , ** represent significant at 1% and 5% level

Table 7: Results of panel ARDL model

Long-run Estimation				
Variable	**Coefficient**	**Standard Error**	**t-Stat**	**P-value**
LGDP	0.376***	0.103	3.649	0.000
LTOR	−0.319***	0.087	−3.677	0.000
LTNI	0.170***	0.043	3.888	0.000
LGOB	2.113	0.337	6.270	0
LTO	−0.215	0.198	−1.086	0.279
Short-run estimation				
Variable	**Coefficient**	**Std. Error**	**t-Stat**	**P-value**
COINTEQ01	0.004	0.022	0.215	0.829
D (LGDP)	0.019	0.017	1.077	0.282
D (LTOR)	−0.031**	0.013	−2.36	0.019
D (LTNI)	0.030	0.065	0.468	0.640
D (LGOB)	−0.250	0.204	−1.222	0.223
D (LTO)	0.121***	0.033	3.569	0.000

The quantile regression also reveals that technological innovation increases energy demand across all quantiles. All coefficients are positive and statistically significant at the 1% level (***), indicating that higher technological innovation is associated with higher energy demand across all quantiles. However, the correlation among LGOB and LEND is negative at the 1st and 2nd quantiles. But the rest of the quantiles shows positive value. According to statistics, a 1% increase in LGOB results in a 0.578% and a 0.490% decrease in energy consumption in the first and second quantile respectively. On the other hand, 1% increase in LGOB will increase LEND by 0.404%, 0.458% and 1.267% respectively in 3rd,4th and 5th quantile respectively.

We also identified first a positive and significant association among LTO and LEND as we found a positive value for first 2 quantile and then negative and significant association in the rest of the quantiles. Initially, it shows that a 1% raise in LTO will increase energy demand by 3.52%, and 0.0294% in the first and second quantiles, respectively. But later 1% increase in trade openness will decrease energy demand in the selected areas by 0.262%, 0.379% and 0.308% in the third, fourth and final quantiles respectively. Besides, except for the second quantile, the coefficient of LTO is statistically significant at 5% level of significance. Thus, the result of quantile regression is in line with the findings of Panel ARDL method.

5. DISCUSSION

In the current research, an attempt was made to look at the empirical association between economic growth, tourism, technological innovation, globalization, trade openness, and energy consumption. The verification was performed on a sample of leading tourist regions in Austria, France, Germany, Greece, Italy, Mexico, Spain, Turkey, the UK, and the USA. The Panel ARDL approach and quantitative regression findings offer an in-depth understanding of the complicated relationship between economic growth and energy demand in the selected region. The findings indicate that the selected countries haven't successfully separated economic growth from energy consumption seeking more strategies and policies for sustainable development. But rapid economic growth still heavily depends on the country's high energy

Table 8: Results of quantile regression

Variables	(1)	(2)	(3)	(4)	(5)
	Q0.05	**Q 0.25**	**Q0.50**	**Q0.75**	**Q0.95**
LGDP	0.519***	0.571***	0.394***	0.456***	0.193***
	(0.063)	(0.084)	(0.069)	(0.081)	(0.049)
LTOR	0.042**	0.025	−0.000	−0.055**	−0.0729***
	(0.020)	(0.027)	(0.022)	(0.026)	(0.015)
LTNI	0.037***	0.040**	0.060***	0.047***	0.107***
	(0.013)	(0.018)	(0.014)	(0.017)	(0.010)
LGOB	−0.578	−0.490	0.404	0.458	1.367***
	(0.384)	(0.512)	(0.420)	(0.496)	(0.302)
LTO	0.352***	0.029	−0.262***	−0.379***	−0.308***
	(0.066)	(0.089)	(0.073)	(0.086)	(0.052)
Constant	2.492**	3.278**	2.782**	3.629**	1.975**
	(1.148)	(1.53)	(1.256)	(1.485)	(0.904)
Observations	230	230	230	230	230

Standard errors in parentheses. *** , ** represent significant at 1% and 5% level consumption in China revealed by Wang et al. (2011). Moreover, the positive correlation between GDP and energy demand may indicate that the selected countries seeking sustainable energy practices to reduce energy usage as well as establish sustainable economic growth. In today's rapidly evolving global landscape, the shift towards knowledge-based economies has brought about a greater emphasis on innovation and technology. This, in turn, has resulted in a decreased dependence on fossil fuels and a more efficient use of resources (Acheampong, 2018).

The study revealed an interesting correlation between tourism and energy demand in the selected region, prompting us to consider the positive impact of tourism in the energy sector. The positive correlation among tourism and energy demand also supported by (Voumik et al., 2023 and Eren and Gokmenoglu, 2019). The positive relationship between technological innovation and energy consumption in the selected major tourist countries is the evident that innovation in technology increases energy consumption. This finding highlights the region's insufficient policies and strategies to adopt technological innovation and ensure sustainable energy practices. This is evident in the positive correlation between technological innovation and energy demand by Dzator et al. (2022). A possible explanation for this phenomenon can be attributed to the region's insufficient efforts on technological advancement and implementing circular economy principles. But the inverse relationship between the variables was found by Husain et al. (2024).

The finding also reveals that globalization (LGOB) demonstrates a positive association among energy demand. This indicates that globalization causes more energy consumption. Globalization has also been considered as an influence on energy consumption by Alkawfi et al. (2019) and Alola et al. (2019). Consequently, it is crucial to look into how energy consumption is affected as the globe moves more and more to achieve exceptional growth performances. In case of trade openness (LTO), it exhibits negative relationships with energy demand. This outcomes indicates that there exits sustainable tourism practices in the selected region which reduces energy demand. Surprisingly, trade openness has no impact on the growth in energy consumption of the developing nations nevertheless, as capital per labor rises; trade liberalization's interaction with it reduces the growth in energy consumption (Ghani, 2012).

6. CONCLUSION AND POLICY RECOMMENDATIONS

This extensive research explores the complex relationships between tourism, innovation in technology, globalization, and energy use in a popular tourism area between 1990 and 2019. The research analyzes the effects of these important variables on the dynamics of energy consumption using the Marshallian Demand Function. In order to guarantee a solid analysis, data stationarity was evaluated using both first- and second-generation unit root tests, which verified that there were no unit root problems in the dataset. In order to clarify heterogeneous coefficients and demonstrate long-term cointegration among the variables under examination, the investigation also used the slope homogeneity test and the panel cointegration test. Quantile regression techniques combined with the Panel Autoregressive Distributive Lag Model (ARDL) allowed for a more in-depth investigation of the complex relationships between the dependent and explanatory variables. The results highlight the critical roles that globalization, technological innovation, and the gross domestic product played in causing higher energy consumption in the popular tourist area. On the other hand, there was an inverse relationship between energy consumption, trade openness, and tourism. This research provides priceless insights into the complex dynamics influencing patterns of energy consumption in popular tourist destinations, with relevant ramifications for stakeholders and policymakers committed to promoting sustainable development in the tourism industry.

Several policy recommendations can be formulated to address the complex dynamics uncovered by the research regarding the impact of tourism, technological innovation, globalization, and energy use in leading tourist regions. First of all, it is important to acknowledge the importance of gross domestic product (GDP) in driving increased energy consumption. Therefore, policymakers should prioritize the implementation of measures that promote sustainable economic growth. One way to accomplish this is by making investments in renewable energy sources and energy-efficient technologies. Additionally, it would be beneficial to provide incentives for industries to embrace cleaner production methods. In addition, implementing policies that focus on diversifying the economy and reducing dependence on energy-intensive sectors can help address the increasing energy demand that comes with economic growth. Additionally, considering the strong link between technological advancement and energy consumption, it is crucial for policymakers to give utmost importance to research and development projects that focus on improving energy efficiency in different industries. This may require encouraging businesses to invest in advanced technologies that can lower energy usage while also promoting cooperation between government, academia, and industry to discover and apply state-of-the-art solutions. In addition, implementing policies that encourage the use of smart grid technologies and decentralized energy systems can effectively optimize energy consumption and reduce inefficiencies. In addition, the findings that suggest globalization is linked to higher energy consumption emphasize the importance of global collaboration and coordination on energy and environmental matters. It is crucial for policymakers to prioritize the establishment of global agreements and frameworks that encourage sustainable energy practices and the reduction of carbon emissions. This could involve enhancing current mechanisms like the Paris Agreement and implementing measures to support technology transfer and capacity-building in developing countries. On the other hand, the negative relationship between tourism and energy consumption highlights the opportunity for policies to capitalize on the advantages of sustainable tourism methods. It is crucial for policymakers to give utmost importance to initiatives that focus on promoting eco-friendly tourism activities and reducing the environmental impact caused by the tourism industry. This could involve implementing measures like promoting public transportation options, encouraging energy-efficient accommodations, and implementing destination management strategies to prevent overtourism and preserve natural resources. Likewise, policies focused on improving trade openness should give priority to sustainability and energy efficiency factors. This could entail integrating environmental standards and criteria into trade agreements while also advocating for green supply chain practices and the adoption of renewable energy sources in international trade activities.

Although this study provides valuable insights into the complex interplay between tourism, technological advancements, globalization, and energy usage in a prominent tourist destination from 1990 to 2019, it does have some limitations. Firstly, the time frame is limited, which may result in overlooking long-term trends and dynamics. Additionally, the narrow geographical focus on a single region restricts the applicability of the findings to other tourist destinations. In addition, the accuracy of the results may have been influenced by data availability and quality constraints, despite the use of rigorous methodologies. In addition, the intricacy of the econometric models utilized may present difficulties in understanding and implementing them. In order to address these limitations, future research could focus on broadening the temporal and geographical scopes, improving the quality of data, and refining modeling approaches. This would help to gain more comprehensive insights into the intricate dynamics of energy consumption in tourism regions.

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