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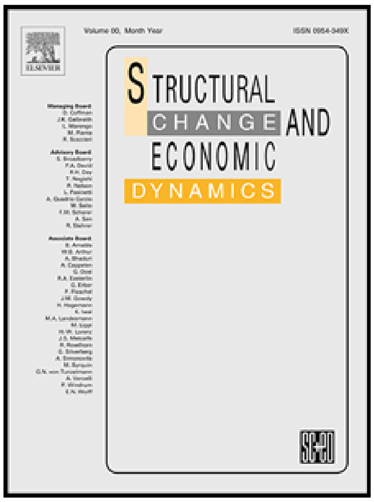

Exploring the nexus between tourism development and environmental quality: Role of Renewable energy consumption and Income

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Highlights

(1) This study develops a tourism-pollution model for G20 economies.

(2) Results show that a 1% increase in tourism decreases CO_2 emissions by 0.05% in long run.

(3) Renewable energy was having supportive role in CO_2 emissions from G20 economies.

(4) There was an inverted U-shape relation between CO_2 emissions and real GDP.

Exploring the nexus between tourism development and environmental quality: Role of Renewable energy consumption and Income

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Abstract

Tourism appears as a catalyst for growth and development; however, recent studies have documented that this sector heavily depends on energy sector and as a consequence, entire tourism industry has been blamed for CO_2 emissions. This study aims to investigate the impact of tourism develop, renewable energy and real GDP on CO_2 emissions for G20 economies for the period of 1995-2015. In the presence of panel unit root, Pedroni and Kao methods confirm long run cointegration among variables. FMOLS results show that a 1% increase in tourism decreases pollution by 0.05% in the long run. Thus, paper adds a novel contribution by revealing that tourism development is a driving force for pollution reduction. Results footprints that an increase in renewable energy consumption reduces pollution emissions. A 1% increase in renewable energy reduces pollution emissions by 0.15% in the long run. There was an inverted U-shaped relation between pollution and real GDP in long run.

Keywords: Tourism development; Carbon emissions; Renewable energy; G20; Economic growth

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1. Introduction

The proportion of tourism and travel in global GDP is increasing in the last consecutive eight years. The total contribution of travel and tourism sector to the world GDP is as high as US$ 8.8 trillion that is around 10.4% of the latter with 319 million jobs created in 2018. Only in 2018, 1 out of 5 jobs belong to this sector (Vicky Karantzavelou, 2019). Roughly 1.5 billion international tourism travel was recorded in 2019 that is the increase of 4% than previous year where almost all regions saw growth in the tourism arrivals. UN World Tourism Travel Secretary-General Zurab Pololikashvili have commented that “in these times of uncertainty and volatility, tourism remains a reliable economic sector”. It is the reason that tourism sector is the heart of global development (UNWTO, 2020). Tourism is the great source of income and job opportunities for the economies that attract foreigner tourists. It does not only generate revenues but also sources growth and development for the economy. Tourism industry modernizes remote areas and speed up economic and cultural development (Yan and Santos, 2009; Yang and Wall, 2009; Candice C. 2015).

The 2015 sustainable development goals (SDGs) by United Nations makes it clear that tourism sector can contribute directly and indirectly to all 17 SDGs. For example, the first two goals are “no poverty” and “zero hunger” and both can be overcome by tourism development as this sector can help in job creation and can offer employment opportunities to everyone. Thus, tourism industry has a special position in the 2030 agenda of SDGs. Although tourism sector makes lives better by generating revenues as tourism arrivals are the source of income, however, it also consumes high energy (Liu, Feng and Yang, 2011) and this energy consumption causes pollution emissions. Due to this reason, World Travel Tourism Council set goals to reduce carbon emissions by 25-30% till 2020 and 50% by 2035 based on 2005 statistics (WTTC, 2009).

Tourism industry does not consume direct energy but 50-60% of carbon emissions is indirectly from tourism industry (Dwyer et al., 2010).

On the other hand, growing environmental pressure urges world to device policies for sustainable development. There have been confirmation from the last 150 years that global earth temperature is changing and have significant impact on lives (Brooke, 2014). The CO_2 emissions that was 19 million kilotons in 1980 have reached to 36 million kilotons revealing around 80% intensification (WDI, 2017). International Energy Agency (IEA) have documented that world energy demand will be as higher as 28% until 2060 (IEA, 2017) and this energy demand can have negative influence on environment. 2015 was the hottest year in the past 40s year history while 1987 was at second position (Dube and Nhamo, 2018). This rising temperature raises several concerns such as extreme temperature raises water demand, evaporation becomes common and water holes get dried. For example, recently, Amazon Brazil, rainforest issue appeal for climate justice to avoid heavy destruction. Although it may be normal to have some fires in Amazon, however, in 2019, fires cross 83% than the 2018 that is alarming! Amazon is considered the lungs of planet with the production of 20% World Oxygen. The fires have destroyed home of indigenous tribes and have proven a serious threat of million animals living there. The large increase in CO_2 emissions and realizing the harsh influence of CO_2 emissions on human race, each year, United Nations Framework Convention on Climate Change (UNFCC) have organized conference from 1995 to onward for the discussion to overcome worldwide emissions. In November and December, 2015, UNFCC meeting in Paris, lays great stress to maintain global temperature under 2°C above pre-industrial level that requires individual country's effort to maintain the trend (Dogan and Lotz, 2017). It has been documented that if we want CO_2 emissions under 2°C as is in Paris accord, we have to reduce greenhouse gas (GHS) emissions by 40-70% by 2050 (Edenhofer, 2014). To reduce emissions, all economic sectors need to play their supportive role where among many others, tourism is one of the important sector that can have strong influence on CO_2 emissions. This paper is an effort to explore the impact of tourism development along with renewable energy and real GDP on CO_2 emissions for G20.

G20 is the group of 19 individual countries and European Union. 19 individual countries includes Argentina, Australia, Brazil, China, Canada, Germany, France, United Kingdom, Indonesia, India, Italy, Japan, South Korea, Mexico, Russia, Saudi Arabia, Turkey, United States and South Africa. G20 economies are important as they accounts for 85% of global economy, 75 percent of world trade and collectively accounts 81% of energy related CO_2 emissions (IEA, 2018). These economies are responsible for three quarters of global greenhouse gas emissions (Elzen et al., 2019) and comprises around 66% global population with the production of 90% of global GDP and emits around 80% of global greenhouse gas emissions (UNEP, 2009). Today, G20 fossil fuels is dominant energy source where coal remains single largest fuel in the electricity mix account 44%, while energy consumption from oil was 39% (IEA, 2018). After Paris Agreement, with the goal to control global temperature well below 2°C relative to pre-industrial levels (UNFCCC, 2015), G20 economies' leaders are encouraged to co-operate for the implementation of Paris agreement.

This paper contributes to the existing literature as the following; first, it investigates the role of tourism sector in the CO_2 emissions of G20 economies. G20 economies are important as these economies accounts for 85% of global economy and accounts 81% of energy related CO_2 emissions and tourism sector is important source of income for these economies. Second, this paper uses renewable energy as input factor to explain pollution emissions as high growth and development deserves proper attention i.e. high growth and development requires more energy consumption that causes environmental pollution. So, renewable energy has been added in the analysis to test if it can help in pollution reduction. If so, then introduction of renewable energy will be important because of its two fold benefits as it will help in pollution reduction as well as in maintaining growth and development. One may think that renewable energy will come up with higher cost than traditional nonrenewable energy. However, we need to think the bigger picture and more benefits associated in the long run because novel methods and technology always come with initial higher cost where fixed cost will be fixed in long run and variable cost will be limited such as solar power planets initial cost may be higher but it can last 15-20 years with limited variables cost including maintenance cost i.e. wear and tear, preparation of wires, connection etc. The third contribution of the study is the investigation of environmental Kuznets curve (EKC) by incorporating real GDP and real GDP square in the model to test its impact on CO_2 emissions as validity of environmental Kuznets curve is a unique solution for pollution reduction. In the presence of EKC, initially rise in real GDP raise CO_2 emissions, but after some specific period of time, this relation turns to inverse and further raise in real GDP reduces CO_2 emissions as country (group of countries in panel setting) starts moving towards sustainable growth and development. It's the reason many researchers are interested to investigate environmental Kuznets curve for policy suggestions. Thus, this study is important for policy makers, industry and state players.

The rest of the paper is structured as follows: Section 2 is for literature review; section 3 is devoted for data, model and estimation procedure; section 4 is for results and discussion; section 5 concludes the paper and section 6 is for policy implications and limitations.

2. Literature Review

Given the existence of ambitious policy goals aimed at enhancing environmental quality and reducing carbon emissions, the dynamic relation among renewable energy, economic growth, tourism development and CO_2 emissions have been investigated in the present work. This section overviews previous literature connected with the current study. In the light of previous literature, it has been documented that tourism sector is energy intensive and heavily depends on energy sector. This sector starts from transportation while include but not limit to accommodation and illumination that consume heavy energy (Becken, 2003). There are studies to confirm the relation between energy consumption and accommodation (Tsagarakis et al., 2011). Researchers like Katircioglu (2014) and Katircioglu, Feridun and Kilinc (2014) have documented that tourism have positive effects on climate change while Lee and Brahmasrene (2013) have pointed out that tourism negatively affects climate change. The work of Tang, Zhong and Ng (2017) is important to guide that tourism sector is among the main contributors to energy consumption and greenhouse gas emissions. They have proposed a unique model to analyze carbon emissions in energy consumption of tourism industry and have shown that growth in the scale of tourists and scale of tourisms result the development of carbon emissions. Literature have highlighted the importance of pollution reduction by documenting that tourists can take effective measures including less travelling and business consideration that consume less energy and sources less CO_2 emissions (Simpson et al., 2008). Slow travel like by buses and trains have been suggested to avoid CO_2 emissions from plane (Dickinson et al., 2001) as United Nations World Tourism Organization have reported that tourism accounts around 5% of global CO_2 emissions where air transport contribute around 40% of total emissions (Dubois and Ceron, 2006).

Zhang and Gao (2016) have documented that tourism sector is among one of the largest carbon emitters. They have explored the effects of international tourism and economic growth in China along with energy consumption and CO_2 emissions. Using panel data for the period of 1995-2011, they have concluded that tourism induced environmental Kuznets curve does not exist in Central China while there were signals for the weak validity of EKC in eastern and western parts of China. Tourism has negative impact on CO_2 emissions for the eastern part of China. China is among the most visited countries and especially, after the reform and open up policy since 1978, it has become the 3rd most visited countries in the world. For example, there were 55.98 million overseas tourist in 2010 while 1.61 billion domestic tourists that is expected to rise more in future. As a consequence of all this, foreign exchange reach to 45 billion USD and it was ranked the fourth in world in 2009 (Zhang and Gao, 2016).

Researchers like Tang, Zhong and Jiang (2017) have offered energy efficiency and carbon efficiency of tourism industry model with the detailed bottom up analysis methods and theory of life cycle assessment. By choosing Wulingyuan and Historic Interest Area as a scenic areas from China, authors have measured carbon efficiency of tourism industry. Results reveal that energy efficiency and carbon efficiency of tourism sector was improved with the passage of time and especially, at the evolution stage of tourism life cycle. Overall, it helps theory of tourism geography and green development of low carbon tourism. They have suggested low carbon tourism product should be developed that will attract more tourists. It has been documented that tourism and transport sector is the fifth largest emitters for China, USA, India and Russia (Zhang and Gao, 2016). All this reveals that tourism related activities such as transportation, accommodation etc. heavily depends on energy consumption that sources CO_2 emissions. Studies have also shown that transportation sector badly adds in CO_2 emissions (Liu, Feng, Yang, 2011). Bouttaba and Ahmad (2017) have explored the determinants of biofuel for 12 OECD countries with the time span of 2002-2012. They have used panel unit root and panel cointegration tests to confirm long-run relationship among variables. FMOLS and DOLS methods have been used to extract coefficient. Results declare that biofuel depends on income and CO_2 emissions more prominent than that of oil and biofuel prices. Further, results declare that biofuel negatively affect the CO_2 emissions. Paper demonstrates that biofuel is offering promising opportunity to reduce the dependency of fossil fuels. Although the share of biofuel is relatively small (12.4% of total energy), however, it is fast growing. Authors have concluded that biofuel is good energy source to fulfil the need to energy, it helps in poverty alleviation by making countries self-sufficient in energy production and environmental friendly that helps towards sustainability.

Recently, Zhang and Liu (2019) have explored the relation among international tourism, CO_2 emissions, real GDP and energy consumption for Northeast and Southeast regions. The authors have utilized panel unit root tests, LLC, IPS, Fisher-ADF and Fisher-PP, to verify the unit root problems for the annual data set during 1995-2014 and the results have confirmed that variables were non stationary at level and become stationary at first difference at 1% level of significance. Panel cointegration tests confirm the long run cointegration among series and finally, FMOLS was adopted to check the coefficient estimates. Results show the nonexistence of environmental Kuznets curve for whole sample, Northeast and Southeast Asian countries. Renewable energy was having positive role in pollution reduction while tourism development was adding in pollution in panel analysis. On the other hand, Shakouri, Yazdi and Ghorchebigi (2017) have explored the impact of real GDP, energy consumption and tourism development on CO_2 emissions for the selected panel of Asian countries. Using panel unit root tests and panel GMM method, authors have confirmed the validity of environmental Kuznets curve. Tourism development was helping in pollution reduction while energy consumption was adding in CO_2 emissions.

Researchers like Zhang and Zhang (2020) have explored the relation among tourism, economic growth, energy consumption and CO_2 emissions for 30 Chinese provinces. Panel unit root tests, Levin–Lin– Chu, Breitung, Im–Pesaran–Shin, augmented Dickey–Fuller (ADF), confirm that variables were non stationary at level and become stationary at first difference at 5% level of significance. Pedroni and Kao tests confirm the existence of cointegration relation among variables. Results show that a 1% increase in tourism increases CO_2 emissions by 0.51% while a 1% increase in energy consumption raises CO_2 emissions by 0.12% in China. The 1% rise in real GDP raises CO_2 emissions by 0.55%. Overall, tourism, economic growth and energy was adding to CO_2 emissions in long run. Similarly, Katircioglu (2014) have explored the relation between tourism, energy consumption and CO_2 emissions for Turkey and have found that these variables have integration in long run and the positive effect of renewable and tourism development have been found in the explanation of CO_2 emissions.

Jebli, Youssef and Apergis (2019) have explored the relation among tourist arrivals, foreign direct investment, trade openness, renewable energy, real GDP and CO_2 emissions for the panel of 22 Central and South American countries, time spanning 1995-2010. The panel unit root tests have been used to test the stationary properties of variables where all variables were non stationary at level and become stationary at first difference. In the presence of unit root, Pedroni tests confirm the long run cointegration among variables. FMOLS results reveal that a 1% increase in real GDP raises CO_2 emissions by 1.26% while a 1% rise in renewable energy decreases CO_2 emissions by 0.12% in long run. The effect of FDI coefficient shows that a 1%

increase in FDI decreases CO_2 emissions by 0.27%. Further, results reveal that a 1% increase in tourism arrivals decreases CO_2 emissions by 0.35% in long run. Researchers like Zhang and Gao (2016) have tested the relation among tourism, economic growth, energy consumption, CO_2 emissions by using the panel of 30 Chinese provinces with the data set of 1995-2011. Three panel unit root tests including IPS, Fisher-ADF test and LLC test confirm that variables are non-stationary at level while they get stationary at first difference. In the presence of unit root, Pedroni tests have been used that confirm the existence of long run relation among variables. FMOLS results show that rise in economic growth raises CO_2 emissions in central and western regions while there was no significance impact in eastern region. The energy consumption was having positive impact on CO_2 emissions in eastern and central region while there was no significance effect of energy consumption on CO_2 emissions in eastern region. Interestingly, tourism was having negative impact on CO_2 emissions in eastern region while in central and western regions the impact was not significant. They have also confirmed the tourism induced environmental Kuznets curve was not valid for central China while there was a weak confirmation from western and eastern region.

The above literature reveal that although tourism sector importance is gradually recognized recently, however, the existing studies results are mix and cannot be generalized on G20 economies. Consequently, it motivates to fill the knowledge gap. Thus, the major purpose of the study was to explore tourism and CO_2 emissions relation for G20. Second goal was to explore environmental Kuznets curve for G20 economics as this EKC offer unique policy suggestions that in the presence of EKC, growth and development should not be reduced to overcome pollution emissions rather there is need to find other alternative measures to reduce CO_2 emissions. The third goal was to explore the renewable energy effect on CO_2 emissions for G20 economies so that it can be tested how the introduction of renewable energy will influence CO_2 emissions for G20 economies.

3. Data, model and estimation procedure

3.1. Data

The annual balance panel data for real GDP per capita, CO_2 emissions per capita, renewable energy per capita and tourism arrivals have been collected for the period of 1995-2015 according to data availability. Real GDP per capita is measured in constant 2010 US$, CO_2 emissions per capita is in kiloton (kt), renewable energy consumption per capita is the % of total final energy and total international tourists' arrival proxy of tourism development. Inspired by the work of Zhang and Liu (2019), Zhang and Gao (2017), we have used international tourism while all kinds of numbers of inbound, outbound, domestic tourists can be considered in future research to see their impact on CO_2 emissions. Similarly, paper uses CO_2 emissions per capita by following the previous mentioned work, however, CO_2 emissions from tourism sector can be used to investigate the relation between tourism and emissions once the separate data is available. The data source is world development indicators (WDI), World Bank, 2018 (http://www.worldbank.org). 19 G20 economies that include Argentina, Australia, Brazil, China, Canada, Germany, France, United Kingdom, Indonesia, India, Italy, Japan, South Korea, Mexico, Russia, Saudi Arabia, Turkey, United States and South Africa have been included in the study. Although European Union (EU) is a member of G20, however, since it is not an independent sovereign state and separate data is not available, therefore, it has not been included in analysis. To avoid fluctuation in data and heteroscedasticity, variables are transformed into log form to interpret coefficients in elasticities. Descriptive statistic i.e. Mean, Median, Maximum, Minimum, Std. Dev. Skewness, Kurtosis are reported in table 1.

[Please insert Table 1]

A graphical representation of tourism arrivals, real GDP per capita, CO_2 emissions per capita have been shown in figure 1, 2 and 3 that confirm variables are interconnected. For example, figure 1 show that Argentina real GDP per capita increases initially, reaches to the highest point and has dropped down sharply while reaching to the minimum point, it starts increasing, finally. Looking at fig. 2 for the same country, CO_2 emissions is showing similar trend as it increases initially, reaches to the highest point and then, it has dropped down quickly and after reaching to minimum point, it is increasing sharply. Australian real GDP per capita is with increasing trend in most of the years while CO_2 emissions increases with slow trend and in last years, it is decreasing revealing that Australia has focused on emissions reduction over the period of time. Brazilian real GDP per capita and CO_2 emissions are moving in same trend pattern i.e. when real GDP per capita is increasing sharply, CO_2 emissions is also increasing. Canada real GDP per capita increases most of the years except few small shocks and similar trend was from CO_2 emissions graph though it was with decreasing trend after 2012. China real GDP per capita has increased dramatically over the sample period and similar, trend was adopted by CO_2 emissions. Some countries such as France and Germany seems to be more focused in emissions reduction where their real GDP per capita were increasing over the period while CO_2 emissions was decreasing during the sample period. France and Germany role is important in the implementation of Paris agreement where CO_2 emissions and global temperature control are stepping stone of the agreement. They have launched several joint research programs and have invited international researchers to join hands for the implementation of Paris agreement such as "MAKE OUR PLANET GREAT AGAIN". Similarly, UK and United States real GDP per capita have increased over the sample period while CO_2 emissions was declining. It reveals that these countries are cutting their CO_2 emissions intensity. Several interesting facts from various combination of real GDP and CO_2 emissions per capita can be seen in figure 1 and 2. Tourism graph (figure 3) reveals strong connection with economic growth (figure 1) that can be seen by comparing the two graphs such as Argentina and Australia real GDP per capita increases with the rise of tourism arrivals for respective country revealing tourism led growth hypothesis is true.

[Please insert Figure 1]

[Please insert Figure 2]

[Please insert Figure 3]

From the graphical representation of figures 1-3, it can be seen that real GDP per capita is tourism dependent and CO_2 emissions is increasing with the rise of real GDP per capita that show these variables are interconnected. Owing the reasons, this study makes novel attempt to explore tourism development and CO_2 emissions nexus for G20 economies. In addition to this, graphs show that increase in real GDP per capita has positive connection with CO_2 emissions per capita i.e. in most cases, with the rise of real GDP per capita shows rise in CO_2 emissions and it may be that at initial stages, these variables have positive relation and in long run, this relation can turn to inverse due to sustainable path for economies. So, paper introduces real GDP per capita square in the model to test how real GDP per will influence CO_2 emissions after the turning point.

3.2. Econometric Model

The study main goal was to test the influence of tourism on CO_2 emissions for G20 economies. Further, paper builds two hypothesis to test the role of renewable energy consumption and real GDP per capita for policy suggestions to help in pollution reduction. Inspired by Zhang and Liu

(2019 and Zhang and Gao (2016), this study uses real GDP per capita (measured in constant 2010 US$), renewable energy consumption (% of total final energy consumption) per capita, CO_2 emissions (kt) per capita, international tourism arrivals to explore nexus among variables. Paper constructs basic panel model as:

$$CO2_{it} = F(TR_{it}, Y_{it}, RE_{it}) \quad (1)$$

CO_2 is carbon dioxide emissions per capita, F stands for function, TR refers to tourism development, Y is real GDP per capita, RE is renewable energy consumption, i is number of countries, i=1,…….., while t is time period of the study that was 1995 to 2015. To avoid fluctuation in data and heteroscedasticity, all variables are transformed into log form to interpret coefficients in elasticity. After taking the log of equation 1, it will be as:

$$LnCO2_{it} = \alpha_0 + \beta_1 LnTR_{it} + \beta_2 LnRE_{it} + \beta_3 LnY_{it} + \varepsilon_{it} \quad (2)$$

It is expected that renewable energy will have negative coefficient so $\beta_2 < 0$ since it is environment friendly while if it was non-renewable, the expectation may be $\beta_2 > 0$. Tourism coefficient can be positive $\beta_1 > 0$ by revealing that tourism will add in pollution emissions as tourism development often use high energy consumption or it can be negative $\beta_1 < 0$ revealing that tourism development is supportive in pollution reduction and in this situation, tourism development will be important to focus as it does not only generate revenues rather also helps in pollution reduction.

Real GDP coefficient may be $\beta_3 > 0$ as it can be expected that economic growth leads to pollution emissions or may be $\beta_3 < 0$ that means real GDP has supportive role in pollution reduction. Recently, it has been commented that there is a nonlinear relation between income level and CO_2 emissions that lead to environmental Kuznets curve specification. Environmental Kuznets curve idea is originally from Grassman and Kruger (1991, 1995) work where they have documented that there is an inverted U-shape relation between income and pollution emissions. Ahmad et al. (2018) have documented that the validity of environmental Kuznets curve is a unique solution for pollution reduction i.e. growth and development has supportive role in the pollution reduction. To evaluate environmental Kuznets curve, we have adopted a standard approach to run panel model with real GDP per capita and real GDP per capita squared. Thus, to test tourism induced environmental Kuznets curve, income square has been introduced in the model as:

$$\text{LnCO2}_{it} = \alpha_0 + \beta_1 LnTR_{it} + \beta_2 LnRE_{it} + \beta_3 LnY_{it} + \beta_4 LnY_{it}^{\;2} + \varepsilon_{it} \quad (3)$$

In equation 3, i is the representation of 19 G20 economies, t is time period (1995-2015), where ε is white noise error term. α_0 is constant, β_1, β_2, β_3 and β_4 are the coefficients of their respective variables. Environmental Kuznets curve will be valid if $\beta_3 > 0$, $\beta_4 < 0$ that reveals initially rise in income raises CO_2 emissions, however, after the specific period (turning point), this relation turns to inverse and further, increase in income reduces CO_2 emissions. Thus, validity of environmental Kuznets curve is important for growth policy. Turning point will be estimated as: $TP = \exp(-\beta_3 / \beta_4)$.

3.3. Estimations procedure

3.3.1. Panel unit root tests

Analysis starts with the examination of panel unit root properties of variables as ignoring it may lead to misleading results and policy may not be appropriate. Owing the reasons, panel unit root tests will be applied on tourism, renewable energy consumption, real GDP and CO_2 emissions. Panel unit root tests have advantages over time series unit roots as they combine cross section and time series to make sample size large and thus, increase testing power. To confirm robust findings, five panel unit root tests that include Levin et al. (2002) proposed test LLC test, Breitung test (Breitung, 2000), IPS test proposed by Im et al. (2003), Fisher ADF and Fisher PP tests will be applied. Maddala and Wu (1999) and Choi (2001) proposed fisher type of tests (Fisher ADF and Fisher PP) that combine p-value from individual unit root tests and these two tests are based on non-parametric econometrics that have advantages over parametric econometric. These tests don't require balance panel data and Monto Carlo simulation reveal these tests outperform in small sample. The tests statistic is $\Lambda = -2\sum_{i=1}^{N} \ln p_i$, where p_i p-value for each single unit root test is.

Levin et al. (2002) proposed LLC test that is based on following formula:

$$\Delta y_{it} = \alpha_i + \beta y_{i,t-1} + \sum_{j=1}^{pi} \beta_{ij} \Delta y_{i,t-j} + \mu_{it} \qquad (4)$$

Where i=1,……., i is number of country, t is time period. $y_{i,t}$ will be series for country i over time span t. μ_{it} is residuals that is hypothesized to be I.I.D and number of lags are determined by P_i. The null hypothesis will be as $H_0: \beta = 0$ while alternative will be $H_1: \beta < 0$. However, LLC assumes homogeneity of each cross section. The IPS test proposed by Im et al. (2003) is superior over LLC as it assumes heterogeneity across the sample, allowing imbalance panel data and is very useful for short time span. IPS test is based on equation 4 with the difference that β can vary. The null hypothesis of the test is $H_0: \beta_i = 0 \; \forall$ i with the alternative hypothesis as $H_1: \beta_i < 0 \; \forall$ i . Similarly, Breitung (2000) proposed test does not require bias correction and have "nice" power with the ability to behave orthogonalization to eliminate dynamic panel bias. Overall LLC and Breitung tests require balance panel data while IPS, Fisher ADF and Fisher PP work in balance or imbalance data.

3.3.2. Panel cointegration tests

If all variables are integrated of order 1 i.e. I(1) and in other words, have panel unit roots, then we can test cointegration among variables and can build the model as:

$$x_{it} = \beta_i + \rho_i t + \beta_{1i} y_{1,it} + \beta_{2i} y_{2,it} + \beta_{3i} y_{3,it} + \varepsilon_{it} \qquad (5)$$

Where i refers to number of country, t is time spanned in the study, β_i and ρ_i are intercept and deterministic trend of each country, respectively. Pedroni (2004) have proposed seven test statistics that can be divided into two categories: one category is panel cotinegration tests and second category is group mean panel cointegration tests. First category is within the dimension that contains four tests statistic namely Panel PP-Statistic, Panel v-Statistic, Panel rho-Statistic and fourth one is Panel ADF-Statistic. The group mean panel cointegration tests contain three tests statistic including ADF-Statistic, Rho-Statistic and PP-Statistic. All seven Pedroni tests assume heterogeneity across the sample. The existence of cointegration is based on residuals test as $\varepsilon_{it} = \eta_i \varepsilon_{it-1} + \mu_{it}$. Addition to Pedroni seven tests, Kao (2000) test that assume homogeneity across the sample will also be applied to confirm robustness. Kao (2000) cointegration test is as: $x_{it} = y_{it}\beta + z'_{it}\delta + \varepsilon_{it}$. Here x_{it} and y_{it} is the integration of order one process, ε_{it} is white noise error term and variable z'_{it} is exogenous of any fixed effect. The null hypothesis of Kao and Pedroni is no cointegration (no long run relation) against alternative hypothesis of cointegration.

3.3.3. FMOLS and DOLS estimates

Pedroni and Kao tests can merely confirm long run relation and cannot give signal for coefficients of variables under investigation. For Panel data different estimators are available such as ordinary least squares (OLS), generalized method of moment (GMM), random effect, fixed effect, fully modified OLS (FMOLS), dynamic ordinary OLS (DOLS) that can perform this job. Kao and Chiang (2001) have studied the limited properties of OLS and have proved that OLS estimator based on panel data has inconsistency characteristics; revealing FMOLS and DOLS should be considered for panel coinegration. DOLS and FMOLS estimates are superior due to their outperformance in small sample, ability to overcome serial correlation and endogenity issues by introducing lead and lags in model. Pedroni (2001) put forward the idea of FMOLS while DOLS method is given by Kao and Chiang (2001). FMOLS method will be used for the extraction of coefficients while DOLS for robustness.

4. Results and Discussion

4.1. Panel unit root results

Panel unit roots and stationary properties become very important over the last decade since in the presence of unit roots, traditional methods such as panel ordinary least squares, random effect, fixed effect or generalized methods of Moment (GMM) can offer misleading results. Analysis starts with the recent five panel unit root tests: Levin et al. (2002) proposed LLC test, Im et al. (2003) proposed IPS test, Maddala and Wu (1999) and Choi (2001) have proposed Fisher type tests namely Fisher ADF and Fisher PP. Breitung (2000) developed pooled panel unit root test that is known as Breitung test. Each test has its own advantages and disadvantages. For example, Levin et al. (2002) proposed test assume homogeneity across the sample that mean it needs regression coefficient of first-order lag variable of each time series is same and cross section is independent. At one side, it assumes homogeneity across the sample and at second side, it is better for long panel, however, in practice, generally, time span is short. Im et al. (2003) proposed IPS test that assumes heterogeneity across the sample and outperform in small sample size, thus, overcome deficiencies of Levin et al. (2002). Breitung (2000) proposed test does not require bias correction and has ability to conduct forward orthogonalization to eradicate dynamic panel bias. Further, Maddala and Wu (1999) and Choi (2001) proposed Fisher-type tests that don't require balance panel data and they fit well in small sample. Generally, panel unit roots are thought to be superior on time series unit roots as they combine time series and cross sections and thus, make sample large. Results in table 2 confirm that tourism development, carbon emissions, renewable energy and real GDP and real GDP square are all non-stationary at level with the majority of tests while all variables become stationary at first difference with 1% level of significance that confirm variables have unit root problem.

[Please insert Table 2]

4.2. Cointegration analysis

In the presence of panel unit root, next step was to verify cointegration (in other words, long run relation) among tourism, CO_2 emissions, renewable energy and real GDP for G20 economies. Kao (1999) and Pedroni (2004) tests have been used to confirm robust panel co-integration. These tests have advantages on time series cointegration analysis as they add cross sections and thus, make sample large. Pedroni proposed seven type of tests that create a mechanism to secure that panel has time effect and heterogeneity across the sample. Kao test assumes homogeneous panel and cross section is independent for each individual. The null hypothesis of Kao and Pedroni is no panel co-integration while alternative hypothesis is the presence of co-integration relation. Results presented in table 3 reveal that four Pedroni tests reject null of no cointegration at 1% level of significance that confirm long run relation among variables. Addition to Pedroni, Kao test also reject the null of no cointegration. Thus, variables have robust long run relation.

[Please insert Table 3]

4.3. Coefficients estimation via fully modified OLS

In the presence of robust long run relation, next step was to extract coefficient estimates as Pedroni and Kao tests just confirm conitnegration and was unable to give signal for coefficients of tourism development, renewable energy and income. Various estimators are available to offer the job including panel ordinary least squares, generalized method of moment, random effect, fixed effect, fully modified OLS (FMOLS), dynamic ordinary OLS (DOLS). FMOLS and DOLS estimates are used as they are superior to outperform in small sample, remove the issue of serial correlation and overcome endogenity by introducing leads and lags in model. Researchers like Kao and Chiang (2001) have compared and have proved that OLS estimators based on panel data has inconsistency characteristics; rather, FMOLS and DOLS are better choices. This paper uses FMOLS method to extract coefficients while DOLS is used to confirm robustness.

FMOLS results in table 4 show that a 1% increase in tourism development reduces pollution emissions by 0.05% in long run. Given the research finding, paper adds novel contribution in the body of literature by revealing that tourism helps in pollution reduction. Tourism development small but negative coefficient (-0.05) seems to offer two-fold signals; (1), negative coefficient reveal that it has important role in pollution reduction and has potential to counter emissions. (2), the small coefficient suggests that there is need to dependent on multiple policies to fight with pollution emissions and one can be tourism development. Researchers like Freitas (2017) have documented that tourism is among the fastest growing sector globally and it helps to exceed macroeconomic growth for economies. Our results are opposite to Zhang and Liu (2019) where they have confirmed that one percent increase in tourism may lead to increasing 0.22% CO_2 emissions in the region. The results difference may be due to the sample difference as each economy/group of economies has its own dimension and one country results cannot be generalized in other economy.

Results show that a 1% increase in renewable energy reduces emissions by 0.15% in long run. More precisely, results present that renewable energy is environment friendly and can help to gauge economic growth vehicle with low pollution emissions. It is consistent with Zhang and Liu (2019) where they have found that a one percent increase in renewable energy decreases CO_2 emissions by 0.15%. Noticing that renewable energy coefficient is several times higher than that of tourism development revealing renewable energy is very important for emissions' reduction. G20 can overcome global carbon emissions with the introduction of renewable energy. These economies have willingness and ability to overcome CO_2 emissions problem by coordinating the interest of all parties in the world and thus, utilize resources to reduce global emissions. Increase in energy efficiency can be a choice along with the introduction of renewable energy. Energy efficiency will not only contribute to socio-economic development but will also improve quality of life. Energy is important factor of production and its role cannot be denied in household services such as heating, cooling and cooking, however, it should be clean and helpful in pollution reduction and renewable energy is ideal alternative solution.

Renewable energy production may increase the initial cost of production as novel method and innovation initially does cost, however, the fixed cost will be fixed in long run and variable cost will be limited that will make renewable energy production easier. Second, environmental damage cost is increasing so by the introduction of renewable energy, we can overcome the issue as well. For example, only in United States, 29% of global warming emissions is from electricity sector and most emissions is from fossil fuels and natural gas (EPA, 2017). The air pollution and water pollution from coal and natural gas plants are directly linked with human health such as cancer, premature death by causing breathing problems (Epstein et al., 2011). So, we need to consider all aspects of the economy while introducing novel source to overcome traditional one. As otherwise, although some pollution emissions may be reduced by increasing the production of renewable energy, other environmental and economic externalities will be increased. Another reason of the nonrenewable energy production such as coal production that seems cheaper may be the full cost of coal is not reflected in the market price that can give an impression that coal buying and burning is quite cheaper. In long run, we are, generally, paying much more cost considering the bigger picture of situation. Researchers have referred the impact of human and environmental health that are not reflected in coal price are known as externalities. Though those who benefits from cheap coal price may not pay the price of these externalities directly, however, overall as a nation, one have to bear this cost in the form of medical bills, environment clean up.

Generally, the increase in the use of renewable energy is inevitable that demand for international cooperation and sustainability criterion to overcome initial cost. For example governments can offer subsidy on solar power planets, encourage people for biogas plants in the rural areas. Abbasi et al. (2011) have pointed out that the debate for renewable energy starts in late 90s when world received shocks in oil prices. Researchers like Popp et al. (2014) have added that the renewable energy is the fast growing energy source. As a matter of fact, reliable energy is important for all sectors of economies such as heating, lighting and transportation etc. and generally, renewable energy can offer helping hands for all sectors as well as it can reduce CO_2 emissions significantly comparing with fossil fuels and it is important when it delivers non harmful goods and services to environment (International Energy Agency, 2014).

Further, world population is growing fast from last four decades and production requires to increase to meet the need where focused is given to agriculture production (FAO, 2011). The global energy demand has turned to double in last 35 years, however, renewable energy contribution remain limited though new renewables i.e. solar, biofuel as well as the wind, have been increasing from very low base. On the other hand, if we look back in history, the bioenergy was the main source of energy before industrial revolution. Till date, traditional biomass is the main source of heat and energy in many countries. They are using the advance biomass form for modern cooking stove like building biogas planets and having biogas for cooking and heat purpose. In many developed countries like European countries, the use of biofuel is increasing. It has been reported that even some airlines have demonstrated to test biofuel in recent years, however, it has been reported that the current share of biofuel is limited to fulfill the demand of planes (Popp et al., 2014). The residuals of biogas is also important to make land fertile with almost no cost. Biogas is produced through biomass that is the dung of animals and requires only water to process for biogas. The production of biodiesel is heavily increasing in Asia and many countries including G20. European Union, United States and Brazil are among top economies to produce biofuel. It is the reason, many countries have targets of renewable energy in their transport sector by 2030. All the above discussion appeals for the introduction of renewable energy.

[Please insert Table 4]

The income coefficient was positive while income square coefficient was negative confirming inverted U-shape relation between income and pollution emissions. Further, the results reveal that initial rise in income raises pollution emissions with fast speed (income coefficient 1.48) while later, this relation turns to inverse and further, rise in income helps in pollution reduction as coefficient of income square turns to negative and significant. The decrease in pollution is bit slower (income square coefficient -0.09) that reveal further steps are required to achieve sustainable development goals. Indeed, pollution reduction require multiple efforts rather than merely focusing on growth and development although growth and development is one important tool since environmental Kuznets curve is valid for G20 economies. Research results acknowledge great concern and recognition in the sustainable tourism research including the engagement of renewable and income to counter pollution emissions.

4.4. Robustness check via alternative method

DOLS results in table 5 show that a 1% increase in tourism development reduces pollution emissions by 0.12% in long run while a 1% increase in renewable energy consumption reduces pollution emissions by 0.23% in long run. Noticing that renewable energy consumption is making stronger contribution in pollution reduction as compare to tourism development that is similar to FMOLS results. Results of income and income square reconfirm the inverted U-shape relation with emissions that is similar to FMOLS results while its insignificancy gives an impression to activate the environmental policies rather than merely relying on income to reduce emissions. Results are robust to appeal the tourism development and renewable energy promotion. Real GDP is important for growth and development as well as for pollution reduction.

[Please insert Table 5]

5. Conclusions, policy recommendations and limitations

5.1. Conclusions

The main object of this paper was to investigate the influence of tourism development on CO_2 emissions. The paper also test the impact of renewable energy consumption and real GDP on CO_2 emissions for G20. A balance panel data for CO_2 emissions, renewable energy consumption, real GDP and tourism arrivals have been collected for 19 G20 economies for the period of 1995-2015 according to data availability. Different panel unit root tests have been applied to confirm unit root properties of variables. Panel unit roots tests have advantages over conventional time series unit roots as they increase the sample size by adding cross sections and time span and thus, make sample large. In the presence of panel unit roots, seven Pedroni tests as well as Kao test have been applied for robust cointegration. Pedroni cointegration tests assume heterogeneity across the sample while Kao test assume homogeneity across sample. Four Pedroni tests and Kao test confirm long run relation among variables. In the presence of long run relation, FMOLS has been applied to extract coefficients estimates as FMOLS are free from serial correlation, overcome endogeneity issues by introducing leads and lags in system and outperforms in small sample. Results reveal that a 1% increase in tourism development reduces CO_2 emissions by 0.05% in long run. A 1% increase in renewable energy consumption reduces CO_2 emissions by 0.15%. Further, results show that initially rise in income raises CO_2 emissions sharply, however, after specific time period, it turns to inverse and further rise in incomes reduces CO_2 emissions slowly. There was an inverted U-shape relation between pollution and income.

Results have documented that tourism industry has an important role for pollution reduction as the empirical model have found statistically significant evidence that tourism development is important for pollution reduction. Despite the abundant tourism factor and arguments in the support of tourism led growth hypothesis, research in the direction of tourism-pollution relation was scarce. Thus, this study have attempted to fill the research gap. First and important conclusion is that tourism is the backbone for the growth and development as well as for pollution reduction. Results are witness to reveal that tourism development is helping in pollution reduction. Second, paper also present that the introduction of renewable energy will be an important to overcome pollution emissions. Third, growth and development reduction suggestions will not be appropriate rather growth and development is important for the economy.

5.2. Policy recommendations

The findings of this paper provide valuable insights for policymakers in quest of efficient policy interventions related of tourism and renewable energy in accelerating economic growth and pollution reduction. Some important policy suggestions are as follows:

(1) The results reveal that tourism is helpful in pollution reduction for G20 economies. Thus, the development of green tourism will be helpful in carbon dioxide reduction as well it will be source of growth and development for the economies. Ecotourism as well as low carbon injection in tourism should be the forefront to introduce green growth. Tourism destination always play important role in the growth and development as well as in pollution reduction. Improvement in the infrastructure as well as transport sector will help in pollution reduction. It should be considered at higher level. It refocuses on the development of innovation and technical progress that will reduce emissions as well as generate revenues from tourism sector. Visa relax policy to low travelling cost should be encouraged along with the attraction of tourist destination.

(2) Most of the economies including G20 heavily depends on nonrenewable energy that injects CO_2 emissions in the environment that is harmful for the world. Owing the reason, we need to replace the nonrenewable energy to renewable energy. Policy makers should care about the policy by shifting nonrenewable energy to renewable energy consumption and clean technology that helps to move sustainable growth and development. For example, fossil fuels consumption should be reduced and coal consumption should be stopped or should be limited as possible. Development and implementation of green regulations will help in moving towards sustainable growth and development. Renewable energy should be developed and encouraged while nonrenewable energy should be discouraged. The new methods and technology should be introduce to preserve and boost the development of wind and power energy. The cost of renewable energy should be reduced via advance technologies. The development of the use of renewable energy is very important for G20 economies as they are fast growing economies and growth and development requires energy consumption. Further, clean and renewable energy should be more widely used in tourism destinations. The development of technology will help in low carbon injections on tourism destinations. Low carbon services can help that will help in carbon reduction and tourism development.

(3) The validity of environmental Kuznets curve were important to consider growth and development is an important for the economy and it should not be discouraged to reduce CO_2 emissions. EKC validity states that the rise in growth and development raises CO_2 emissions initially, but after the specific period of time (in long run), this relation turns to inverse and further rise in real GDP reduces emissions. Growth and development should be more environment friendly as real GDP is contributing positively in pollution reduction for G20 economies. In this situation, more environment friendly policies should be introduced by

government to maintain the balance of growth and development as well as to reduce CO_2 emissions.

5.3. Limitations and future research directions

Just like any study, this paper is not exceptional and there are limitations in the work. First, this study only target G20 economies and cannot be applicable to entire world or other regions of the world. Future studies are needed for different regions, country and group of countries to see if tourism industry can help in pollution reduction. Second, this paper considers tourism arrivals as tourism development variable while in future research other variables such as all kinds of numbers of inbound, outbound, domestic tourists and their impact on emissions can be explored. Third, the study has utilized data set for the period of 1995-2015 for G20 economies that is relatively a short data set. The time spanned can be expanded according to data availability in future research. Fourth, this study does not consider the influence of coronavirus (COVID-19) while investigating the relationship between tourism and CO_2 emissions. Till date, COVID-19 have badly affect the economies with the confirmed cases as high as 6,737, 872 while death rate is also very high that crossing 393,784. There is no vaccine available to control this deadly coronavirus so it is serious to use proper measures that help to avoid this virus such as stay home stay safe, keeping 6 feet social distance from while outside, going out just for necessary purposes, washing and sanitizing hands frequently. Isolation of 14 days is recommended to see clearly the symptoms and to avoid the outspread of coronavirus. It has been reported that each infected individual can affect more two to three people that is alarming. This coronavirus has badly affected entire world when international flights are banned and restricted. Though few special flights with special permissions are still moving, however, they are charging very high price and one have to quarantine herself for 14 days while entering into new country. Tourism destinations are under lock down and touristic spots have been closed for visitors as gathering and moving together have been restricted in most of the world. Stay home stay safe idea is proposed to avoid the coronavirus that limit the tourism activities. World Travel and Tourism Council have reported recently that “only G20 economies can drive forward a coordinated recovery response to COVID-19 crisis”. The COVID-19 problem have have influenced the CO_2 emissions dramatically. So, testing the relation between tourism development and CO_2 emissions while considering the influence of COVID-19 will offer unique future ideas that need to be consider for future research.

Declaration of Interest Statement

The authors declare no conflict of interest.

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Table 1: Descriptive Statistics

	CO2	RE	TR	Y	Y^2
Mean	-2.19	-7.16	7.14	4.16	17.52
Median	-2.08	-6.99	7.21	4.25	18.02
Maximum	-1.70	-6.13	7.93	4.74	22.47
Minimum	-3.07	-9.72	6.30	2.79	7.81
Std. Dev.	0.35	0.74	0.42	0.49	3.90
Skewness	-0.66	-1.39	0.05	-0.78	-0.57
Kurtosis	2.55	5.43	1.88	2.82	2.33
Observations	399	399	399	399	399

Source: authors' calculation using EVIEWS 9.0

Table 2: Panel unit root test results

	CO2	*TR*	*RE*	*Y*	*Y^2*
Level					
LLC	3.234	3.680	-0.918	-4.014***	-4.175***
	(0.999)	(1.000)	(0.179)	(0.000)	(0.000)
IPS	4.589	5.169	3.37219	-0.451	-0.455
	(1.000)	(1.000)	(0.9996)	(0.326)	(0.324)
Fisher-ADF	15.762	16.890	20.783	39.828	39.791
	(1.000)	(1.000)	(0.9896)	(0.389)	(0.390)
Fisher-PP	19.462	61.202***	35.873	52.185*	50.712*
	(0.995)	(0.0099)	(0.5682)	(0.062)	(0.081)
Breitung	2.074	0.775	0.903	1.273	1.174
	(0.981)	(0.781)	(0.817)	(0.899)	(0.880)
1st Difference					
LLC	-5.102***	3.439	-5.058***	-7.627***	-7.649***
	(0.000)	(0.999)	(0.000)	(0.000)	(0.000)
IPS	-7.638***	-6.425***	-8.198***	-5.759***	-5.745***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Fisher-ADF	130.588***	111.120***	142.101***	101.287***	100.908***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Fisher PP	299.421***	506.483***	743.939***	193.839***	196.857***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Breitung	-2.643***	-3.797***	-4.328***	-4.746***	-4.622***
	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)

Note: P-values in parentheses. Individual intercept and time trend is included in test regressions. ***: Rejection of the null hypothesis at 1% significance level, **: Rejection at 5%, and *: Rejection at 10%. Source: Eviews 9.0 output.

Table 3: Pedroni and Kao Results for Cointegration

Alternative hypothesis: common AR coefficients (within-dimension)				
	Statistic	P-Value	Weithed statistic	P-value
Panel v-Statistic	0.427	0.335	-1.527	0.937
Panel rho-Statistic	0.377	0.647	-0.006	0.498
Panel PP-Statistic	-3.295***	0.001	-5.146***	0.000
Panel ADF-Statistic	-3.246***	0.001	-5.798***	0.000
Alternative hypothesis: individual AR coefficients (between-dimension)				
	Statistic	P-value		
Panel Rho-Statistic	2.012	0.978		
Panel PP-Statitic	-3.874***	0.000		
Panel ADF-Statistic	-3.839***	0.000		
KAO- ADF	-2.116**	0.017		

Of the seven tests, the panel v-statistic is a one-sided test where large positive values reject the null hypothesis of no cointegration whereas large negative values for the remaining test statistics reject the null hypothesis of no cointegration. Under the null hypothesis, all the statistics are distributed as normal. The finite sample distribution for the seven statistics has been tabulated in Pedroni (2004). ***: Rejection of the null hypothesis at the 1% significance level. Residual variance for KAO was 0.001 and HAC variance was reported as 0.000.

Table 4: Fully Modified OLS results

Variable	Coefficient	Std.Error	Prob.
TR	-0.05	0.02	0.01
RE	-0.15	0.01	0.00
Y	1.48	0.01	0.00
Y^2	-0.09	0.02	0.00
Adj. R^2	0.98	Mean dependent var	-2.19
S.E. of regression	0.04	S.D. dependent var	0.35
Long-run variance	0.00		

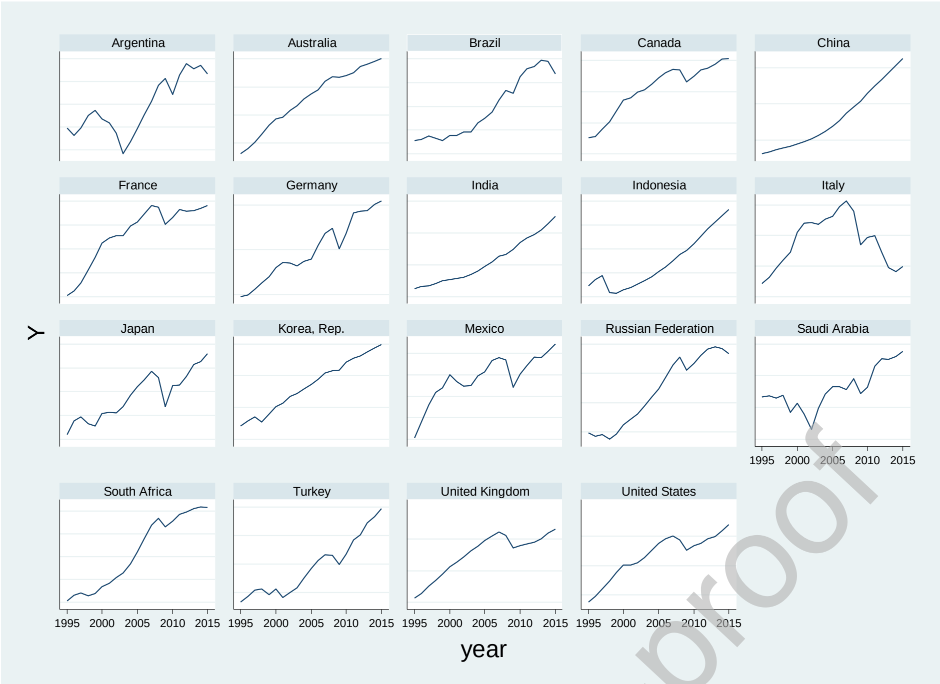
Source: Authors' estimations using EVIEWS 9.0

Table 5: DOLS results

Variable	Coefficient	Std. Error	Prob.
TR	-0.115	0.036	0.002
RE	-0.239	0.042	0.000
Y	2.259	1.342	0.096
Y^2	-0.233	0.167	0.0167
Adj. R^2	0.99	Mean dependent var	-2.18
S.E. of regression	0.02	S.D. dependent var	0.35

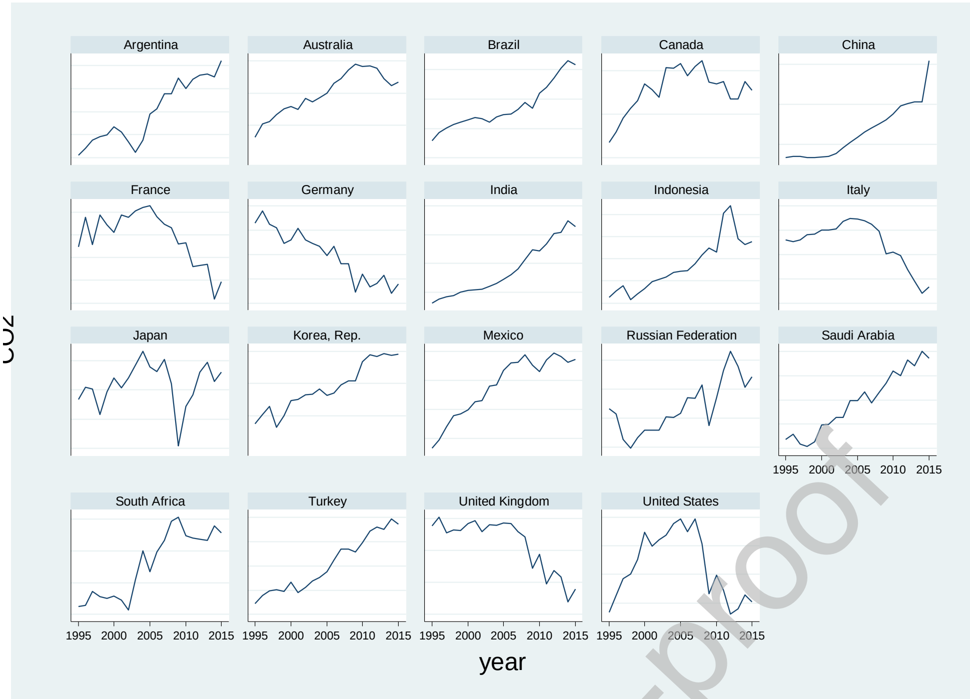
Source: Authors' estimations using EVIEWS 9.0

Figure 1: Real GDP per capita graphs



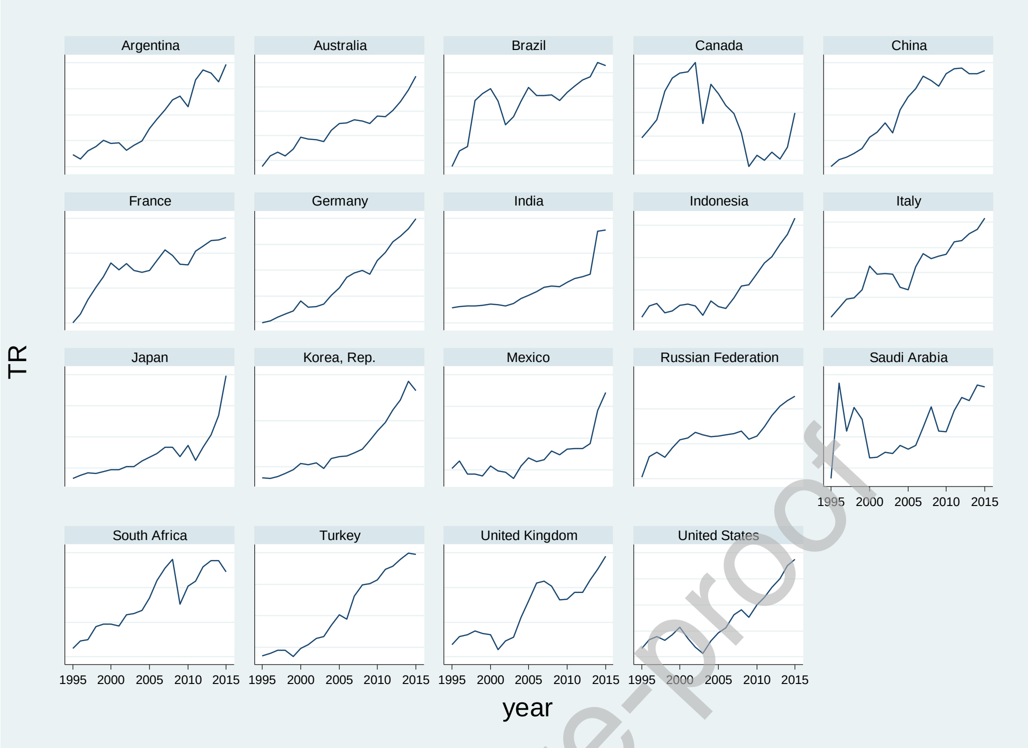
Note: Real GDP per capita is measured in constant 2010 US$, for G19 economies for the period of 1995-2015. Graphs are authors own construction using world development indicators (WDI), World Bank data retrieved in 2018.

Figure 2: CO_2 emissions graphs



Note: CO_2 emissions (kt) for G19 economies for the period of 1995-2015. Authors own construction using world development indicators (WDI), World Bank data retrieved in 2018.

Figure 3: Tourism arrivals



Note: Tourism arrivals is measured in total number of tourists' arrival for G19 economies for the period of 1995-2015. Authors own construction using world development indicators (WDI), World Bank data retrieved in 2018.