The effect of tourism investment on tourism development and CO_2 emissions: Empirical evidence from the EU nations

Abstract

The objective of this study is to investigate the effect of tourism investment on tourism development and CO_2 emissions in a panel of 28 EU countries using annual data from 1990-2013. The empirical results from a panel cointegration test confirm the presence of long-run equilibrium relationship among the variables. The long-run elasticities indicate that tourism investment has significant positive and negative impacts on tourism development and CO_2 emissions, respectively. Finally, the short-run heterogeneous panel non-causality test results show the evidence of bidirectional causality between tourism investment and tourism revenue. These results therefore suggest that tourism investments not only increase tourism revenue but also reduce CO_2 emissions. Given these findings, we suggest the policy makers of the EU nations to initiate more effective policies to increase the tourism investments. The increasing tourism investments will allow the industry to grow further by ensuring sustainable tourism development across the EU member countries.

Keywords: Sustainable tourism investments, Tourism development, CO_2 emissions, the European Union

1. Introduction

Tourism investment is a critical component for sustainable tourism development. According to the World Travel and Tourism Council (WTTC), tourism investment includes accommodation development and maintenance of new buildings, furniture and equipment to renovate existing hotels, motels and holiday homes; tourist transportation such as buses, aircraft and cruise ships; capital projects and restorations of renowned tourist places and sights; tourism-related information and communication technology (ICT) projects; and 'green' or 'sustainability-oriented' investments (WTTC, 2015). These investments not only ensure an economic return, but also generate an environmental return. The economic return includes tourism revenue, employment generation, skill development, higher wages and tax revenues. The environmental return includes improvement of energy efficiency, proper maintenance of water and waste, and protection of ecosystem and biodiversity. Thus, greater investment in the tourism industry will stimulate long-term tourism revenue, innovation and sustainable growth in the sector (Jackson et al., 2009).

In recent years, investment in tourism by both the private and public sectors has grown rapidly and kept pace with the growth of total investment. The global tourism-related investment was nearly US$290 billion in 2000. However, within 15 years, the figures almost tripled, reaching US$775 billion in 2015, which is 4.3% of total investment. It is projected that tourism-related investment will grow at 4.3% per year during 2015 to 2025 and will reach US$1,254 billion by 2026, which will be 4.7% of total investment (WTTC, 2016a). Despite its significance, the issue has received very little attention from tourism researchers. To our knowledge, there is no empirical study that has examined the role of tourism investment on its economic and environmental return. This study aims to fill this gap in the literature by examining the role of tourism investment on tourism revenue and CO_2 emissions, taking the European Union (EU) as a case study. To achieve this objective, the study attempts to answer a number of important questions. First, is there a long-run equilibrium relationship between tourism investment, tourism development and CO_2 emissions? Second, how much of additional tourism revenue can be generated by increasing one unit of tourism investment? Third and finally, does the growth of tourism investment significantly decrease overall CO_2 emissions?

The EU is considered to be an interesting case study since the region enjoys a significant contribution from global tourism in terms of its contribution to GDP, employment, raising income levels, standard of living and tax revenues for the EU governments. In 2015, the total contribution of tourism to the GDP was US$1610 billion, which is 10% of the total EU's GDP. Moreover, the tourism sector generated 26 million direct and indirect jobs – more than any other sector including banking, ICT, and mining industries. In terms of investment, the industry attracted US$153 billion in capital investment; this is expected to rise by 2.9% per annum over the next ten years and will reach US$282 billion by 2026 (WTTC, 2016b). Furthermore, the EU is the pioneer in promoting sustainable tourism development as it has already undertaken various programs to invest in sustainable transnational tourism products (European Commission, 2015). In light of the above, investigating the influence of tourism investment on tourism development and CO_2 emissions in the context of the EU would make significant contributions to the tourism development literature and policies.

Our study makes four unique contributions compared to the existing tourism literature. First, this is the first study to investigate the role of tourism investment on tourism development and CO_2 emissions. Hence, findings derived from this study will open a new horizon in tourism research and policy standpoint. Second, the analysis follows a widely used theoretical model to construct empirical models. The analysis employs

I=P.A.T (Impact=Population x Affluence x Technology) model to investigate the factors that cause environmental degradation. Third, given the significance of EU in the tourism development, we make use of 28 EU countries in the analysis as the findings derived from this analysis will be critical for the policy and practice. Finally, this study uses various panel econometric methodologies which provide robust and reliable findings of the relationships between tourism investment, tourism development and carbon emissions.

The organization of this paper is as follows. The next section provides the theoretical underpinnings of the influence of tourism investment on tourism development and environmental outcomes, and also briefly reviews the major studies in the literature. Section 3 displays some stylized facts on tourism revenue, tourism investment and CO_2 emissions of the EU countries. Section 4 describes the empirical methodology, nature of the data and measurement. Section 5 presents empirical results and their discussion. Finally, Section 6 provides a conclusion, policy implications and directions for future research.

2. Literature Review

2.1. The role of tourism investment on tourism development and environmental outcomes

According to WTTC (2015), tourism investment, based on its source, can be classified into two major groups: public (or government) investment and private investment. Public investment usually includes bulk investment on tourism-related infrastructural development, including government funded airports; utilities such as water, sanitation and electricity supply; ICT-based infrastructure; and the construction of the resorts, visitor centers and tourist information offices. However, public tourism investments do not cover investments spent in multi-use infrastructures such as roads or public transport, although these may be partially used for tourism purposes. On the other hand, private investments are small and medium undertakings usually made for commercial purposes and mostly driven by profit motives. Therefore, private investment in tourism focuses on commercial accommodation and transport services such as vacation houses, hotels, convention centers, aircraft, cruise ships and buses. It also includes tourism-related products such as food and beverage services, entertainment and other recreational services, cultural services, tourist guide and tour operator services. Besides public and private investment, public–private partnership (PPP) has also appeared as an alternative source of tourism investment in recent years (WTTC, 2015).

Both government and privately funded investment along with PPP play a key role in supporting tourism development and environmental protection in three important ways: expanding capacity, stimulating demand and providing environmental benefits.

Expanding capacity: Continued investment in new and existing infrastructure plays a central role in improving and maintaining functionality and quality through major refurbishment and upgrading. Significant infrastructure investment is required to build more visitor accommodation, increase airport capacity and expand tourist facilities to support higher demand from increasing tourist arrivals. Insufficient capacity can lead to supply-side bottlenecks and a limit on growth, as well as put upward pressure on prices, such as hotel room rates, all of which affect competitiveness (WTTC, 2015).

Stimulating demand: Tourism investment in places of historical and scenic value not only protects the places but also generates new visitor attractions to the region or country. Thus, an additional demand will be generated, which helps to retain market share in the competitive market. In addition, investment in tourism-related products ensures a highquality service that will attract more tourists and generate more tourism revenue (WTTC, 2015).

Providing environmental benefits: Tourism-related investment may provide environmental benefits both directly and indirectly. Investment in modern transport, renewable energy, and water and waste management will have direct, positive effects on the environment. Moreover, recent tourism investment has been shown to help maintain ecosystems and conserve biodiversity, which directly protect the environment (USAID, 2015). The indirect benefits are generated by improved infrastructure. For example, investment in the case of road and rail transport – such as more lanes, higher quality road surfacing, improved safety through more and wider lanes – can be expected to lead to reduced fuel consumption and CO_2 emissions (Khadaroo and Seetanah, 2008).

The above arguments suggest that tourism investment plays a significant role in tourism development and environmental protection. However, to date, empirical studies on the importance of tourism investment for the sustainable development of the tourism industry have been particularly scarce.

2.2. Related Research

As we discussed earlier, no study has empirically investigated the role of tourism investment on tourism development and CO_2 emissions. One of the reasons for limited research on this topic could be a lack of reliable data. However, in many tourism studies, the relationship between foreign direct investment (FDI) and tourism development has been examined. Nevertheless, the impact of tourism development on CO_2 emissions is now well established in the literature. Consequently, we divide the relevant literature into two subsections: (i) FDI and tourism development and (ii) tourism development and CO_2 emissions.

2.2.1. FDI and tourism development

From a theoretical standpoint, FDI leads to the development of the tourism industry as it transfers new technology, skills and standards, which undoubtedly benefit and increase the industry's capacity, capability and competitiveness, and so attract new tourists (UNCTAD, 2008). For example, Dwyer and Forsyth (1994) claim that FDI may attract more tourists from the home country of investors through greater promotional effort in that country. Moreover, Haley and Haley (1997) point out that FDI can increase international business travel as investors often visit FDI recipient countries both before investing – to understand the differences in cultural, political, and economic structure between the FDI source and recipient countries – and after investing, to supervise their established business activities. However, a number of studies (Dunning and McQueen, 1981; Kundu and Contractor, 2000) claim that tourism may lead to increased FDI in a country or region since growing tourism will attract foreign investment in hotel, restaurant and other tourist-related activities. Sandford and Dong (2000) have argued that international tourism provides potential investors with the chance of acquiring first-hand knowledge and information of the atmosphere of the country or region being visited and, therefore, investment prospects could be recognized. Likewise, FDI through transnational companies (TNCs) allows host countries to be integrated into international tourism networks (e.g., vertically integrated tour operators), which will lead to increase in the flow of tourists and generating more income from tourism-related activities (Endo, 2006).

While there are strong theoretical arguments supporting the relationship between FDI and tourism, the empirical evidence is scarce, and only a few studies are available. Sanford and Dong (2000) employed an econometric analysis to investigate the relationship between tourism and FDI in the case of the USA. Using the Tobit regression model, they found that tourism significantly increases inward FDI. However, the authors did not investigate the role of FDI on tourism. Tang et al. (2007) examined the causal relationship between tourism arrivals and inward FDI by using quarterly time series data from China for the period 1985–2001. Employing Granger causality tests, the authors found a unidirectional causality running from FDI to tourism. Using panel causality tests, Craigwell and Moore (2008) examined the dynamic relationship between FDI and tourism in nine small islands of Latin America. Their study used data for the short time period of 1997–2003, and found that FDI influenced the expansion of the tourism sector in the selected countries by expanding their tourism services.

Katircioglu (2011) investigated the link between FDI and tourism in Turkey during 1970–2005. Applying the ARDL bounds testing approach, the study provides empirical evidence that there is a unidirectional causality that runs from tourism to FDI in the long-run. Fereidouni and Al-mulali (2012) also explored the impact of tourism on FDI in real estate in 24 OECD countries for the period 1995–2009. Results from the panel cointegration and panel Granger causality techniques suggest the presence of bidirectional causality between tourism and FDI in the long-run. Selvanathan et al. (2012) studied the case of India by using the Granger causality test under a VAR framework and found that there is a two-way causality between tourism and FDI. Recently, Dwyer et al. (2014) revealed that marketing investment has a positive and significant impact on tourism revenue in the case of Australia. The study claims that an extra 1 million of promotion expenditure creates $10 million of tourism revenue.

2.2.2. Tourism development and CO_2 emissions

In many theoretical studies, the authors have argued that tourism activities, particularly transport and accommodation, are primarily responsible for energy consumption, mainly from fossil fuels. The use of energy in tourism-related activities leads to a significant amount of CO_2 emissions, and the industry is considered as one of the important contributors to global warming and climate change. For example, Becken and Simmons (2002) and Jones and Munday (2007) reported that tourism is an important source of energy consumption, so a malefactor of global environmental change. Likewise, Tovar and Lockwood (2008) claimed that tourism has a tremendous negative impact on the environmental degradation in the Cradle Coast region in the northwest of the Australian state of Tasmania, a rural area where the tourism industry is considered as an important sector of economic development. Moreover, Scott et al. (2010) projected an even more alarming estimation of the potential threat of CO_2 emitted by the tourism industry. The authors claimed that the tourism sector will become one of the leading sources of global CO_2 emissions in the near future.

Table 1 presents summary of the some selected studies which have sought to quantify the impact of tourism activities on CO_2 emissions. Gössling (2002), one of the pioneer quantitative studies on tourism-CO_2 emissions nexus, claimed that air travel associated with tourism-related transport emitted 467 Megatonnes (Mt) of CO_2 across the world in 2001. In a subsequent paper, Gössling et al. (2005) measured how much CO_2 is released to generate one unit (€) of tourism revenue in a number of selected countries. The study reveals that, in 2002, one unit (€) of tourism revenue emitted 3.18 kg, 2.09 kg, 1.93 kg, 1.91 kg and 1.22 kg of CO_2 in Australia, New Zealand, Canada, the US and Finland, respectively. Using two approaches – a bottom-up and a top-down analysis – Becken and Patterson (2006) measured the national CO_2 emissions arising from the tourism industry in New Zealand. The two approaches provided a virtually identical result and indicate that the tourism industry of New Zealand emitted 1400 Kilotonnes (kt) (1600 kt in the second approach) of CO_2 in 2000. Kuo and Chen (2009) explored the environmental impacts of tourists in Penghu, an Island of Taiwan, in 2006. The study used the life cycle assessment (LCA) and reported that each tourist consumed 1606 Megajoule (MJ) of energy and produced 109.03 kg of CO_2 per trip. Wu and Shi (2011) calculated energy consumption and CO_2 emissions from the Chinese tourism sector in 2008. According to their calculations, the Chinese tourism industry consumed approximately 428 Petajoule (PJ) of energy, which released 51 Mt of CO_2 emissions, accounting for 0.86% of the total emissions in China.

[Insert Table 1 here]

Tang et al. (2014) also investigated the impact of tourism transportation, accommodation and other activities on CO_2 emissions in the case of China. Using the bottom-up approach, the study reveals that the total CO_2 emissions from the tourism industry increased from 1468.08×10^4 t in 1990 to $11,568.17 \times 10^4$ t in 2012, maintaining a 12.6% growth rate per year. Tsai et al. (2014) calculated and analyzed the amount of CO_2 emitted from several hotel types in Taiwan in 2011. According to the findings of their study, the average CO_2 emissions of homestay facilities, general hotels, standard tourist hotels and international tourist hotels were 6.3, 12.5, 19.2 and 28.9 kg-CO_2/person-night, respectively. The analysis also suggests that hotel CO_2 emissions can be considerably decreased by increasing stays with low CO_2 emission hotels such as general hotels and homestay facilities, by accommodating more guests together per room, and by raising energy efficiency. Sun and Pratt (2014) forecasted that an additional 0.8% increase in economic output from Chinese visitors will increase 2.7% CO_2 emissions in Taiwan in 2016. More recently, Huang and Wang (2015) investigated the greenhouse gas emissions of tourism-based leisure firms in Taiwan. Their results indicate that each tourist produced an average of 10.9 kg-CO_2 per trip. The study also reveals that high-end vacation leisure farms generated 2.46 times CO_2 emissions compared to natural eco-conservation farms.

Ragab and Meis (2015) examined the impact of tourism development on CO_2 emissions considering the Egyptian accommodation industry as a case study. By adopting tourism satellite accounts as a conceptual framework, the study shows that 1 million of direct value added by tourists in the accommodation industry generates 464.3 tons of CO_2 emissions directly. Meng et al. (2016) quantified the direct and indirect impact of tourism on CO_2 emissions of the Chinese tourism industry. The study, using both the bottom-up and top-down approach, calculated that the total carbon emissions of the Chinese tourism industry in 2002, 2005, 2007 and 2010 were 111.49 Mt, 141.88 Mt, 169.76 Mt and 208.4 Mt, respectively, accounting for 2.489%, 2.425%, 2.439% and 2.447%, respectively, of the total carbon emission of all industries in China. Finally, Sun (2016) used an analytical framework for decomposing the tourism greenhouse gas emissions. Considering Taiwan as a case study, the study reveals that one dollar spent on tourism-related products and services generates a smaller contribution to the national GDP and contributes more to greenhouse gas (GHG) emissions than spending this dollar in another sector.

In recent years, there have been several studies that employ an econometric methodology to examine the role of tourism development on CO_2 emissions. Katircioglu (2014a) examined the relationships between tourism and environmental degradation in the case of Turkey. The study used CO_2 emissions as a proxy for environmental degradation. Employing the autoregressive distributed lag model (ARDL) approach; the study found that tourism development in Turkey exerted positive and significant effects on CO_2 emissions both in the short- and long-run during 1960 to 2010. Katircioglu et al. (2014) investigated the causal relationship between tourism and CO_2 emissions in Cyprus during the period 1970–2009. The conditional Granger causality tests provided evidence that international tourist arrivals had a positive and statistically significant impact on CO_2 emissions. Durbarry and Seetanah (2015) also found the same result in the case of Mauritius during 1978–2011.

Employing the dynamic ordinary least square (DOLS) method, Dogan et al. (2015) analyzed the long-run relationship between tourism and emissions. Using panel data from OECD countries, the study found that tourism increases CO_2 emissions significantly. Ng et al. (2015) investigated the linkage between tourism and environmental degradation through CO_2 emissions in the context of Malaysia between 1981 and 2011. The vector error correction model (VECM) suggests that there is a causal relationship between tourism and CO_2 emissions. Considering Turkey as a case study, Yorucu (2016) analyzed the impact of tourist arrivals on CO_2 emissions during the period of 1960-2010. The results of the ARDL model suggest that the growing number of foreign tourist arrivals increases the CO_2 emissions significantly. In the same country, de Vita et al. (2015) examined whether the EKC hypothesis exists in the context of tourism development. The analysis of the study provides empirical evidence to support the EKC hypothesis, indicating that exponential tourism growth reduces CO_2 emissions significantly. Likewise, Zaman et al. (2016) also validated the EKC hypothesis in a panel of 34 developed and developing countries. Furthermore, using regional level panel data over the period 1995–2011, Zhang and Gao (2016) revealed that the tourism induced EKC weakly exists in the Eastern and Western China. Raza et al. (2016) employed wavelet-based analysis to investigate the relationship between tourism revenue and CO_2 emissions in the case of the US data. They found that environmental degradation is cause of tourism development in short, medium and long-runs. Finally, comparing between developed and developing economies across the world, Paramati, Alam et al. (2016)

empirically examine the effect of tourism on CO_2 emissions. The results of the study provide evidence for the existence of EKC hypothesis in both developed and developing economies. However, Lee and Brahmasrene (2013) provide different empirical evidence from the EU countries. By using panel data from 1988 to 2009, their study revealed that tourism had a significant negative impact on CO_2 emissions. Katircioglu (2014b) also confirmed the same findings in Singapore by employing various time-series techniques for the period 1971–2010. To support their findings, the authors of both these studies argued that the sample countries undertook various sustainable tourism development plans, such as utilization of more clean energy and lower emissions technology, which helped to decrease CO_2 emissions even after the rapid evolution of the tourism industry.

From the above literature review, it is apparent that there has been no study on the relationships among tourism investment, tourism development and CO_2 emissions. Although some studies are available on FDI and tourism development, these studies were conducted on the aggregate FDI data but not on the tourism related investments. However, an analysis focusing on tourism-related investment may provide more concrete and reliable findings. Moreover, the results of the existing studies have not been uniform across countries, periods or estimation methods. Hence, the current study is designed to narrow these research gaps and, by contributing to the literature, also provide fresh insights for policy makers and practitioners**.**

3. Some stylized facts on EU Countries

In this section of the paper, we aim to provide some stylized facts on the EU member countries. As mentioned earlier, According to WTTC (2016b) the direct contribution of tourism to GDP in 2015 was US$606 billion which is 3.7% of region’s total GDP. At the same time, tourism has a significant indirect impact on the region’s economic activities and the impact is almost double of its direct ones. In 2015, the total contribution of tourism to GDP was US$1, 610 billion that represents 9.9% of GDP. The contribution of the tourism industry in terms of employment generation is also significant in the EU. In 2015, the tourism industry generated 26 million jobs directly and indirectly which was 11.4% of region's total employment. This is expected to rise by 1.4% per year and reach to 30 million jobs by 2026, or 12.9% of total employment. In 2015, the tourism investment in the EU as a whole was US$153 billion, or 4.9% of region's total investment.

The country-wise summary statistics (mean) during 1990-2013 are reported in Table 2. Among the sample countries, the tourism investment was higher in France ($29464 million), Germany ($27533 million) and the UK ($19097 million) while the lowest was in Latvia ($180 million), Lithuania ($226 million) and Malta ($227 million). Similarly, the tourism revenue was higher in Germany, the UK, Italy and France whereas Latvia, Lithuania and Malta had the lowest among all of the EU countries. Likewise, we also present the countries that have the lowest and highest CO_2 emissions. The countries such as the Germany, the UK, Italy and France emit largest amount of CO_2 emissions while Malta, Cyprus, Latvia and Luxembourg releases the least emissions. The statistics show that Luxembourg had the highest per capita GDP among all the EU nations while other closest nations are Denmark, Sweden and the Netherlands. Surprisingly, some of the EU member countries have less than 10 thousand US$ of per capita GDP such as Bulgaria, Romania, Latvia, Lithuania and Poland. Overall, these summary statistics show that there is a significant divergence within the consider variables across the sample countries.

[Insert Table 2 here]

Table 3 presents the compounded annual average growth rates for the period of 1990-2013. The growth rates indicate that among the EU member countries Estonia (18%), Slovenia (13%) and Latvia (9%) had the highest tourism investment growth rates while Italy, Portugal, Denmark, Finland, Austria and Greece had the negative rates. The results show that the countries like Estonia, Latvia and Slovekia had the highest positive growth in tourism revenue whereas only Portugal had the negative growth. Interestingly, we found that out of the 28 EU member countries 18 countris have the negative growth in CO_2 emissions while only one country has more than 1% growth that is Cyprus. This therefore indicates that mojority of the EU countries are showing negative trend in the CO_2 emissions' growth. Finally, the growth rates display that the per capita GDP has a positive growth among all the EU countries, being highest in Lithuania, Latvia and Estonia and the lowest was in Italy and Greece. Overall, these growth rates suggest that majority of the EU countries have positive growth in tourism investment and tourism revenue and have shown singificant negative trend in the CO_2 emissions' growth during the sample period.

[Insert Table 3 here]

4. Methodology and data

4.1. Model specification

This study has two objectives: to determine the impact of tourism investment on tourism development and to ascertain the effect of tourism investment on the CO_2 emissions in a panel of 28 EU member countries. To achieve the first objective, we use the following model:

$$TR_{it} = f\,(REER_{it}, GDPPC_{it}, TI_{it}, TO_{it}, v_i) \qquad (1)$$

where, tourism revenue (TR) is a function of real effective exchange rates (REER), GDP per capita (GDPPC), tourism investment (TI) and trade openness (TO). This means that tourism revenue is treated as a dependent variable while tourism investment and other variables are treated as exogenous variables in the model. This is a general specification which is aimed at examining the role of tourism investment on tourism development in the EU. The symbol v_i represents individual fixed country effects; countries and time periods are indicated by the subscripts i $(i = 1,......,N)$ and t $(t = 1,.......,T)$, respectively.

To achieve the second objective of the study, we used the existing theoretical model; that is, the IPAT environmental model (Ehrlich and Holdren, 1971). To examine the potential determinants of the CO_2 emissions, a number of previous studies based their empirical analyses on the IPAT model (e.g. Raskin, 1995; York et al., 2002; Paramati, Alam et al., 2016). This model is developed on the baseline relationships among population, income (or affluence), technology and environmental impact, as presented in the following equation:

$$I = P \times A \times T \qquad (2)$$

where I is the pollution or environmental impact, which is sourced from the population (P), the level of economic activities or per capita consumption or affluence (A) and the technological level or efficiency defined by the amount of pollution per unit of economic activity or consumption (T). This model is further extended by Dietz and Rosa (1994, 1997) to a stochastic version which is popularly known as the STIRPAT (STochastic Impacts by Regression on Population, Affluence and Technology) model. It is well argued that this revised model is no longer considered as just an accounting equation, but can be used to test the hypotheses empirically. Thus, following the common specification of the STIRPAT model, we framed the following equation for our empirical analysis:

$$CDE_{it} = f\ (TP_{it}, GDPPC_{it}, TECH_{it}, TI_{it}, TO_{it}, v_i) \quad (3)$$

where carbon dioxide emissions (CDE) is a function of total population (TP), per capita income (GDPPC), technology (we have used patent applications as the proxy for the technology) (TECH), tourism investment (TI) and trade openness (TO). The model in Equation (3) aims to address the impact of tourism investment on the total CO_2 emissions by accounting for other potential determinants including population, per capita income, technology, and trade openness. The equations (1) and (3) are empirically examined using the following methodology.

4.1.1. Panel unit root tests

In this study, we use two-panel unit root tests. For instance, the common unit root process was examined using the Levin et al. (2002) (LLC) test, while the individual unit root process was investigated by employing the Im et al. (2003) (IPS) test. The application of these unit root tests is critical for identifying the order of integration of the variables. For instance, if all of the variables are integrated of the order of one or I (1), then this indicates that all of the variables are non-stationary at levels and may be stationary at their first order differentials. This suggests that these variables, as a group, may have a cointegration relationship in the long-run.

4.1.2. Panel cointegration technique

We employed a panel cointegration method to investigate the long-run equilibrium relationship among the variables of equations (1) and (3) in a panel of 28 EU countries. The panel cointegration technique is most useful if the time series duration of each cross-section is shorter. Due to these advantages, researchers started using a panel cointegration approach to examine the long-run equilibrium relationship among the variables. In this study, we applied the Fisher-type Johansen cointegration methodology, which has been proposed and developed by Maddala and Wu (1999).[1] This test uses the Johansen (1991) approach. Maddala and Wu (1999) argued that this panel cointegration test is more robust than the conventional cointegration tests, which are based on the Engle-Granger two-step approach. This method uses two ratio tests such as trace test and maximum eigenvalue test to identify the number of cointegrating vectors. The findings of both trace and max-eigen tests can be utilized to determine the presence of cointegrating vectors; however, these two tests may not always provide an equal number of cointegrating vectors (Paramati, Alam et al., 2016). If both tests do not offer the same number of cointegrating vectors, then we can draw the conclusions based on the max-eigen test as it carries the independent analysis on each eigenvalue.

4.1.3. Long-run elasticities

The next step is to examine the long-run elasticities. More specifically, we estimated a single cointegrating vector, based on Equations (1) and (3) to investigate the long-run elasticities of tourism revenue and CO_2 emissions, respectively. For this purpose, we make use of the panel approach suggested by Pesaran et al. (1999). The significance of this panel ARDL model is that it assumes cross-sectional independence, implying that disturbances are independently distributed across units and over time with zero mean and constant variances (Paramati, Ummalla et al. 2016). The models are estimated by incorporating constant and trend variables and also the appropriate lag length has been selected using Schwarz Information Criteterion (SIC). Given that these models are expected to provide more reliable and robust results.

[1] A number of previous studies (e.g. Alam et al. 2015; Alam and Paramati, 2016) have used panel cointegration test to examine the long-run equilibrium relationship among the variables.

4.1.4. Heterogeneous panel causality test

Finally, the study aims to explore the short-run dynamic bivariate panel causality among the variables using a model that supports for heterogeneity across the cross-sections.[2] Dumitrescu and Hurlin (2012) suggested a simple approach for testing the null hypothesis of homogeneous non-causality against the alternative hypothesis of heterogeneous non-causality. This test has to be applied to a stationary data series using the fixed coefficients in a vector autoregressive (VAR) framework. The significance of this test is that it allows for having a different lag structure and also heterogeneous unrestricted coefficients across the cross-sections under both the hypotheses. Under the null hypothesis, no causality in any cross-section is tested against the alternative hypothesis of causality at least for a few cross-sections. The Wald statistics for testing Granger non-causality are computed for each of the cross-section separately. Then, the panel test value is acquired by taking the cross-sectional average of individual Wald statistics. Authors suggested that this panel test value converges to a normal distribution under the homogeneous non-causality hypothesis when T tends to infinity first, and then N tends to infinity.

4.2. Nature of data

This section aims to describe the nature of data, measurement and the list of countries that have been considered in this study. The selection of the sample period was based on the availability of the annual data from 1990 to 2013 (i.e. 24 observations for each cross-section or country) for the EU member countries. This implies that we used a balanced panel data set on 28 economies of the EU. The selected countries are Austria, Belgium,

[2] The recent literature (e.g. Alam, Paramati, et al. 2016; Bhattacharya et al. 2017; Paramati, Sinha et al. 2017) started to employ a panel non-causality test which accounts for heterogeneity in the analysis. Hence, the findings derived from this analysis will be more reliable than those of the conventional causality tests.

Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK. The measurement of the variables is described below.

In this study, tourism investment (TI) is the total direct capital investment in travel and tourism in constant US$ million; tourism revenue (TR) is the total contribution of the tourism and travel sector to the GDP in constant US$ million; total CO_2 emissions (CDE) of the country in kilotonnes (kt);[3] gross domestic product per capita (GDPPC) has been measured in constant 2010 US dollars; total number of patent applications (TECH) by the residents; the real effective exchange rate index (REER) uses a base year of 2010; trade openness (TO) is the total exports and imports as a percentage of the GDP; and total population (TP) of the country. The considered time series data on CDE, GDPPC, TECH, REER, TO, and TP were obtained from the World Development Indicators (WDI) online database published by the World Bank, while the data on TI and TR were sourced from the World Travel and Tourism Council (WTTC) online database, respectively.

Given that our variables are measured in different units, therefore it is important to normalize the data series and transform all of the variable data into a uniform measurement unit before employing any econometric model. This transformation of the data series into natural logarithms helps to avoid the problems associated with distributional properties of the data series (Bhattacharya et al. 2016; Paramati, Shahbaz et al. 2017). The advantage of this approach is that each of the estimated coefficients in a regression model can be interpreted as elasticities.

[3] The previous literature (e.g. Lee and Brahmasrene, 2013; Paramati, Alam and Chen, 2016) has used country level CO_2 emissions to see the impact of tourism on the emissions. Therefore, in this study we use country level CO_2 emissions to see the effect of tourism investment on the emissions.

5. Results and discussion

5.1. Results of panel unit root tests

In this study, we applied two-panel unit root tests, which are based on the common unit root process (LLC test) and the individual unit root process (IPS test). The results of these tests are displayed in Table 4. The results of these two tests, based on the level data series, indicate that the null hypothesis of a unit root (non-stationary) cannot be rejected at the 5% significance level for all of the variables. This implies that all of the variables are non-stationary at the levels. However, the null hypothesis is strongly rejected when applied to the first difference data series for all of the variables at the 1% significance level. Thus, these results confirm that all of the variables are non-stationary at levels and stationary at their first differences. These results further indicate that there may be a cointegration relationship among the variables of Equations (1) and (3). This is explored in the next section.

[Insert Table 4 here]

As a robustness check we applied the panel unit root test with unknown breaks of Karavias and Tzavalis (2012). The chosen panel data unit root tests allow for a common structural break in the individual effects, and this allows the date of the break to be unknown. The tests assume that the time-dimension of the panel (T) is fixed (finite) while the cross-section (N) is large. Under the null hypothesis of unit roots, they are similar to the initial conditions of the model and its individual effects. The results of Table 5 indicate that the null hypothesis of a unit root in all variables is accepted in favor of a unit root.

[Insert Table 5 here]

5.2. Results of long-run equilibrium relationship

To examine the long-run equilibrium relationship among the variables of the study, we employed a robust panel cointegration test, the Johansen-Fisher technique. This test requires the appropriate lag length to be used while estimating the long-run equilibrium relationship between the variables. For this purpose, we used the SIC to identify the appropriate lag length for each of the models, as defined in Equations (1) and (3). The results of the panel cointegration test are reported in Table 6. The findings show that there is a significant long-run equilibrium relationship among the variables of tourism revenue, exchange rates, per capita income, tourism investment and trade openness. Similarly, the cointegration test results confirm the long-run association among the variables of CO_2 emissions, population, per capita income, technology, tourism investment and trade openness. These two models are statistically significant at the 5% level. This, therefore, confirms that there is a significant long-run equilibrium relationship among the variables of Equations (1) and (3). This means that these variables as group reach to an equilibrium point in the long-run despite of their varying trends over time. As robustness check we also applied the panel cointegration with unknown break test of Westerlund (2006), the panel LM statistic for variables of Equation (1) and Equation (3) is 27.525 and 29.771 respectively, indicating the presence of cointegration[4].

[Insert Table 6 here]

[4] For details of the test on estimation and inference, please refer to p.125-p.126 of Westerlund (2006). We allow for two breaks as maximum, as the break date for the relationship of Equation (1) is year 1990 and year 2003. The break date for the relationship of Equation (3) is year 1993 and year 2009.

5.3. The long-run elasticities of tourism revenue and CO_2 emissions

In this section, we identify the impact of tourism investment on tourism development and CO_2 emissions in the long-run. For this purpose, we used an ARDL approach. This is a robust technique and provides more reliable findings on the long-run elasticities.[5] The empirical results of ARDL models are displayed in Table 7. The results of Equation (1) show that a 1% increase in tourism investment raises tourism revenue by 0.197% in the EU countries. This finding supports theoretical arguments presented by Jackson et al. (2009). The empirical results also indicate that a 1% increase in per capita income and trade openness increase tourism revenue by 0.502%and 0.222%, respectively. Overall, the above findings imply that the per capita income, tourism investment and trade openness are positively and significantly contributing to tourism development in the EU countries. This further suggests that higher the economic development, tourism investment and the expansion of trade openness through the exports and imports will lead to higher tourism development in those of the EU economies. As expected, exchange rates have a considerable negative impact on the tourism revenue. Based on these findings, we suggest that policy makers to initiate effective policies to increase tourism investments across the EU countries as there is a significant potential for the tourism industry to expand further in the EU and may yield positive returns.

Similarly, the long-run elasticity results for the Equation (3) show that a 1% rise in population growth and per capita income increase CO_2 emissions by 0.831% and 1.126%, respectively. However, a 1% increase in tourism investment decreases CO_2 emissions by 0.033%. This finding is consistent with the theoretical argument of Khadaroo and Seetanah (2008). Similarly, a 1% increase in technology and trade

[5] The recent literature (Paramati, Apergis et al. 2017) suggest the significance of ARDL model for estimating the long-run elasticities. Hence, we use this approach to estimate the long-run elasticities in this study.

openness reduces CO_2 emissions by 0.046% and 0.045, respectively. Thus, our findings imply that the growth in population and per capita income increases CO_2 emissions whereas further growth in technology, tourism investment and trade openness significantly reduces CO_2 emissions. This, therefore, confirms that the growth of tourism investment is working in favour of environmental protection in the EU countries. This is a significant policy outcome as EU government officials and policy makers have initiated sustainable tourism investments in the aspiration of reducing the adverse effect of tourism on the environment.

[Insert Table 7 here]

Overall, our findings on the long-run elasticities indicate that the growth of tourism investment has a substantial positive impact on tourism development and that it significantly reduces CO_2 emissions. Given these findings, we suggest that the policy makers of the EU nations to initiate effective tourism investment policies to promote further investment in the tourism sector. This will not only ensure expansion of the tourism industry but also help to achieve a sustainable tourism sector in the EU.

5.4. The direction of causality

Finally, we explored the direction of causality among the variables of the study using the Dumitrescu and Hurlin (2012) heterogeneous panel non-causality test. This is a significant model for identifying the flow of information among the variables in the short-run. The results of this model are presented in Table 8. The findings show the evidence of bidirectional causality between tourism investment and tourism revenue. This means that tourism investment causes tourism revenue and vice versa. Further, results indicate that tourism revenue Granger causes CO_2 emissions. We also found unidirectional causality that runs from trade openness to tourism revenue and per capita income to CO_2 emissions in the short-run. All of these variables are statistically significant.

Overall, the short-run causality test results suggest that the growth of tourism investment effects tourism revenue and hence the tourism revenue also affects tourism investments. This means that higher the investment in the tourism sector then higher would be the tourism revenue and vice versa. Our results could not establish short-run causal relationship between tourism investment and CO_2 emissions. However, we found that tourism revenue and per capita income inclufences CO_2 emissions in the short-run. Given these findings, we argue that the growth of tourism investment significantly affects tourism development in the EU, both in the short-run and long-run. Therefore, further tourism investments need to be encouraged in the EU nations to expand the tourism industry and obtain positive returns both in the short-run and long-run.

[Insert Table 8 here]

6. Conclusion and policy implications

The tourism industry in the EU is significant in terms of employment, income opportunities, and tax revenues for the governments and also for socio-economic development. Researchers have started to explore the impact of tourism on economic development in the EU as well as in other regions while some studies have also explored the effect of tourism on environmental degradation. However, none of the previous studies examine the impact of tourism investment on tourism development and CO_2 emissions. Further, EU governments have initiated several policies to promote sustainable tourism investment with the aim of minimizing the adverse effects of tourism activities on the environment. Furthermore, the EU alone attracted about 39% of international tourist arrivals in 2013 (435 million out of 1123 million, WDI, 2015). These factors all motivated us to undertake a systematic investigation of the impact of tourism investment on tourism development and CO_2 emissions. For our empirical analysis, we used annual data from 1990 to 2013 across a panel of 28 EU member countries and employed several robust panel econometric models to achieve the study objectives.

The results show the presence of a long-run equilibrium relationship among the variables. Further, our results on long-run elasticities suggested that tourism investment has a significant positive impact on tourism development. Results also showed that tourism investment has a substantial negative effect on CO_2 emissions. Finally, the causality test results on the short-run showed the evidence of feedback relationship between tourism investment and tourism revenue. The results also confirmed unidirectional causality that runs from tourism revenue to the CO_2 emissions.

Given these findings, our study makes significant contributions to the formulation of policies for sustainable tourism development. First, our findings implied that tourism investment promotes tourism growth in the EU. This means that policy makers and government officials of the EU nations should further promote tourism investment as it encourages expansion of the tourism industry in these countries. The expansion of the tourism industry will further help those countries in terms of creating additional employment opportunities for the people, and raising tax revenues for the governments. Second, the results showed that tourism investment significantly reduces CO_2 emissions. The purpose of initiating sustainable tourism investment in the EU is to reduce the negative impact of tourism activities on the environment. These findings indicated that the objective of tourism investment has been successfully achieved to some extent in the EU as the effect of tourism investment on the CO_2 emissions is -0.033. Given that, we suggest the policy makers to initiate further policies to promote tourism investment across the member nations of the EU. This will not only expand the tourism industry in those countries but also ensure substantial reduction in the CO_2 emissions. This will ensure sustainable tourism development in the EU.

Given that our study makes an important contribution to the body of knowledge and also to the existing empirical literature. Since, this is the first study to examine the impact of tourism investment on tourism development and CO_2 emissions in a sample of 28 EU member countries. Hence, this is the pioneer study in terms of understanding the dynamic impact of tourism investment on tourism development and CO_2 emissions. However, for the advancement of knowledge on this research area, we suggest that future research to focus on the impact of tourism investment on tourism revenue and CO_2 emissions at the individual country levels when data become available for the longer time period.

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Table 1: Summary of the relevant literature on the relationship between tourism and CO_2 emissions

Authors	Country	Period	Method	Conclusion
Gössling et al. (2005)	Australia, New Zealand, Canada, the United States and Finland	2002	Aggregated top-down approach	One unit (€) of tourism revenue emitted 3.18 kg in Australia, 2.09 kg in New Zealand, 1.93 kg in Canada, 1.91 kg in United States and 1.22 kg in Finland
Kuo and Chen (2009)	Penghu Island, Taiwan	2006	Life cycle assessment (LCA) approach	Each tourist consumed 1606 MJ of energy and produced 109.03 kg of CO_2 per trip
Wu and Shi (2011)	China	2008	Bottom-up approach	The Chinese tourism industry consumed approximately 428 PJ of energy and released 51 Mt of CO_2 emissions
Lee and Brahmasrene (2013)	EU	1988—2009	Fixed effect	Tourism deceases CO_2 emissions significantly
Tsai et al. (2014)	Taiwan	2011	CO_2 emissions audit approach	The average CO_2 emissions of homestay facilities, general hotels, standard tourist hotels and international tourist hotels were are 6.3, 12.5, 19.2 and 28.9 kg-CO_2/person-night, respectively
Ragab and Meis (2015)	Egyptian accommodation industry	2009	Tourism satellite accounts	1 million of direct value added by tourists in the accommodation industry generates 464.3 tons of CO_2 emissions
Katircioglu (2014a)	Turkey	1960–2010	ARDL model	Tourism increases CO_2 emissions significantly
Katircioglu (2014b)	Singapore	1971–2010	Dynamic OLS	Tourism reduces CO_2 emissions significantly
Katircioglu et al. (2014)	Cyprus	1970–2009	Conditional Granger causality test	International tourism arrivals increases CO_2 emissions
Yorucu (2015)	Turkey	1960—2010	ARDL model	International tourism arrivals increases CO_2 emissions
Zaman et al. (2016)	34 developed and developing countries	1965–2011	Dynamic OLS	Validated EKC hypothesis
Zang and Gao (2016)	Eastern and Western China	1995–2011	FMOLS	Tourism induced EKC exists

Table 2: Summary statistics (mean), 1990-2013

Country	TI	TR	CDE	GDPPC	TECH	REER	TO	TP
Austria	4390.16	53350.85	64.42	41699.56	2103.75	101.18	84.99	8.10
Belgium	2777.04	26953.54	108.53	39862.42	637.08	99.13	134.99	10.43
Bulgaria	623.79	6793.66	50.80	4987.17	287.33	74.85	97.75	7.97
Croatia	1273.62	9507.92	19.72	11336.93	327.67	92.80	75.28	4.48
Cyprus	368.62	4718.00	6.64	26925.47	10.10	93.48	115.56	0.97
Czech Republic	1639.44	14813.01	120.76	16174.91	717.08	73.62	103.21	10.32
Denmark	2943.22	22234.28	52.37	54100.30	1493.67	96.43	82.52	5.37
Estonia	279.69	2458.56	18.05	11696.01	28.46	80.38	141.66	1.40
Finland	1425.72	16787.72	56.77	40133.86	2046.83	105.42	69.09	5.21
France	29464.02	232226.38	363.68	37824.93	13654.13	101.22	50.19	61.88
Germany	27533.46	340022.38	826.08	38128.80	44362.79	104.37	62.07	81.74
Greece	5824.13	35690.64	85.92	23825.96	418.33	90.76	48.42	10.80
Hungary	1056.94	12912.26	56.79	11111.02	950.50	80.95	116.19	10.17
Ireland	4903.65	15039.15	38.22	40565.18	798.04	96.97	152.38	4.00
Italy	15216.57	233995.75	429.91	34857.24	8016.94	99.76	46.99	57.72
Latvia	179.64	1356.45	8.78	8625.99	147.96	80.15	90.87	2.33
Lithuania	226.12	1825.35	15.30	8788.71	100.88	78.05	105.86	3.41
Luxembourg	572.37	2295.07	9.90	88984.48	52.35	98.57	262.11	0.45
Malta	227.24	2132.28	2.40	16895.73	12.92	93.15	170.99	0.39
Netherlands	4514.44	45688.11	169.24	44757.15	2219.92	98.02	120.85	15.98
Poland	2373.72	20343.02	322.86	9149.20	2794.96	84.94	63.59	38.29
Portugal	3344.22	31679.49	54.45	20483.16	221.92	95.87	64.49	10.30
Romania	2495.90	7706.94	103.90	6235.07	1326.46	81.15	65.89	21.72
Slovakia	449.67	3326.90	39.04	11976.51	224.83	68.57	131.51	5.37
Slovenia	457.19	4433.68	14.87	19472.72	302.42	95.73	110.44	2.01
Spain	18511.59	184663.00	278.81	27855.11	2734.92	95.37	50.71	42.22
Sweden	2619.73	36892.47	51.34	45040.26	3163.04	112.26	76.23	9.00
United Kingdom	19097.49	299392.88	525.70	34843.66	18341.25	108.31	53.90	59.88
Average	5528.19	59615.70	139.12	27726.34	3839.16	92.19	98.17	17.57

Notes: TI- tourism investment in constant US$ million; TR- tourism revenue in constant US$ million; CDE- total CO_2 emissions in 1000 kilotonnes; GDPPC- GDP per capita in constant US$; TECH- total patent applications by the residents; REER- real effective exchange rate index (2010 = 100); TO- trade (% of GDP); and TP- total population in millions.

Table 3: Compounded annual average growth rates, 1990-2013 (percent)

Country	TI	TR	CDE	GDPPC	TECH	REER	TO	TP
Austria	-0.39	0.75	0.34	1.52	0.29	-0.02	1.61	0.43
Belgium	1.47	2.27	-0.54	1.25	0.46	-0.03	1.32	0.50
Bulgaria	7.45	4.32	-2.79	2.40	1.55	2.89	2.89	-0.79
Croatia	1.17	3.48	0.31	2.05	-3.14	0.38	1.31	-0.50
Cyprus	0.61	0.79	1.35	1.00	-7.50	0.61	-0.39	1.75
Czech Republic	5.29	2.07	-1.45	1.53	0.42	3.29	3.73	0.08
Denmark	-0.70	0.79	-1.20	1.11	0.42	0.08	1.82	0.38
Estonia	18.10	21.42	-0.79	3.74	1.96	3.20	0.78	-0.76
Finland	-0.47	2.08	-0.48	1.36	-1.10	-1.45	2.37	0.38
France	3.49	1.81	-0.52	1.03	0.75	-0.37	1.45	0.52
Germany	2.31	1.00	-0.89	1.29	1.90	-0.29	2.70	0.15
Greece	-0.12	1.33	-0.31	0.60	4.73	0.82	2.05	0.32
Hungary	4.15	1.75	-2.23	1.85	-5.70	2.29	4.72	-0.21
Ireland	0.91	2.46	0.49	3.42	-3.38	-0.26	2.71	1.18
Italy	-1.65	0.34	-0.83	0.41	0.41	-0.64	1.84	0.26
Latvia	9.29	16.34	-2.96	4.27	5.02	4.24	2.27	-1.21
Lithuania	5.65	4.63	-2.41	4.39	6.25	3.71	2.98	-0.97
Luxembourg	6.64	3.54	0.07	2.04	4.51	0.03	2.95	1.55
Malta	1.04	2.17	0.08	2.43	8.48	0.20	0.45	0.78
Netherlands	1.96	2.34	0.31	1.49	0.33	0.15	1.71	0.51
Poland	8.77	4.82	-0.86	3.66	0.14	2.37	2.99	-0.01
Portugal	-1.36	-0.01	0.39	1.05	8.41	0.83	0.79	0.20
Romania	2.78	2.55	-3.46	2.22	-4.34	1.87	2.76	-0.65
Slovakia	7.93	6.34	-1.17	3.64	-1.84	3.60	5.11	0.09
Slovenia	12.70	3.50	0.64	1.78	14.47	0.49	1.91	0.13
Spain	0.94	1.97	0.35	1.13	1.36	-0.16	2.34	0.80
Sweden	2.21	4.62	-0.69	1.49	-1.24	-1.08	1.66	0.50
UK	0.81	0.89	-0.84	1.48	-1.10	-0.04	1.22	0.50
Average	3.61	3.58	-0.72	1.99	1.16	0.95	2.15	0.21

Note: Growth rates are calculated using original data.

Table 4: Panel unit root tests

	LLC test				IPS test			
	Null: Unit root (assumes common unit root process)				Null: Unit root (assumes individual unit root process)			
	Level		First difference		Level		First difference	
Variable	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
TI	3.924	1.000	-4.515	0.000	-0.016	0.494	-10.528	0.000
TR	-0.116	0.454	-5.407	0.000	-0.126	0.450	-12.081	0.000
CDE	2.141	0.984	-19.171	0.000	3.128	0.999	-18.578	0.000
GDPPC	4.982	1.000	-11.523	0.000	5.442	1.000	-8.538	0.000
TECH	4.905	1.000	-11.616	0.000	1.662	0.952	-10.668	0.000
REER	4.428	1.000	-11.605	0.000	0.625	0.734	-9.322	0.000
TO	3.315	1.000	-13.323	0.000	-0.625	0.266	-11.093	0.000
TP	0.043	0.517	-3.647	0.000	0.791	0.786	-4.853	0.000

Notes: The LLC test and IPS test are estimated using constant and trend variables in the model.

Table 5. Panel unit root test (with structural break)

S. No	Variable	minZ1 Statistics	Critical Value	Break date	First difference	minZ1 Statistics	Critical Value
1	TI	-4.1212	-5.4894	1992	TI	-10.0519	-3.2424
2	TR	-2.7875	-6.0153	2009	TR	-19.6417	-5.0802
3	CDE	-2.4428	-4.0757	2000	CDE	-9.4469	-1.9078
4	GDPPC	1.3879	-25.8408	2007	GDPPC	-12.7335	-0.192
5	TECH	-3.684	-3.8551	1991	TECH	-24.1451	-2.4328
6	REER	-0.4651	-6.1194	1994	REER	-20.4197	-2.4328
7	TO	-1.6285	-5.1699	1993	TO	-18.4854	-2.4328
8	TP	2.7513	-1.15	1994	TP	-14.642	-2.4328

Note: Critical values are taken from Yiannis and Tzavalis (2012). Critical values are based on 10,000 simulations, allowing for both break in intercept and trend.

Table 5: Johansen-Fisher panel cointegration test

Hypothesized No. of CE(s)	trace test	Prob.	max-eigen test	Prob.
TR = f (REER, GDPPC, TI, TO)				
None	708.200	0.000	466.500	0.000
At most 1	314.500	0.000	180.800	0.000
At most 2	168.300	0.000	111.500	0.000
At most 3	95.080	0.001	80.660	0.017
At most 4	55.050	0.511	55.050	0.511
CDE = f (TP, GDPPC, TECH, TI, TO)				
None	1286.000	0.000	683.300	0.000
At most 1	735.500	0.000	422.500	0.000
At most 2	394.800	0.000	219.800	0.000
At most 3	223.900	0.000	131.600	0.000
At most 4	147.200	0.000	124.000	0.000
At most 5	100.200	0.000	100.200	0.000

Notes: Trend assumption: Linear deterministic trend;
Lag length: Selected based on SIC;
Probabilities are computed using asymptotic Chi-square distribution.

Table 6: Long-run elasticities using ARDL models

Variable	Coefficient	t-Statistic	Prob.
TR = f (REER, GDPPC, TI, TO)			
REERI	-0.665	-5.635	0.000
GDPPC	0.502	5.624	0.000
TI	0.197	10.098	0.000
TO	0.222	2.503	0.013
CDE = f (TP, GDPPC, TECH, TI, TO)			
TP	0.831	4.034	0.000
GDPPC	1.126	22.881	0.000
PA	-0.046	-3.650	0.000
TI	-0.033	-7.018	0.000
TO	-0.045	-2.251	0.025

Note: The above models are estimated using constant and trend variables.

Table 7: Pairwise heterogeneous panel causality tests

Null Hypothesis:	Zbar-Stat.	Prob.
TR does not homogeneously cause TI	3.739	0.000
TI does not homogeneously cause TR	4.879	0.000
CDE does not homogeneously cause TI	0.963	0.335
TI does not homogeneously cause CDE	-0.477	0.633
GDPPC does not homogeneously cause TI	0.480	0.631
TI does not homogeneously cause GDPPC	-1.518	0.129
TO does not homogeneously cause TI	-0.003	0.998
TI does not homogeneously cause TO	0.154	0.877
CDE does not homogeneously cause TR	0.195	0.845
TR does not homogeneously cause CDE	-2.050	0.040
GDPPC does not homogeneously cause TR	0.209	0.834
TR does not homogeneously cause GDPPC	-1.002	0.316
TO does not homogeneously cause TR	-1.720	0.086
TR does not homogeneously cause TO	-0.812	0.417
GDPPC does not homogeneously cause CDE	2.384	0.017
CDE does not homogeneously cause GDPPC	-0.287	0.774
TO does not homogeneously cause CDE	0.881	0.378
CDE does not homogeneously cause TO	-1.283	0.199
TO does not homogeneously cause GDPPC	0.625	0.532
GDPPC does not homogeneously cause TO	1.449	0.147

Note: The causality is explored using the Dumitrescu and Hurlin (2012) test.