CO_2 Emissions in Asia–Pacific Region

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Global warming has become the main concern in the current world; increased CO_2 emissions are believed to be the main reason for this climate change. Therefore, the impacts of energy consumption, economic growth, financial development, and international trade on the CO_2 emissions of 17 Asia–Pacific countries. Using unbalanced panel data for 61 years (1960–2020), the Driscoll and Kraay's standard error and panel-corrected standard error (PCSE) models are employed to observe the effect of the studied variables on the CO_2 emissions.

Keywords: CO2 emissions ; energy consumption ; economic growth

1. Introduction

Over the past few decades, climate change has been the most serious and challenging environmental issue worldwide, as it has various economic, social, and ecological impacts. With rapid globalisation, economic development, growing population, and financial development, carbon dioxide (CO_2) emissions are also continuously increasing. The increased level of CO_2 emissions is considered the main cause of climate change and global warming; hence, the issue has drawn the attention of researchers, international organisations and policy makers (Rahman [1]; Acheampong [2]; Heidari et al. [3]). According to BP statistics, global CO_2 emissions grew by 1.4% per annum from 2009 to 2019, which creates stern alarm for the living condition of the earth [4]. Thus, reduction in CO_2 emissions is still a top-most priority for the policy makers, and seeks unanimous and effective steps agglomerating important elements such as energy consumption, economic growth, trade, and financial development in an articulated way.

Therefore, the matter of CO_2 emissions is still a vital area of research to promote environmental quality and sustainable economic development. The dilemma is that CO_2 has negative consequences, but is also directly linked to economic growth and energy consumption (Rahman [1]; Hossain [5]). Hence, researchers and policy makers have different opinions in relation to dealing with CO_2 emissions. The general view is that, irrespective of the level of development, each country can attempt to reduce CO_2 emissions as a way to improve environmental quality. Since the consumption of fossil fuels increases CO_2 emissions, the demand for energy can be decreased to mitigate CO_2 emissions (Lamb et al. [6]; Rahman [1]; Acheampong [2]). In contrast, it is also argued that mitigation of CO_2 emissions has macroeconomic costs (Acheampong [2]; Fan et al. [7]) and quick implementation of emission reduction policies by reducing energy use will negatively affect economic growth, as energy is a vital factor in the production process (Nain et al. [8]; Ahmad et al. [9]; Omri et al. [10]; Sadorsky [11][12]). Many empirical studies such as Shahbaz et al. [13], Andersson and Karpestam [14], Wang et al. [15], and Narayan and Smyth [16] supported this latter sentiment, implying that emission reductions alone will not bring a positive outcome for sustainable economic growth if low-carbon technologies are not properly developed (Rahman [1]). These conflicting arguments provide the rationale for further empirical investigation on the links between CO_2 emissions, energy consumption, and economic growth to ease the current debate on economic, environmental, and energy conservation policies, and help in achieving sustainable economic development.

Financial development in both developed and developing countries is rapidly occurring, with the increase in economic growth. Many scholars and policy makers consider the financial sector as a vital element for ensuring economic growth (Goldsmith [17]; McKinnon [18]; King and Levine [19]). The improvement of the financial sector can also affect CO_2 emissions by stimulating different developmental activities. If financial development is identified to be a significant variable affecting CO_2 emissions, this will have important implications in climate change and sustainable development policies (Shen et al. [20]; Wang et al. [21]). Therefore, it is logical to include financial development as a significant variable in any investigation of the nexus between energy use, economic growth, and CO_2 emissions.

Furthermore, international trade is also connected to energy consumption and CO_2 emissions (Rahman [1]). Nasir and Rehman [22] and Haq et al. [23] viewed trade as a significant variable for environmental quality, and the former found detrimental effects of trade to the environment while the latter considers that environmental quality may be improved if environmentally friendly commodities are traded. On the other hand, the study of Rahman and Mamun [24] found no nexus

between international trade and energy consumption in Australia. Given this controversy, it is still important to consider trade as an explanatory variable in the empirical investigation of CO_2 analysis.

This research, therefore, endeavours to investigate the effects of energy consumption, economic growth, international trade, and financial development on the CO_2 emissions of 17 Asia–Pacific countries. The reasons for selection of Asia–Pacific countries are: (i) the share of CO_2 emissions of this region is 52.4%, which is the highest compared to other regions of the world such as North America (16.6%), Europe (11.2%), the Middle East (6.3%), and Africa (3.7%) in 2020 [4]; (ii) the annual growth rate of CO_2 emissions is also the highest (2.7%) in the Asia–Pacific region in 2020 against the figures of −0.4% for North America, −1.1% for Europe, 2.7% for the Middle East, and 2.0% for Africa [4]; (iii) the share of energy use of the Asia–Pacific region is also the highest in the world in comparison to other regions; this region used 45.5% of the world's energy consumption in 2020 against the consumption share of North America (19.4%), Europe (13.9%), the Middle East (6.5%), and Africa (3.3%) [4]; (iv) the growth rate per annum of energy consumption in 2020 was also the highest (3.3%) in this region compared to North America (0.6%), Europe (−0.2%), the Middle East (3.1%), and Africa (2.5%) [4]; (v) this region experienced the highest GDP growth rate, which was 5.8% in 2017 (UN [25]) compared to advanced economies (3.1%), Europe and Central Asia (4.1%), and the Middle East and North Africa (1.2%) [26]; (vi) the global merchandise trade share of this region was 38.5% in 2017, with the growth rates of exports and imports of 11.5% and 15%, respectively (UN [27]); and (vii) the regional distribution of domestic credit to private sector (as a proxy of financial development) is 167.08% of GDP [26].

2. Economic Growth–CO_2 Emissions Nexus

This first strand of research explores the linkage between CO_2 emissions (proxy for environmental quality) and economic growth. Basically, this strand explores the evidence of the EKC hypothesis, which describes that CO_2 emissions and growth are positively linked at the early level of development, and when the economy is matured with a fixed level of income, CO_2 emissions start falling with the increase in income as the country is able to buy carbon-friendly technologies. This implies that EKC is an inverted U-shaped, non-linear curve. Many studies (see Rahman [28] and [1]; Pao et al. [29]; Shahbaz et al. [30]; Dinda and Condoo [31]; Zoundi [32]; Akbostanci et al. [33]; Lean and Smyth [34]; Ozturk and Acaravci [35]; He and Richard [36], Tiwari et al. [37]; Ertugrul et al. [38], among others) tested this hypothesis, but failed to unanimously establish the existence of the EKC hypothesis for all countries. While several of the mentioned studies found the existence of the EKC, including Rahman [1], Dinda and Condoo [31], He and Richard [36], Akbostanci et al. [33], Ozturk and Acaravci [35], and Pao et al. [29], others found the opposite results: Rahman [1] found a U-shaped affiliation for Asian populous countries; He and Richard [36], Ozturk and Acaravci [35], Pao et al. [29], and Rahman et al. [39] observed no significant confirmation of the EKC hypothesis for the Canadian economy, Turkey, Russia, and Newly Industrialised countries, respectively. Akbostanci et al. [33], Kashem and Rahman [40], and Rahman and Alam [41], Rahman [28], and Rahman and Vu [42] exposed the growing long-run linear connection between CO_2 emissions and economic growth in Turkey, Bangladesh, top 10 electricity-consuming countries, Australia, and Canada, respectively, whereas the falling effect is also uncovered by Rahman [43] for India. In terms of causal association, the unidirectional causal nexus between economic growth and CO_2 emissions was found by Mbarek et al. [44] for Tunisia, and bidirectional causality was also revealed by Saidi and Rahman [45], and Rahman et al. [46] in four out of five OPEC countries, and five South Asian countries, respectively. Thus, more investigation of the role of economic growth in CO_2 emissions is needed.

3. Economic Growth, Energy Consumption, and CO_2 Emissions Nexus

The second strand of research focuses on the dynamic link between CO_2 emissions, economic growth, and energy consumption, and empirical findings are not unanimous in the literature. Among the studies in this group, Alam et al. [47] found bidirectional causality between CO_2 emissions and energy use without any link between CO_2 emissions and economic growth in India. A bidirectional nexus between CO_2 emissions and energy consumption is also confirmed by Alam et al. [48] for Bangladesh, with a unidirectional causality from emissions to economic growth. On the other hand, Shahbaz et al. [13], Uddin et al. [49], Ang [50], Hossain [5], Kasman and Duman [51], and Rahman and Kashem [52] established a unidirectional causal link from economic growth to energy use and CO_2 emissions for Malaysia, Indonesia, Japan, the EU member and candidate countries, Sri Lanka, and Bangladesh, correspondingly. Furthermore, no causal link between CO_2 emissions and income and between energy and income is revealed by the study of Soytas et al. [53] for the USA. Li et al. [54] also found that reduction in energy intensity and CO_2 emissions do not significantly hamper economic growth in the case of 20 Asia–Pacific countries, whereas Nyiwul [55] found insignificant association between energy consumption and CO_2 emissions in 10 African countries. Nyiwul [56] also noted that the renewable energy is linked with the climate change concern generated by pollutants such as CO_2 emissions in the Sub-Saharan African countries.

Therefore, the further analysis of the role of economic growth and energy consumption on CO2 emissions is essential for better policy making.

4. Trade–CO_2 Emissions Nexus

The third strand of research deals with the nexus between trade and CO_2 emissions. Theoretically, the net effect of international trade on CO_2 emissions could either be positive or negative (Rahman [1]). The positive effect stems from the fact that free trade enables a country to have larger admission to international markets and thus increases the power of the competition and competence to import cleaner and efficient technologies that decrease carbon emissions (Shahbaz et al. [13]). The counter argument for inverse effects is that trade increases industrial manufacturing activities and depletes natural resources that ultimately worsen environmental quality by increasing CO_2 emissions. The empirical findings of Jebli et al. [57] in 22 Central and South American countries, Halicioglu [58] in Turkey, Tiwari et al. [37] in India, and Mongelli et al. [59] in Italy support the positive effect of international trade on CO_2 emissions. In contrast, the findings of Shahbaz et al. [60] show the negative outcome of trade in Pakistan while no, weak, and inconclusive effects are also revealed by two recent studies of Haug and Ucal [61] and Hasanov et al. [62] in Turkey, and oil exporting countries, respectively. Rahman and Alam [41] observed no impact of trade on CO_2 emissions in Bangladesh. These inconclusive impacts of trade on CO_2 emissions seek more attention.

5. Financial Development–CO_2 Emissions Nexus

The fourth strand of research describes the association between financial development and carbon emissions, where the researchers are of different opinions about the linkage. Zhang [63] and Jiang and Ma [64] take the view that financial development generates more CO_2 emissions. Conversely, some other researchers such as Zaidi et al. [65] and Dogan and Seker [66] argue that CO_2 emissions can be reduced with the increase in financial development through the efficient use of developmental process concerning environment. Empirically, the positive consequence of financial development on CO_2 emissions is revealed by Zhang [63] and Shen et al. [20] in China, Jiang and Ma [64] for 155 countries, Boutabba [67] in India, Ehigiamusoe and Lean [68] in 122 countries, Ali et al. [69] in Nigeria, and Wang et al. [21] for G7 countries.

In contrast, the negative outcome of financial development on CO_2 emissions is also revealed by Zaidi et al. [65] in APEC countries, Vo and Zaman [70] in 101 countries, Odhiambo [71] in 39 sub-Saharan African (SSA) countries, Dogan and Seker [66] in top renewable energy countries, and Sheraz et al. [72] in G20 countries. Moreover, Ozturk and Acaravci [73] found no linkage between financial development and CO_2 emissions in Turkey. **Table 1** summarises the findings of studies noted in these four strands.

Table 1. Summary of outcomes of previous empirical studies.

First Strand of Research: CO_2 Emissions–Economic Growth Nexus		
Authors	**Countries of Study ***	**Findings**
Tiwari et al. [37]; Shahbaz et al. [30]; Rahman [28]; Ertugrul et al. [38]	**India; France; 10 top electricity-consuming countries 10 developing countries**	**Existence of EKC**
Ozturk and Acaravci [35]; He and Richard [36]; Zoundi [32]; Rahman et al. [39]; Pao et al. [29]	**Turkey; Canada; 25 African countries; Newly industrialized countries; Russia**	**Non-confirmation of EKC**
Rahman [1]	**11 Asian countries**	**U-shaped association**
Lean and Smyth [34]	**5 ASEAN countries**	**CO_2 emissions influence economic growth**
Akbostanci et al. [33]; Kashem and Rahman [40]; Rahman and Alam [41]; Rahman [28], Rahman and Vu [42]; Rahman [43]	**Turkey; Bangladesh; top 10 electricity-consuming countries; Australia and Canada; India**	**Economic growth affects CO_2 emissions**
Dinda and Condoo [31]	**88 countries**	**CO_2 emissions and economic growth affect each other**
Mbarek et al. [44]; Saidi and Rahman [45]; Rahman et al. [46]	**Tunisia; 4 out of 5 OPEC countries; 5 South Asian countries**	**Unidirectional and bidirectional causal association between economic growth and CO_2 emissions**
Second Strand of Research: CO_2 Emissions–Economic Growth–Energy Consumption Nexus		

First Strand of Research: CO_2 Emissions–Economic Growth Nexus		
Authors	**Countries of Study ***	**Findings**
Alam et al. [47]; Alam et al. [48]	India; Bangladesh	Bidirectional relationship between energy use and CO_2 emissions in both countries; no link between CO_2 emissions and economic growth in India, but unidirectional association from CO_2 emissions to economic growth in Bangladesh
Uddin et al. [49]; Shahbaz et al. [13]; Ang [50]; Hossain [5]; Kasman and Duman [51]; Soytas et al. [53]; Rahman and Kashem [52]	Sri Lanka; Indonesia; Malaysia; Japan; the EU member and Candidate countries; the USA; Bangladesh	Unidirectional causal association from economic growth to energy consumption and CO_2 emissions
Soytas et al. [53]	The USA	No causal link between economic growth and energy use, and between economic growth and CO_2 emissions
Li et al. [54]	20 Asia–Pacific countries	The reduction in energy intensity and CO_2 emissions do not significantly hamper economic growth
Nyiwul [55]	10 African countries	Insignificant association between energy consumption and CO_2 emissions
Nyiwul [56]	Sub-Sahara African countries	The renewable energy is linked with the climate change concern generated by pollutants such as CO_2 emissions
Third Strand of Research: CO_2 Emissions–International Trade Nexus		
Jebli et al. [57]; Mongelli et al. [59]; Tiwari et al. [37]; Halicioglu [58]	22 Central and South American countries; Italy; India; Turkey	Positive effect of trade on CO_2 emissions
Shahbaz et al. [60]	Pakistan	Negative impact of trade on CO_2 emissions
Hasanov et al. [62]; Rahman and Alam [41]	Oil exporting countries; Bangladesh	No effects of trade on CO_2 emissions
Haug and Ucal [61]	Turkey	Inconclusive results
Fourth Strand of Research: CO_2 Emissions–Financial Development Nexus		
Zhang [63]; Shen et al. [20]; Jiang and Ma [64]; Boutabba [67]; Ehigiamusoe and Lean [68]; Ali et al. [69]; Wang et al. [21]	China; China; 155 countries; India; 122 countries; Nigeria; G7 countries.	Positive effect of financial development on CO_2 emissions
Zaidi et al. [65]; Dogan and Seker [66]; Vo and Zaman [70]; Odhiambo [73]; Sheraz et al. [72]	APEC countries; top renewable energy countries; 101 countries; 39 Sub-Saharan African (SSA) countries; G20 countries	Negative effect of financial development on CO_2 emissions
Ozturk and Acaravci [73]	Turkey	No link

* Following the authors, countries of studies are noted, respectively.

Clearly, the existing empirical findings on the link between CO_2 emissions and other variables are diversified, and the researchers disagree not only about the presence of the link but also about the direction of causality direction between the variables. The root cause of inconclusive results is because of the differences in the use of data periods, methodological approaches, and country/region heterogeneity. Therefore, research on this important issue with updated data and improved methodology will continue and is justified. To address the issue, the combined effect of energy consumption, economic growth, trade, and financial development on CO_2 emissions in the Asia–Pacific regions is quite vital as it has not been discussed in the past literature.

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