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A Nexus of CO_2, Tourism Industry, GDP Growth, and Fossil Fuels

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The study investigates the nexus of CO_2 emissions, tourism, fossil fuels, and GDP growth using China's data from 1970 to 2019. The research applied the upset U-molded EKC and the ARDL -models to calculate the time series stationarity variables. The results showed that in the initial enlargement phases, a sophisticated GDP adversely impacts CO_2 emissions, then a higher GDP positively influences CO_2 emissions. The development of tourism, use of fossil fuels (coal and oil), and population growth show an important influence on CO_2 emissions but the use of gas and electricity has little effect on CO_2 emissions. In contrast, foreign direct investment besides population development had little effect on increasing CO_2 emissions. Retreating foreign direct investment, strengthening the use of sustainable electricity, and improving transportation for explorers, especially the green tourism business, are excellent ways to reduce environmental degradation in China.

Keywords: CO_2 emissions, FDI inflows, GDP growth, natural gas consumption, electricity consumption, ARDL methods

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INTRODUCTION

In recent decades, researchers have grown increasingly concerned about the CO_2 emissions caused by global warming. Chinese tourism has seen a dramatic shift in recent decades as demand for visitors has grown at an exponential rate. China is suffering from environmental deterioration because of the rising use of fossil fuels like oil, coal, and gas. High energy consumption for China's GDP development creates pollution, mostly in the form of CO_2 emissions, as a result of FDI, population growth, and the creation of a high level of energy for industrial output. Zaman et al. (2017) concluded that a greater GDP per capita nust be raised to meet the higher energy consumption and environmental pollution. The link between economic growth, tourism, and CO_2 emissions can be used to examine the repercussions of economic and tourist activities on the environmental quality using the instance of China. There will be a short-term increase in non-renewable energy sources because of a rise in population and greater personal well-being (Lee, 2011). According to empirical evidence, experiments show that oil use and carbon emissions deter renewable energy adoption by inelastic amounts. The deployment of carbon sequestration technology propels the energy transition's growth (Kassouri et al., 2022). The study purpose is to determine the relationship between tourism, coal and oil consumption, population growth, and CO_2 emissions. Rojas-vallejos and Lastuka (2020) states a tradeoff between fossil fuel byproducts and wage disparity, the compromise varies and depends on the level of advancement in each of these countries' economies. ARDL results show that a rise in wealth, energy intensity, and resource rent causes a decrease in the load capacity factor, whereas human capital enhances environmental quality in the long term (Pata and Isik, 2021). When fossil fuels like coal, oil, and natural gas are burned, CO_2 is released into the atmosphere, causing environmental damage (Sun et al., 2022b). Non-renewable energy, such as oil, gas, and coal, significantly influenced CO_2 emissions (Khan et al., 2019). Renewable energy is a better option for the environment than fossil fuels. Economic development is not affected by integrating renewable energy and fossil fuels in all environmental degradation metrics (Altntaş and Kassouri, 2020; Sun et al., 2022c). Because of the rising demand for fossil fuels such as oil and gas, China's rapidly growing population might have an effect on climate change and the consequent rise in CO_2 emissions. China accounts for 28% of global CO_2 emissions which might exacerbate climate change. In China, however, economic growth's short-term elasticity is less than its long-term one, indicating that the EKC hypothesis is invalid (Yilanci and Pata, 2020).

The remainder of the study consists of a literature review described in chapter-2. In chapter-3, the methodology is discussed, along with data collection sources and an econometrical explanation of variables. Chapter-4 explains the results and descriptions of the tables. Chapter-5 described the conclusions.

LITERATURE REVIEW

Zhang and Cheng (2009) discovered that GDP drives energy consumption, which causes pollution. According to Meng and Niu (2011), CO_2 emissions, energy consumption, and financial development are all linked in eight Asian countries. In a study of 27 OECD countries, Saboori and Sulaiman (2013) revealed a bidirectional relationship between energy usage, CO_2 emissions, and financial development. The good and negative shocks to FDI and natural resources lower carbon emissions, which has a positive effect on the environment (Udemba and Yalçintaş, 2021). Liu et al. (2019) claims no substantial relationship between tourism and CO_2 emissions. The scheduled operations and transportation exercises are highly linked to inbound travel, whereas petroleum products and fossil fuel byproducts negatively affect outbound travel in Thailand (Zhang and Cheng, 2009; Sun and Razzaq, 2022a). The country's energy and industrial sectors are properly regulated by effective legislation (Udemba et al., 2021). Shi et al. (2019) observed that CO_2 emissions in low-income countries are more adaptable to increased per capita traveler consumption. Tourists in a country would raise GDP, but they would also impair environmental quality due to petroleum derivatives' high energy consumption (Tsui et al., 2018). Economic growth, institutional quality, and renewable energy all have a beneficial and detrimental influence on Chile's environment by reducing and encouraging emissions (Udemba, 2021a). The burgeoning travel sector has coincided with increased financial prospects in Asia, and travel is now a significant industry contributing to the region's financial prosperity. Anser et al. (2020) observed that population increase and per capita GDP are major sources of CO_2 emissions in the SAARC area. Autoregressive disturbed lag limits testing results indicated that economic growth, coal consumption, financial development, imports, industrialization, and urbanization had a positive influence on CO_2 emissions (Pata, 2018a). According to Grunewald et al. (2017), lower fossil fuel byproducts are related to higher pay disparity, while higher pay disparity increments per capita are associated with higher fossil fuel byproducts. Economic growth, population, and FDI all have one-way transmissions from ecological footprint and FDI to energy use in the long run; from ecological footprint and FDI to energy use in the short run; and from ecological footprint and FDI to energy use in the long run (Udemba, 2021b). It was found by identified a causal association between coal consumption and GDP growth in South Korea. Economic expansion was shown to be the leading contributor to rising CO2 emissions, followed by urbanization and financial development (Pata, 2018b). However, Jinke et al. (2008) identified a one-way causal relationship between GDP growth and coal consumption in Japan and China, but none in India, South Korea, or South Africa. Bilgili et al. (2021b) determined the encouraging exploration stage financing for geothermal energy research and tax incentives for the exploration stage and expanding the resource base through joint oil and gas drilling production. Rufeal (2010) revealed that while flammable gas consumption negatively influences CO_2 emissions in most places, there may be a direct correlation in select areas. Compared to fossil fuels and renewable energy research and development, energy efficiency research and development is more successful in reducing carbon emissions (Bilgili et al., 2021a; Sun et al., 2022d). According to (He and Richard, 2010), increasing oil prices decreases oil consumption, lowering CO_2 emissions. The globalization, openness to commerce, and increased affluence all contribute to environmental damage, whereas growing human capital lessens the ecological footprint in the long run (Pata and Caglar, 2021). Payne (2012) found that rising oil prices had a long-term detrimental influence on US CO_2 emissions. Experts supported a cost level below market pricing to stimulate the use of flammable gas as a coal substitute. During the 2008 Beijing Olympics, the authorities increased coal to gas conversion in Beijing. GDP growth and FDI have been demonstrated to negatively impact Australia's environmental quality *via* increasing carbon emissions (Udemba and Alola, 2022). According to Chang (2010). In contrast to electricity and gas, unprocessed petroleum and coal promote economic growth. All forms of energy consumption contribute to CO_2 emissions, but the relationship between financial expansion and CO_2 emissions is just one-way. Gaseous fuel can be used by the government to pursue its financial activities with minimum environmental impact in this case. Digging in gaseous fuel can occasionally restrict the unrestrained spread of low-carbon energy offices because gas is affordable, impeding the expansion of renewable energy sources like wind and sunshine.

RESEARCH METHODOLOGY

Data Collection

This study examines electricity, oil, flammable gas, and coal use from 1970 to 2019 using China's Energy Center point, real GDP per capita, and CO_2 emissions. The research used data before COVID-19 started since including data from 2020 to 2021

TABLE 1 | Variables, descriptions, sources of data collection, and symbols.

Variables	Description	Source	Symbols
CO_2 Emissions	CO_2 emissions (metric tonne per capita)	World Bank database	CO_2
Coal Use	Total Coal Consumption	World Bank database	CU
Oil Use	Total Oil Consumption	World Bank database	OU
Foreign Direct Investment	foreign direct investment inflows	World Bank database	FDI
Population	Population growth rate	https://www.worldometers.info	PoP
Gas Consumption	Total Gas consumption in-country	World Bank database	GC
Tourism Growth	Total number of tourists visiting annually	https://www.statista.com	TG
Electricity Consumption	Total production of electricity	https://www.statista.com	EC
Economic Growth	Constant LCU	World Bank database	GDP

requires additional analytical methods. **Table 1** shows all applicable variables and data gathering sources.

Research Design

LogCO_2 is the log of carbon dioxide emissions, while logGDP is the log of GDP per capita. When it comes to population growth, the study can use several metrics to track it. These include lnPoP, which stands for population growth, lnTG, which stands for tourist arrivals, lnFDI, which stands for foreign workers, and lnEU, which stands for electricity consumption. EKC and IPAT financial models are combined in this study to create a unique model in its own right. This study investigates the upset U-molded EKC using the EKC model. In the following image, the model is shown.

$$ln\, EC_t = \vartheta GDP_t + \theta\, ln\, GDP_t^2 + u_1 \tag{1}$$

GDP^1 is defined as a gross domestic product in the early stages of improvement, GDP^2 as a gross domestic product in the latter stages of improvement, and v as the mistaken term, φ and $\varnothing$ are parameters, such that $\varphi > 0$ and $\varnothing < 0$. An additional model used in this study is called the IPAT model; it is described as follows:

$$\mathrm{I} = f(\mathrm{P}, \mathrm{A}, \mathrm{T}) \tag{2}$$

The IPAT and EKC models have been used to study the influence of energy use and economic growth on CO_2 emissions. This study focuses on the energy, combustible gas, oil, and coal, with the following model specifications:

$$\begin{aligned} LnCO_{2t} = {} & \sigma_0 + \sigma_1\, ln\, GDP_t + \sigma_2\, ln\, GDP_t^2 + \sigma_3\, ln\, PoP + \sigma_4\, ln\, TGG \\ & + \sigma_5\, ln\, FDI + \sigma_6\, ln\, EU + \sigma_7\, ln\, CU + \sigma_8\, ln\, OU \\ & + \sigma_9\, ln\, GUC + u_t \end{aligned} \tag{3}$$

The log of CO_2 emissions is represented by lnCO_2, while the log of GDP per capita is represented by lnGDP. When it comes to population growth, the study can use several metrics to track it. These include lnPoP, which stands for population growth, lnTG, which stands for tourist arrivals, lnFDI, which stands for foreign workers, and lnEU, which stands for electricity consumption. For the ARDL method, the Johansen approach and Engle-Granger strategies provide greater advantages. If you're interested in learning more about how the model works, you can see how it compares to other models that use request I(0) and I(1) components. Because of this, the Expanded Dickey-Fuller (ADF) test is used to determine if a time-series data set has a unit root.

$$\Delta M_t = \alpha_0 + \alpha_1 M_{t-1} - M_{t-1} + \epsilon_t \tag{4}$$

Where Δ is the first differential operator, ϵ_t is the white noise and M_t is a time-series variable. Co-integration estimates are needed to get a sense of how the time series variables relate to one another over the long term. As a result, the equation looks like this:

$$\begin{aligned} \Delta\, ln\, CO_{2t} = {} & \beta_0 + \sum_{i=1}^{j}\beta_i \Delta\, ln\, CO_{2t} + \sum_{i=0}^{k}\gamma_i \Delta\, ln\, GDP_{t-1} \\ & + \sum_{i=0}^{l}\delta_i \Delta\, ln\, GDP_{t-1}^2 + \sum_{i=0}^{m}\lambda_i \Delta\, ln\, PoP_{t-1} \\ & + \sum_{i=0}^{n}\omega_i \Delta\, ln\, TG_{t-1} + \sum_{i=0}^{o}\mu_i \Delta\, ln\, FDI_{t-1} \\ & + \sum_{i=0}^{p}\vartheta_i \Delta\, ln\, EC_{t-1} + \sum_{i=0}^{q}\vartheta_i \Delta\, ln\, CU_{t-1} + \sum_{i=0}^{r}\rho_i \Delta\, ln\, OU_{t-1} \\ & + \sum_{i=0}^{s}\tau_i \Delta\, ln\, GU_{t-1} + \varnothing_0\, ln\, CO_{2t-1} + \varnothing_1\, ln\, GDP_{t-1} \\ & + \varnothing_2\, ln\, GDP_{t-1}^2 + \varnothing_3\, ln\, PoP_{t-1} + \varnothing_4\, ln\, TG_{t-1} \\ & + \varnothing_5\, ln\, TG_{t-1} + \varnothing_6\, ln\, EC_{t-1} + \varnothing_7\, ln\, CU_{t-1} \\ & + \varnothing_8\, ln\, Ou_{t-1} + \varnothing_9\, ln\, GU_{t-1} + u_t \end{aligned} \tag{5}$$

For example, consider the first differential operator (j), (k), and (l), (m), (n), and (p), (q), (r), and (s). The F-statistic evaluates the null and alternative hypotheses for a long-run connection between the variables.

$H_{0=}\varnothing_0 = \varnothing_1 = \varnothing_2 = \varnothing_3 = \varnothing_4 = \varnothing_5 = \varnothing_6 = \varnothing_7 = \varnothing_8 = \varnothing_9 = 0$ (Long—run relationship does not Exist)

$H_{1=}\varnothing_0/ = V_1/ = \varnothing_2/ = \varnothing_3/ = \varnothing_4/ = \varnothing_5/ = \varnothing_6/ = \varnothing_7/ = \varnothing_8/ = \varnothing_9/ = 0$ (Long—run relationship exists)

As a result, determining whether or not there is a co-joining is a challenge. It is necessary to assess the long-term ARDL model after establishing whether or not the co-*incorporation* exists, and the following conditions are present:

TABLE 2 | Shows the results of descriptive statistics.

Variables	Mean	Median	Max	Min	Std. Dev	Observations
lnCO_2	5.5324	3.7968	7.5726	4.354	0.6935	48
lnCU	6.578	6.7946	6.6057	4.6426	0.7854	48
lnOU	6.6926	6.8534	19.3572	8.5768	0.6408	48
lnFDI	31.4679	27.7264	19.6248	18.5326	0.7953	48
lnGU	8.6035	8.2672	6.8354	4.6968	2.4534	48
lnPoP	0.7957	0.726	2.035	0.1862	0.262	48
lnTGA	31.1868	26.24	14.1857	24.5768	0.7964	48
lnGDP	19.0536	19.1862	19.6572	6.4648	0.4726	48
lnGDP2	192.5768	212.6157	157.6453	72.4628	8.6457	48
lnEU	16.8532	19.0072	18.7262	6.2576	0.5764	48

TABLE 3 | Shows the results of the unit root test for intercept and trend.

Variable	Intercept		Intercept and trend	
	Level	1st difference	Level	1st difference
lnCO_2	3.4235	5.5153 ***	0.0375**	−3.977***
	0.0000	−0.0026	0.0031	0.0005
lnCU	−3.1537	−10.7305**	−5.7539	−10.9009***
	0.1973	0.00002	0.00003	0.00001
lnOU	3.1443	−5.7265***	−0.4277	−5.091***
	0.1737	0.00007	0.8526	0.0026
lnFDI	1.5376	−5.4467***	−1.7705**	−5.7119***
	0.5091	0.000001	0.7039	0.00003
lnGU	3.3979	−7.1919**	−5.015	−7.3595***
	0.1915	0.000003	0.0177	0.00001
lnPoP	0.9003	−9.1942**	−3.5176***	−9.445**
	0.7543	0.00001	0.3119	0.00003
lnTG	1.1759	−7.53***	−3.3503	−7.423***
	0.7753	0.00003	0.5039	0.00003
lnGDP	0.5171	−5.8505**	−1.7719	−5.9171***
	0.7547	0.00001	0.7515	0.0019
lnGDP2	0.1739	−5.0737***	−1.8537	−5.7274***
	0.7671	0.0000	0.7537	0.0015
lnEU	3.4451	−5.5039***	−0.5261	−5.0177***
	0.1097	0.0026	0.8519	0.0015

**** and ** Indicating significant thresholds of 1% and 5% would be appropriate.*

$$CO_2 = \propto_0 + \sum_{i=1}^{j} \propto_1 ln\,CO_{2t-1} + \sum_{i=0}^{k} \propto_2 ln\,GDP_{t-1} + \sum_{i=0}^{l} \propto_3 ln\,GDP_{t-1}^2 + \sum_{i=o}^{m} \propto_4 ln\,PoP_{t-1} + \sum_{i=0}^{n} \propto_5 ln\,TG_{t-1} + \sum_{i=0}^{o} \propto_6 \Delta\, ln\,FDI_{t-1} + \sum_{i=0}^{p} \propto_7 \ln EC_{t-1} + \sum_{i=0}^{q} \propto_8 \Delta\, ln\,CU_{t-1} + \sum_{i=1}^{r} \propto_9 \Delta\, ln\,OU_{t-1} + \sum_{i=0}^{s} \propto_{10} ln\,GU_{t-1} + u_t \quad (6)$$

The short-run ARDL model is derived from the long-run ARDL model, which contains the error correction component (ECT). The ECM equation and error correction model are as follows:

$$\Delta\, ln\,CO_{2t} = \gamma_0 + \sum_{i=1}^{j} \gamma_1 \Delta\, ln\,CO_{2t-1} + \sum_{i=0}^{k} \gamma_2 \Delta\, ln\,GDP_{t-1} + \sum_{i=0}^{l} \gamma_3 \Delta\, ln\,GDP_{t-1}^2 + \sum_{i=0}^{m} \gamma_4 \Delta\, ln\,PoP_{t-1} + \sum_{i=0}^{n} \gamma_5 \Delta\, ln\,TG_{t-1} + \sum_{i=0}^{o} \gamma_6 \Delta\, ln\,FDI_{t-1} + \sum_{i=0}^{P} \gamma_7 \Delta\, ln\,EC_{t-1} + \sum_{i=0}^{q} \gamma_8 \Delta\, ln\,CU_{t-1} + \sum_{i=0}^{r} \gamma_9 \Delta\, ln\,OU_{t-1} + \sum_{i=0}^{s} \gamma_{10} \Delta\, ln\,GU_{t-1} + u_t + \vartheta_2 + ECT_{t-1} + \mu_t \quad (7)$$

TABLE 4 | Displays the results of the bound test.

F-statistic	5.7370 **	
Lag Model	0, 1, 1, 2, 2, 0, 0, 0, 2, 1	
R^2	0.7028	
Adjusted R^2	0.7453	
Acute Rate	Minor Certain	Advanced Certain
1%	−3.46	−6.02
5%	−2.32	−5.53
10%	−2.09	−2.97

*** indicates the significance level of 5%, respectively.*

TABLE 5 | Shows the long-term impacts of employing the ARDL method.

Variable	Coefficient	Standard error	Probability
LNCU	0.3474 **	0.0854 **	0.0278 **
LNOU	2.4864 ***	0.2648 ***	0.0000 ***
LNFDI	0.2639	0.2242	0.2252
LNGU	−0.0339	0.0248	0.3972
LNPOP	−0.2548	0.2539	0.4539
LNTG	0.2278	0.0868 ***	0.0067 ***
LNGDP	−2.8398 ***	0.2052 ***	0.0000 ***
LNGDP2	0.0473	0.0208 **	0.0340 **
LNEU	0.239	0.2454	0.5208

**** and ** indicate significance levels of 1% and 5%, respectively.*

There may also be a long-term correlation between tourist arrivals, foreign employment, population expansion, and CO_2 emissions.

RESULTS AND DISCUSSIONS

The descriptive statistics for all of the variables in this study are shown in **Table 2**. *lnCO_2, lnCU, lnOU, lnTG, lnGU, lnPoP, lnGDP, lnGDP^2*, and *lnEU* are all included in the table which gives the maximum, minimum, mean, and standard deviation values. According to the **Table 2**, each variable has a substantial variance.

Using the unit root test, you can see the results in **Table 3**. Only *lnCU* and *lnGU* are fixed at the level with a pattern, whereas all the other components are not fixed at the level with no pattern. The results also reveal that all parameters are fixed at 1% at the main difference with almost no pattern. In terms of a pattern, all

TABLE 6 | Shows the results of the ARDL short-term impact method.

Variable	Coefficient	Standard error	Probability
lnCU	0.0752**	0.0468**	0.0376**
lnOU	0.4374*	0.2860*	0.0802*
lnFDI	0.0865	0.0602	0.2646
lnGU	−0.0070	0.0384	0.4688
lnPOP	0.0027	0.0686	0.6466
lnTG	0.3774**	0.0474**	0.0374**
lnGDP	−0.7064***	0.3700***	0.0020***
lnGDP^2	0.0682	0.0370***	0.0002***
lnEU	−0.3782	0.3848	0.4206
ECT	−0.6284***	0.3747***	0.0004***

****, ** and * Indicating significant thresholds of 1%, 5%, and 10%, respectively.*

TABLE 7 | Shows the results of several diagnostic procedures.

Stat	F-Stat./Jarque-Bera	Prob
Correlation Breusch-Godfrey-Serial LM	0.5628	0.6207
Ramsey re-establishes order	0.0198	0.9526
Heteroscedasticity	0.4026	0.6406
Regularity	0.0295	0.7408

the variables except for $lnCO_2$, which is enormous at 5%, are set at 1%, and before evaluating the long-run coefficients, the bound test was run.

As shown in **Table 4**, the bound test is complete, and it is more than the basic value at the 5% level of relevance, according to the F-value. The study may use the method of the impact of energy consumption, foreign direct investment, the tourism industry, GDP, GDP^2, and electric use on CO_2 emissions.

Application of ARDL Method

Using the ARDL technique, researchers have discovered the long-term impacts on CO_2 emissions of coal usage, oil use, gas use, energy use, unknown direct investment, population growth, vacationer appearances, GDP and GDP^2. In addition, the findings reveal that traveler looks can have a long-term influence on CO_2 emissions, which is crucial at 1%. The usage of combustible gases has also been proven to have no long-term connection with CO_2 emissions (**Table 5**).

There is no long-term influence on CO_2 emissions from increased petroleum gas usage, and CO_2 emissions have no long-term correlation with population growth. In China, population growth has little effect on CO_2 emissions over the long term. When GDP reaches its latter stages, it has a positive and important relationship with CO_2 emissions, significant at 1%. A 1% increase in GDP^2 can increase CO_2 emissions over the long term, revealing long-term success with a U-molded EKC. The addition of FDI does not have a long-term impact on CO_2 emissions and no link was made between electricity use and environmental decline. The study may conclude that unrefined petroleum consumption is linked positively to CO_2 emissions, which are crucial at 1% and error correction term (ECT), energy consumption, FDI, tourism industry, GDP and GDP^2 all have an impact on CO_2 emissions in the short run using the ARDL technique.

Short-Run Impact of ARDL Technique

Table 6 illustrates these impacts, and the ECT coefficient is minus 1%, which is a large number. There is a strong correlation between the amount of CO_2 released and the amount of coal used. According to the coefficient esteem, an increase in coal utilization of 1% can lead to a rise in the short term.

While electricity usage impacts CO_2 emissions, the use of combustible gas has no such effect and energy consumption increases by one percent in this technique will have no direct influence on CO_2 emissions. According to a coefficient of tourist appearances, tourists' arrival has a five percent correlation with CO_2 emissions. CO_2 emissions are linked to the consumption of unrefined petroleum by 5%. There may be a rise in ecological corruption if raw petroleum grows in the short future. Diagnostic testing findings are summarized in **Table 7** and include LM, Ramsey RESET stability, and Heteroscedasticity (Breusch-Godfrey Serial Correlation). The outcomes reveal that the model is free of diagnostic issues, implying that it can explain the influences of energy use, foreign direct investment inflows and tourist industry growth on CO_2 emissions.

Robustness Test

Table 8 shows the elasticity estimates based on the robustness analysis. The augmented mean group and common correlated effects estimators are also employed to forecast long-run elasticities in order to verify the long-run discoveries. Technology long-run elasticities related with GDP growth, population growth, innovation electrical generation capacity, and technical innovation are homogeneous across all the regression estimators.

However, the technological elasticity parameters associated with GDP and population growth are considered as actually irrelevant under the augmented mean group (AMG) and common correlated effects (CCE) research. With these findings, it is possible to make a better informed decision about whether or not to use the ARDL technique to address the cross-sectional dependency and inclination heterogeneity concerns in the data. The relapse exams are followed by a board causality inquiry. As the results show, financial reorganization has the potential to substantially increase the amount of cloudiness contamination, both in the short term and over the long term.

DISCUSSIONS

The study's findings may be explained by China's recent shift in energy strategy, which aims to minimize the country's dependence on foreign oil. When flammable gas is used, there is no indication that electricity has any influence on emissions (Dong et al., 2017a). When generating energy, combustible gas poses the least environmental risk. CO2 emissions are greatly affected by the usage of crude oil and coal. According to Pata and Kumar, (2021) the raw petroleum CO_2 outflows nexus and coal

TABLE 8 | Shows the results of the Robustness test.

Variables	AMG			CCE		
	Coefficient	Standard error	*p* Value	Coefficient	Standard error	*p* Value
lnGDP	3.087*	2.007	0.045	0.099**	0.297	0.043
lnFDI	−0.532*	0.353	0.103	−0.098***	0.353	0.034
lnTEC	−0.647**	0.243	0.075	−0.403*	0.087	0.102
lnPoP	0.307	0.512	0.078	0.058	0.103	0.073
lnCU	0.231	1.087	0.304	0.106	0.097	0.105

**** specifies impact at 1%; ** directs consequence at 5%; * specifies importance at 10%.*

and CO_2 emissions in China and India are connected. When oil and coal are utilized as energy sources, carbon dioxide is emitted into the environment. CO_2 emissions may be affected significantly by the presence of visitors. In the early stages of improvement, GDP is positively correlated with CO_2 emissions. China's southwest, central, and upper east regions have a U-shaped EKC similar for China's tourism business (Jiang et al., 2020). The transportation sector's growth will be accompanied by an increase in energy consumption. Unknown experts have little effect on CO_2 emissions, either immediately or in the long run.

CONCLUSION

The study investigated the nexus of CO_2 emissions, tourism, fossil fuels, and GDP growth using China's data from 1970 to 2019. As a result of the attack on COVID-19, the research has omitted data from 2020 to 2021. The study applied the upset U-molded EKC using EKC and the ARDL models to calculate the time series stationarity variables. Gaseous fuel, electricity, or population increase has no immediate or long-term impact on natural debasement. Coal and oil use and increasing travel will raise CO_2 emissions in the long and short terms alike. The bulk of new hires are working in fields that do not produce a lot of CO_2 emissions, including construction and agriculture, so the GDP directly impacts CO_2 emissions in both the short and long terms because these are all the resources of GDP growth. Finally, GDP per capita positively stimulates environmental decline in the long run and short run. The results of the study do not sustain the inverted U-shaped EKC. Long- and short-term impacts of GDP per capita on natural debasement can be attributed to both GDP^1 and GDP^2. These results are helping the politicians in selecting the appropriate course of action, as FDI, tourism industry, and electricity production energy use can lead to more GDP growth which directly plays a role in the environmental degradation of China. While the country may use gasoline and diesel more frequently, gas consumption creates a high quantity of CO_2 emissions. Since China will not harm the ecology, it may attract more tourists.

Future Research Suggestions

In these two considerations, new research reveals that in the last phases of the revolution, GDP per capita can raise CO_2 emissions. Even though the study can accomplish its goal, there are still areas that need to be addressed. Future studies may look at other countries, especially those rapidly developing, and to obtain better results, exclusively examine China (Dong et al., 2017b; Sharif et al., 2017; Udemba and Tosun, 2022).

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

AUTHOR CONTRIBUTIONS

YS: Conceptualizing, writing, drafting—Original draft MZ: Conceptualizing, writing MC: Data and methodology XW: writing, drafting—Original draft YD: Conceptualizing, writing, drafting—Original draft.

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REFERENCES

Altıntaş, H., and Kassouri, Y. (2020). Is the Environmental Kuznets Curve in Europe Related to the Per-Capita Ecological Footprint or CO2 Emissions? *Ecol. Indic.* 113, 106187. doi:10.1016/j.ecolind.2020.106187

Anser, M. K., Alharthi, M., Aziz, B., and Wasim, S. (2020). Impact of Urbanization, Economic Growth, and Population Size on Residential Carbon Emissions in the SAARC Countries. *Clean. Techn Environ. Policy* 22 (4), 923–936. doi:10.1007/s10098-020-01833-y

Bilgili, F., Nathaniel, S. P., Kuşkaya, S., and Kassouri, Y. (2021a). Environmental Pollution and Energy Research and Development: an Environmental Kuznets Curve Model through Quantile Simulation

Approach. *Environ. Sci. Pollut. Res.* 28 (38), 53712–53727. doi:10.1007/s11356-021-14506-0

Bilgili, F., Kuşkaya, S., Gençoğlu, P., Kassouri, Y., and Garang, A. P. M. (2021b). The Co-movements between Geothermal Energy Usage and CO2 Emissions through High and Low Frequency Cycles. *Environ. Sci. Pollut. Res.* 28 (45), 63723–63738. doi:10.1007/s11356-020-11000-x

Chang, C. C. (2010). A Multivariate Causality Test of Carbon Dioxide Emissions, Energy Consumption and Economic Growth in China. *Appl. Energy* 87, 3533–3537. doi:10.1016/j.apenergy.2010.05.004

Dong, K., Sun, R., and Hochman, G. (2017a2017). Do natural Gas and Renewable Energy Consumption Lead to Less CO2 Emission? Empirical Evidence from a Panel of BRICS Countries. *Energy* 141, 1466–1478. doi:10.1016/j.energy.2017.11.092

Dong, K., Sun, R., Hochman, G., Zeng, X., Li, H., and Jiang, H. (2017b). Impact of Natural Gas Consumption on CO2 Emissions: Panel Data Evidence from China's Provinces. *J. Clean. Prod.* 162, 400–410. doi:10.1016/j.jclepro.2017.06.100

Grunewald, N., Klasen, S., Martínez-Zarzoso, I., and Muris, C. (2017). The Trade-Off between Income Inequality and Carbon Dioxide Emissions. *Ecol. Econ.* 142, 249–256. doi:10.1016/j.ecolecon.2017.06.034

He, J., and Richard, P. (2010). Environmental Kuznets Curve for CO2 in Canada. *Ecol. Econ.* 69 (5), 1083–1093. doi:10.1016/j.ecolecon.2009.11.030

Jiang, M., Kim, E., and Woo, Y. (2020). The Relationship between Economic Growth and Air Pollution-A Regional Comparison between China and South Korea. *Int. J. Environ. Res. Public Health* 17, 2761. doi:10.3390/ijerph17082761

Jinke, L., Hualing, S., and Dianming, G. (2008). Causality Relationship between Coal Consumption and GDP: Difference of Major OECD and Non-OECD Countries. *Appl. Energy* 85, 421–429. doi:10.1016/j.apenergy.2007.10.007

Kassouri, Y., Altuntaş, M., and Alola, A. A. (2022). The Contributory Capacity of Natural Capital to Energy Transition in the European Union. *Renew. Energy* 190, 617–629. doi:10.1016/j.renene.2022.03.142

Khan, M. K., Teng, J.-Z., and Khan, M. I. (2019). Effect of Energy Consumption and Economic Growth on Carbon Dioxide Emissions in Pakistan with Dynamic ARDL Simulations Approach. *Environ. Sci. Pollut. Res.* 26, 23480–23490. doi:10.1007/s11356-019-05640-x

Lee, R. (2011). The Outlook for Population Growth. *Science* 333 (333), 569–573. doi:10.1126/science.1208859

Liu, Y., Kumail, T., Ali, W., and Sadiq, F. (2019). The Dynamic Relationship between CO2 Emission, International Tourism and Energy Consumption in Pakistan: a Cointegration Approach. *Tour. Rev.* 74 (4), 761–779. doi:10.1108/TR-01-2019-0006

Meng, M., and Niu, D. (2011). Modeling CO2 Emissions from Fossil Fuel Combustion Using the Logistic Equation. *Energy* 36 (5), 3355–3359. doi:10.1016/j.energy.2011.03.032

Pata, U. K., and Caglar, A. E. (2021). Investigating the EKC Hypothesis with Renewable Energy Consumption, Human Capital, Globalization and Trade Openness for China: Evidence from Augmented ARDL Approach with a Structural Break. *Energy* 216, 119220. doi:10.1016/j.energy.2020.119220

Pata, U. K., and Isik, C. (2021). Determinants of the Load Capacity Factor in China: A Novel Dynamic ARDL Approach for Ecological Footprint Accounting. *Resour. Policy* 74, 102313. doi:10.1016/j.resourpol.2021.102313

Pata, U. K., and Kumar, A. (2021). The Influence of Hydropower and Coal Consumption on Greenhouse Gas Emissions: A Comparison between China and India. *Water* 13, 1387. doi:10.3390/w13101387

Pata, U. K. (2018a). Renewable Energy Consumption, Urbanization, Financial Development, Income and CO2 Emissions in Turkey: Testing EKC Hypothesis with Structural Breaks. *J. Clean. Prod.* 187, 770–779. doi:10.1016/j.jclepro.2018.03.236

Pata, U. K. (2018b). The Influence of Coal and Noncarbohydrate Energy Consumption on CO2 Emissions: Revisiting the Environmental Kuznets Curve Hypothesis for Turkey. *Energy* 160, 1115–1123. doi:10.1016/j.energy.2018.07.095

Payne, J. E. (2012). The Causal Dynamics between US Renewable Energy Consumption, Output, Emissions, and Oil Prices. *Energy Sources, Part B Econ. Plan. Policy* 7 (4), 323–330. doi:10.1080/15567249.2011.595248

Rojas-vallejos, J., and Lastuka, A. (2020). The Income Inequality and Carbon Emissions Trade-Off Revisited. *Energy Policy* 139, 111302. doi:10.1016/j.enpol.2020.111302

Rufeal, Y. (2010). Coal Consumption and Economic Growth Revisited. *Appl. Energy.* 87, 160–167. doi:10.1016/j.apenergy.2009.05.001

Saboori, B., and Sulaiman, J. (2013). Environmental Degradation, Economic Growth and Energy Consumption: Evidence of the Environmental Kuznets Curve in Malaysia. *Energy Policy* 60, 892–905. doi:10.1016/j.enpol.2013.05.099

Sharif, A., Afshan, S., and Nisha, N. (2017). Impact of Tourism on CO2emission: Evidence from Pakistan. *Asia Pac. J. Tour. Res.* 22, 408–421. doi:10.1080/10941665.2016.1273960

Shi, H., Li, X., Zhang, H., Liu, X., Li, T., and Zhong, Z. (2019). Global Difference in the Relationships between Tourism, Economic Growth, CO2 Emissions, and Primary Energy Consumption. *Curr. Issues Tour.* 23, 1122–1137. doi:10.1080/13683500.2019.1588864

Sun, Y., and Razzaq, A. (2022a). Composite Fiscal Decentralisation and Green Innovation: Imperative Strategy for Institutional Reforms and Sustainable Development in OECD Countries. *Sustain. Dev.*, 1–14. doi:10.1002/sd.2292

Sun, Y., Guan, W., Razzaq, A., Shahzad, M., and An, N. (2022b). Transition Towards Ecological Sustainability Through Fiscal Decentralization, Renewable Energy and Green Investment in OECD Countries. *Renew. Energy* 190, 385–395. doi:10.1016/j.renene.2022.03.099

Sun, Y., Razzaq, A., Sun, H., and Irfan, M. (2022c). The Asymmetric Influence of Renewable Energy and Green Innovation on Carbon Neutrality in China: Analysis From Non-Linear ARDL Model. *Renew. Energy* 193, 334–343. doi:10.1016/j.renene.2022.04.159

Sun, Y., Anwar, A., Razzaq, A., Liang, X., and Siddique, M. (2022d). Asymmetric Role of Renewable Energy, Green Innovation, and Globalization in Deriving Environmental Sustainability: Evidence from Top-10 Polluted Countries. *Renew. Energy* 185 , 280–290. doi:10.1016/j.renene.2021.12.038

Tsui, W. H. K., Balli, F., Tan, D. T. W., Lau, O., and Hasan, M. (2018). New Zealand Business Tourism. *Tour. Econ.* 24 (4), 386–417. doi:10.1177/1354816617731387

Udemba, E. N., and Alola, A. A. (2022). Asymmetric inference of carbon neutrality and energy transition policy in Australia: The (de)merit of foreign direct investment. *J. Clean. Prod.* 343, 131023. doi:10.1016/j.jclepro.2022.131023

Udemba, E. N., Güngör, H., Bekun, F. V., and Kirikkaleli, D. (2021). Economic Performance of India amidst High CO2 Emissions. *Sustain. Prod. Consum.* 27, 52–60. doi:10.1016/j.spc.2020.10.024

Udemba, E. N. (2021a). Mitigating Environmental Degradation with Institutional Quality and Foreign Direct Investment (FDI): New Evidence from Asymmetric Approach. *Environ. Sci. Pollut. Res.* 28 (32), 43669–43683. doi:10.1007/s11356-021-13805-w

Udemba, E. N. (2021b). Nexus of Ecological Footprint and Foreign Direct Investment Pattern in Carbon Neutrality: New Insight for United Arab Emirates (UAE). *Environ. Sci. Pollut. Res.* 28 (26), 34367–34385. doi:10.1007/s11356-021-12678-3

Udemba, E. N., and Tosun, M. (2022). Energy Transition and Diversification: A Pathway to Achieve Sustainable Development Goals (SDGs) in Brazil. *Energy* 239, 122199. doi:10.1016/j.energy.2021.122199

Udemba, E. N., and Yalçıntaş, S. (2021). Interacting Force of Foreign Direct Invest (FDI), Natural Resource and Economic Growth in Determining Environmental Performance: A Nonlinear Autoregressive Distributed Lag (NARDL) Approach. *Resour. Policy* 73, 102168. doi:10.1016/j.resourpol.2021.102168

Yilanci, V., and Pata, U. K. (2020). Investigating the EKC Hypothesis for China: the Role of Economic Complexity on Ecological Footprint. *Environ. Sci. Pollut. Res.* 27 (26), 32683–32694. doi:10.1007/s11356-020-09434-4

Zaman, K., Moemen, M. A.-e., and Islam, T. (2017). Dynamic Linkages between Tourism Transportation Expenditures, Carbon Dioxide Emission, Energy Consumption and Growth Factors: Evidence from the Transition Economies. *Curr. Issues Tour.* 20 (16), 1720–1735. doi:10.1080/13683500.2015.1135107

Zhang, X. P., and Cheng, X. M. (2009). Energy Consumption, Carbon Emissions and Economic Growth in China. *Ecol. Econ.* 68 (10), 2706–2712. doi:10.1016/j.ecolecon.2009.05.011

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