Masud, Rony; Enam, Jihan Binte

Article

Consideration of the impact of the transition from a cash crop economy on the carbon footprint

Reference: Masud, Rony/Enam, Jihan Binte (2023). Consideration of the impact of the transition from a cash crop economy on the carbon footprint. In: Technology audit and production reserves 4 (4/72), S. 40 - 54.
https://journals.uran.ua/tarp/article/download/286236/280235/660569.
doi:10.15587/2706-5448.2023.286236.

UDC 502.1:338
JEL Classification: Q58
DOI: 10.15587/2706-5448.2023.286236

**Md. Rony Masud,
Jihan Binte Enam**

CONSIDERATION OF THE IMPACT OF THE TRANSITION FROM A CASH CROP ECONOMY ON THE CARBON FOOTPRINT

The object of the study is the carbon footprint (CO_2), which is skyrocketing despite augmented awareness of this issue and a growing willingness to act. The effects of climate change have recently become more severe and have garnered international attention. Recent discussion has focused on carbon footprint as one of the most urgent global issues facing all nations. The tradeoff between carbon footprint and economic growth for credible climate change measures is still understudied in terms of rigorous economic causal analysis. To comprehend the magnitude and speed of the transition away from an agricultural-based economy, it is necessary to quantify and compare the levels of carbon footprint associated with the agricultural, industrial, and service sectors of the country. In order to understand each economic sector's individual contributions to the overall carbon footprint and to assess the relationship between level of economic diversification and the levels of emissions, first identify the main factors and forces that have an impact on each sector's carbon footprint and then consider how the country's transition away from an agricultural-based economy has affected emissions in other economic sectors. This study investigates the impact of the economy's transition away from cash crops on carbon footprint, analyzes the conversion-affecting variables, and quantifies the significance applying the environmental Kuznets curve (EKC), and then regress the model. It is found that there is an inverted U-shaped pattern in the association between carbon footprint and each of industry, service, and manufacturing value added; agriculture, however, shows insignificant inverted U-shaped pattern. In addition, we discovered that every dependent variable – aside from the GDP contribution of agriculture – has a positive correlation with carbon footprint. Analysis revealed that improving agriculture results in lower carbon dioxide emissions. While the economic contributions of agriculture are more environmentally friendly, those of industry, services, and manufacturing leave carbon footprints behind to achieve sustainability, agricultural policy subsidies and deregulation may function as driving factors for the expansion of the cash crop economy. On the one hand, tax policy may be an effective instrument for boosting low-carbon energy consumption in the sector. It is presumptive that environmental phenomena, such as earthquakes, tsunamis, and flues, have not had a significant impact on the economy. This article is pertinent to the nations now dealing with significant environmental problems.

Keywords: *Bangladesh, carbon footprint, environmental Kuznets curve, foreign direct investment, economic growth, gross value added.*

Received date: 24.06.2023
Accepted date: 21.08.2023
Published date: 23.08.2023

How to cite

Md. Masud, R., Binte Enam, J. (2023). Consideration of the impact of the transition from a cash crop economy on the carbon footprint. Technology Audit and Production Reserves, 4 (4 (72)), 40–54. doi: https://doi.org/10.15587/2706-5448.2023.286236

1. Introduction

Carbon footprint displacement has slower spillover effect [1, 2]. Environmental issues are among the most critical problems and the threat of climate change brought on by growing global warming has been a significant environmental problem over the past thirty years. The creation of greenhouse gases (GHG), the majority of which are carbon dioxide (carbon footprint), is the primary factor causing climate change [3]. According to the US EPA's 2017 report, carbon footprint, methane, NO_2, and fluorinated gases account for 79 %, 11 %, 7 %, and 3 % of all greenhouse gases [4]. In the 5th IPCC Review Article, the international community decided that global temperatures should not rise beyond 2 °C by the twenty-first century's end [5]. The majority of nations committed to combating environmental pollution by establishing nationally determined contributions by signing the Paris Agreement. Countries are encouraged to reprioritize their sustainable economic drive by promoting the economic policies explained by the environmental Kuznets curve (EKC) hypothesis. EKC claims that there is an inverse U-shaped relationship between income and environmental deterioration [6]. Initially, income increases in response to environmental degradation increases until a turning point is attained, and then the environmental condition is expected to revive. Previous studies in-depth examined EKC relationship and tested the validity of it using various indicators. A few earlier studies looked at the applicability of EKC for Bangladesh, but their findings were different on the basis of indicators. While the current study aims to use the value-added components of the economy, the aforementioned studies all examined the relationship among income, environmental quality and the aggregate level of gross domestic product (GDP) and some other interconnected variables. *The aim of research* is to examine EKC at fragmented GDP levels in terms of gross value added in manufacturing, services, industries, and agriculture. Bangladesh is expected to lose around four percent of its GDP annually because of environmental concerns [7], making it one of the nation's most susceptible to climatic change as a result of global warming. In the last 20 years, combustion of fossil fuels was responsible for about 75 % of the carbon footprint that was caused by humans. Fossil fuels, on the other hand, are the main source of electricity, manufacturing, transportation, and consumer spending, all of which are closely related to economic expansion.

There is growing concern about the potential impact of this economic transformation on carbon footprint as countries move away from a cash crop economy and toward industrialization and service-oriented sectors. This paper looks into how the shift from an agricultural economy to other sectors may affect carbon footprint. The study seeks to shed light on the environmental effects of economic diversification and the requirement for sustainable development policies by examining the potential ramifications of this shift.

To quantify and compare the levels of carbon footprint associated with the agricultural, industrial, and service sectors over the 32 years period between 1990 and 2020 in Bangladesh in order to understand the extent and swiftness of the shift away from an agricultural-based economy. After that, determine the primary forces and variables that affect the carbon footprint within each economic sector to comprehend their individual contributions to the overall carbon footprint and evaluate the relationship between Bangladesh's degree of economic diversification and the levels of emissions. Finally, consider how policy changes and regulatory actions have affected emissions in various economic sectors as the country moves away from an agricultural-based economy.

This article intends to demonstrate how a nation's economic transition affects its carbon footprint and greenhouse gas emissions. It refers to the effects on the nation's carbon footprint and greenhouse gas emissions of its transition from a cash crop economy to an alternative economy. Increased energy demand, altered land use, technological advancements with the potential to enable cleaner practices, changes in consumption patterns, problems with waste generation and management, the introduction of emission regulations and policies are all common effects of industrialization. Countries must prioritize sustainable development policies to lessen the effects on the environment, which include implementing cleaner technology, boosting renewable energy, enforcing emission controls, and promoting energy efficiency and waste reduction initiatives.

Countries place a high priority on sustainable development to ensure long-term economic growth while tackling issues like natural catastrophes and erratic food security. This entails encouraging economic development while protecting the environment, diversifying the economy, investing in renewable energy, resource efficiency, innovation, and technology, being resilient to natural disasters, practicing sustainable agriculture, promoting social inclusivity, and putting into practice green policies and regulations. By implementing these sustainability principles, economies may pursue robust and successful growth while avoiding environmental damage and safeguarding the wellbeing of people and the world. Since natural disasters and unstable food security are the world's top concerns, increasing GDP through Carbon footprint does not guarantee sustainable economic growth. Which economy is preferable to secure long-term economic growth?

The Inverted U-shaped EKC hypothesis postulates a nonlinear link between environmental deterioration, particularly carbon footprint, and economic progress. Environmental deterioration increases initially when economies grow and become more industrialized. Beyond a certain point in economic advancement, the trend, however, reverses, and environmental degradation starts to decline as a result of raised environmental awareness and the adoption of cleaner technologies and policies. If an investigation reveals an impartial association between the carbon footprint and cash crop-based economic development, it suggests that the relationship between these two variables is not significant and does not follow the EKC pattern.

Hypothesis 1: Based on EKC, there is an insignificant correlation exists between cash crop-based economic development and the carbon footprint.

Hypothesis 2: EKC has an inverted U shape affiliation between carbon footprint and industrialized economic growth.

2. Materials and Methods

2.1. Literature review. Carbon footprint is a global problem that needs to be addressed if a sustainable society is to be built. Previously related studied conducted and some of them are very interesting. According to research [8], GDP and Carbon footprint in Algeria have a significant relationship between 1970 and 2010. In bivariate and multivariate models for Pakistan's 1971–2019 period [9] used the autoregressive distributed lag model (ARDL) and Johansen cointegration to investigate the connection between Carbon footprint, energy use, and economic progress. These results show that a rapidly expanding economy and energy use have a positive and significant impact on Carbon footprint. The relationship between the use of renewable energy, economic growth, and Carbon footprint for a group of seven countries was examined [10] using the ARDL limit test. It is demonstrated that cointegration exists in the G7 countries when real GDP per capita and Carbon footprint are used as dependent variables. In [11] examined the connection between Carbon footprint, energy use, and GDP at the state level in the United States from 1997 to 2016 where the results demonstrate a long-term relationship between various forms of energy consumption and Carbon footprint for both static and dynamic models. In investigation [12] looked at the relationship between Carbon footprint, energy consumption, GDP, and trade liberalization. This statistic shows that energy use and trade liberalization have a single-direction causal relationship with GDP and Carbon footprint. The contribution of several major energy sources (oil, coal, natural gas, hydroelectricity, and other renewables) to global Carbon footprint was examined in a study [13]. In [14] the relationships examined among Carbon footprint, energy consumption, economic growth, exports, and population density in 11 Asian states between 1960 and 2014 in order to assess the long-term effects on Carbon footprint using FMOLS and dynamic ordinary least squares (DOLS) methods. The test results suggest that these five factors have been cointegrated over time. Study in Indonesia [15], in France [16], and in Malaysia [17] all revealed how economic growth affects energy use and Carbon footprint. Many recent studies have employed the KOF index to examine how globalization has affected Carbon footprint [18–20]. The analysis of the trajectory of Carbon footprint in Iran, Canada, and Italy using a general regression neural network (GRNN) and grey wolf optimization (GWO), and the results demonstrate that the recommended technique is more accurate in long-term Carbon footprint forecasting. Iran's Carbon footprint were predicted in 2030 using time series and regression analysis [21]. Based on their results, Iran is unlikely to adhere to the Paris Agreement if business continues as usual (BAU). By using a general regression neural network (GRNN) and grey wolf optimization (GWO) to assess the trend of Carbon footprint in Iran, Canada, and Italy, and the findings show that the suggested method is more accurate in long-term Carbon footprint forecasting [20]. According to findings [21], Iran is unlikely to keep its goal to the Paris agreement based on the business as usual (BAU's) assumptions. A deep learning hybrid approach was utilized in India to forecast Carbon footprint [22]. The prediction was made using a deep learning hybrid model convolutional neural network-long short-term memory (CNN-LSTM). By using the simple exponential smoothing (SES) and autoregressive integrated moving average (ARIMA) models try to predict Carbon footprint. Since the ARIMA model has the lowest fractional mean absolute error (FMAE) value, they found that it is suitable.

Prior research on the EKC theory has mostly concentrated on the GDP as a whole; however, the sectoral EKC has received less attention [23]. The construction sector, other economic activities, and the agricultural, forestry, and fisheries industries all had a U-shaped EKC established by the study; however, the manufacturing and transportation sectors had an inverted U-shaped relationship. It is also examined the sectoral EKC for OPEC nations and came to the conclusion that there was a positive correlation between the value-added in the manufacturing sector and Carbon footprint, but a negative correlation between the value-added in agricultural and Carbon footprint [24]. However, it is discovered a contradictory finding for the value-added of the service sector, with the short-term reduction of Carbon footprint outweighing the long-term contribution to Carbon footprint. Additionally, in [25] the investigation of the EKC hypothesis for sub-sectors in the service industry after looking at aggregated value-added findings, which showed that the EKC hypothesis was supported by aggregated value-added results but not by sub-sectors. Authors of [26, 27] showed sectoral EKC for Portugal and came to conflicting conclusions on the relationship between sectoral value-added and Carbon footprint supporting both the N-shaped and inverted U-shaped associations. To account for the above, prior research has indicated that the sectoral EKC's impact on Carbon footprint is varied that necessitates more research. In contrast to sectoral EKC, several research evaluated the EKC hypothesis while additionally using a sectoral value-added variable to account for the sectoral effect. These studies likewise produced a variety of outcomes [28–35]. It was investigated the harm that agriculture was doing to the environment. In African countries [36], Pakistan [37], G20 countries [35], Nigeria [38], E7 countries [39], and in Azerbaijan [40] supported the EKC theory, however, the relationship between the value-added to agricultural and Carbon footprint is not unambiguous. Some research looked at other industries outside agriculture to evaluate the link. In [41] studied how South Asian nations' GDP value-added in the manufacturing, service, and agricultural sectors impacted Carbon footprint, finding a negative correlation for agriculture and a positive correlation for those in the manufacturing and service sectors. In [42] supported the favorable correlate for industry sector value-added across twenty emerging economies. In [43] looked into the relationship between manufacturing sector value-added and discovered a favorable correlation. Despite the sectoral value-added's inclusion in the EKC model, the outcomes is inconsistent and for the purpose of measuring the effect precisely, more research based on the sectoral EKC model is required. Energy consumption increases Carbon footprint. Some studies focused on the relationship between renewable energy and Carbon footprint [44–48] or the environmental aspects of alternative energy usage due to the negative effects of the energy-intensive sectors [48]. For instance, [49] discovering a causal link between population growth and Carbon footprint, as well as renewable energy (RE). The per capita use of renewable energy and carbon footprint are negatively correlated, although the per capita GDP is favorably correlated [50]. Long-term usage of renewable energy is beneficial in lowering consumption-based Carbon footprint [51]. Long-term Carbon footprint was greatly reduced by renewable energy, as demonstrated. Table 1 shows the summary of recent studies.

Table 1

Summary of recent studies

Source	Method, Country	Period	Result
1	2	3	4
[52]	Second- and third generation panel cointegration/7 emerging countries	1995–2018	In both the short term and long term, imports and economic growth increase Carbon footprint, while financial instability, technological innovation, and exports significantly decrease consumption-based Carbon footprint
[53]	OLS, FMOLS/182 countries	1990–2015	Trade openness reduces carbon footprint in high-income and upper middle-income countries, while rises in low-income countries. For low-middle-income countries, there is no significant relation
[51]	Panel regression, quantile regression/22 developed, and developing countries	1991–2016	The outcome of agriculture has a positive and significant effect on Carbon footprint from liquid with a 36.75 % increase in environmental degradation and a negative impact on Carbon footprint in the total emissions by 19.12 %
[54]	Structural fracture unit root tests, ARDL, Toda-Yamamoto causality test/Turkey	1968–2016	There is cointegration. In the long term, Carbon footprint is diminished by agriculture value-added and agricultural land. The EKC holds for Turkey
[49]	Panel cointegration and Granger causality/13 developed and developing countries in Asia Pacific Region	2005–2017	AGR↔GDP In the short run, the causality between agriculture and CO_2 is bidirectional. The causality between renewable energy, population, and Carbon footprint is one-way

Continuation of Table 1

1	2	3	4
[55]	Granger causality, Panel cointegration/115 countries	1990–2016	There is no significant relation between agricultural GDP growth and Carbon footprint for lower middle-, upper middle-, and high-income countries, whereas the relationship is significant and positive for low-income countries
[53]	CS-ARDL/G7 countries	1996–2017	Economic globalization, financial development, and natural resources have a positive impact on carbon footprint, while agriculture value-added has an inverse impact
[56]	FMOLS, DOLS, CCR/Australia	1972–2014	In the long run, the relation between expansionary commercial policy and Carbon footprint is significant and positive. While contractionary commercial and monetary policies are able to diminish Carbon footprint, remittance, and fossil fuel increase
[57]	China	2013–2016	The carbon footprint trading policy has a positive effect on a firm's environmental innovation that supports carbon reduction innovation
[58]	Cointegration test, auto regressive distributed lag test/Malaysia	1978–2016	In the long run, the relation between economic growth and urbanization and Carbon footprint is positive and significant, while the relation is also positive but insignificant for livestock. Specifically, crops, fisheries, and renewable energy significantly and inversely affect Carbon footprint. The EKC holds
[59]	The EU land use futures model (EULUF)/EU-28	–	The greenhouse gas emissions can be reduced by shifting to more vegetarian diets, decreasing food waste, and rising in crop and livestock yields and land multiuse
[60]	The gross export decomposition methodology and the world input-output database/EU	–	Carbon footprint embedded in value-added trade can decrease Carbon footprint because of the repetitive passing of intermediate products over numerous borders
[51]	Augmented mean group (AMG) and common correlat ed effect mean group (CCEMG) methods, second-generation panel cointegration methodologies/G7 countries	1990–2017	In the long term, the relation between Carbon footprint and trade, income, environmental innovation, and the renewable energy consumption is stable. Imports and income increase consumption-based carbon footprint, whereas exports, environmental innovation, and renewable energy consumption decrease it
[29]	Carbon decomposition model, panel data/China	1995–2009	The effect of embedding in the global value chain (GVC) on the carbon footprint of China's exports is analyzed and concluded that GVC is one of the reasons for high carbonization in manufacturing exports
[42]	Improved panel GMM/24 emerging economies	2000–2017	The EKC holds for nitrous oxide emissions but not for Carbon footprint and fossil fuel energy consumption. Industry value-added raises CO_2 and nitrous oxide emissions, while it decreases fossil fuel energy consumption
[32]	ARDL, VECM causality/Brazil	1980–2013	AGR$\leftrightarrow CO_2$. There is cointegration. The causality between agriculture and CO_2 is bidirectional
[33]	ARDL, Granger causality/South Africa	1990–2013	AGR$\rightarrow CO_2$. There is cointegration. The causality between agriculture and CO_2 is one-way
[35]	Panel FMOLS, VECM causality/G20 countries	1990–2014	AGR$\rightarrow CO_2$. There is cointegration. The causality between agriculture and CO_2 is one-way
[51]	Johansen cointegration, ARDL, Granger causality/Pakistan	1961–2014	In the long run, the relation between Carbon footprint, land under cereal crops, and agriculture value-added is positive and insignificant, while in the short run, the relation between CO_2 and GDP is negative and insignificant
[61]	Structural VAR model/Turkey	1965–2017	The relation between economic growth and the primary energy consumption and the carbon footprint is positive, and the primary energy consumption has more effect on carbon footprints than growth. Moreover, the impact of growth on primary energy consumption is positive and permanent
[62]	Agglomerative cluster analysis, the random forest algorithm/Eindhoven, Netherlands	–	The effect of different categories of land use on carbon footprints is analyzed. The contribution of the retail trade and residential land use categories to carbon footprints is larger than other categories. Among the residential building category, terrace houses contribute the most
[34]	Panel PMG, MG, AMG/Central and West African countries	1996–2015	AGR$\leftrightarrow CO_2$. There is cointegration. The causality between agriculture and CO_2 is bidirectional
[31]	ARDL, FMOLS, DOLS, VECM/Pakistan	1990–2014	AGR$\rightarrow CO_2$. There is cointegration. The causality between agriculture and CO_2 is one-way
[30]	Pedroni cointegration, DOLS, FMOLS, PMG/emerging countries	1971–2013	AGR$\leftrightarrow CO_2$. There is cointegration. The causality between agriculture and CO_2 is bidirectional
[63]	Johansen, Toda Yamamoto causality, FMOLS, CCR/Pakistan	1981–2015	No causal relation found between agriculture and CO_2
[64]	Panel data analysis/81 countries	1995–2013	The effect of carbon footprints on economic growth is significant and positive. The rise in the use of primary energy resources in the industry due to economic development has raised the carbon footprints and hence the economic growth
[65]	GMM, DOLS/Turkey	1960–2014	EKC hypothesis holds. Energy consumption and Carbon footprint are positively related
[29]	Pedroni cointegration, FMOLS, DOLS, VECM causality/ASEAN countries	1970–2013	AGR$\rightarrow CO_2$. There is cointegration. The causality between agriculture and CO_2 is one-way
[66]	PVAR, panel effect-response function model/106 countries	1971–2001	The relation between economic growth and energy consumption is bidirectional and the effect of energy consumption on economic growth and Carbon footprint is heterogeneous

 ISSN 2664-9969

Continuation of Table 1

1	2	3	4
[67]	PVAR/BRICT countries	1990–2015	The causality between GDP and urbanization, renewable energy, oil prices, and carbon footprints is one-way
[68]	Johansen cointegration and Granger causality/MIST countries	1971–2010	The causality between economic growth and Carbon footprint and energy consumption is one-way
[69]	ARDL/Italy	1960–2011	In both the short run and long run, renewable energy consumption reduces Carbon footprint, whereas, in the long run, international trade increases Carbon footprint
[70]	GMM/58 countries	1990–2012	Carbon footprint and energy consumption are positively related, while the effect of growth on energy consumption is positive and significant
[50]	ADF, Johansen cointegration/Turkey	1990–2012	One-way causality exists between per capita consumption of renewable energy and per capita carbon footprints. Furthermore, the relation between per capita consumption of renewable energy and carbon footprint is negative, while the relation between per capita GDP and per capita carbon footprints is positive
[71]	ARDL/Turkey	1961–2010	In the long run, the relation between electricity production from renewable sources, excluding hydropower and Carbon footprint, is inverse and significant
[41]	Regression analysis/South Asian countries	1972–2010	The effect of agriculture value-added on Carbon footprint is negative and significant, while the impact is positive and significant for industrial and services value-added. The EKC does not hold

2.2. Theory, data and model. The dramatic increase in greenhouse gas, mainly Carbon footprint, during the past few years is the primary contributor to the current serious environmental issue, warming around the world. In order to examine the relationship among all examined variables, the descriptive statistics conducted including the carbon footprint (CO_2), agriculture gross value added, industry gross value added, service gross value added, manufacturing gross value added, export value-added, foreign direct investment, trade openness, and labor force participation percentage. To assist in the mobilization of stationarity, natural logarithms (ln) have been used to all variables. EKC model, developed by Grossman and Krueger in 1995, suggests a non-linear relationship between environmental deterioration and economic growth. According to this theory, when an economy expands and develops, its effects on the environment first deteriorate, but after reaching a particular stage of economic growth, environmental degradation begins to improve. An inverted U-shaped curve is a typical graphic representation of the EKC model. The curve demonstrates that initially, environmental deterioration grows as a country's GDP per capita increases. The «ascending limb» of the curve is what is referred to as this stage. Beyond a certain point in economic development, however, the curve turns, and as the economy expands further, environmental degradation starts to decline. The «descending limb» of the curve is what we refer to as this stage. To analyze the EKC let's regress raw variable with squire term of this variable. Consequently, employing descriptive statistics for the dependent and independent variables, the study's econometric model is as follows:

Carbon footprint=f(agriculture, industry, service, manufacturing, export, fdi, trade openness, labor force participation).

$$Carbon\ footprint=\beta_0+\beta_{1agriculture}+\beta_{2industry}+\beta_{3service}+ +\beta_{4manufacturing}+\beta_{5export}+\beta_{6fdi}+\beta_{8trade\ openness}+ +\beta_{9labor\ force\ participation\ percentage}+\in_{it}.$$

Table 2 shows the explained and explanatory Variables.

Table 2

Explained and explanatory Variables

Explained and explanatory Variables	Definition	Unit of measurement	Logarithmic forms	Source
Carbon footprint (CO_2)	Damage to the environment due to Carbon footprint	Million tonnes	LCP	WDI
Greenhouse gas (GHG)	Damage to the environment due to greenhouse gas	Million tonnes	LGG	WDI
Economic growth (GPC)	Representing the GDP per capita	Current USD in million	LGPC	WDI
Agriculture gross value-added (AGC)	Representing the agriculture, forestry, and fishing sector	USD in million	LAGC	WDI
Industry gross value added (IGC)	Representing the industry and manufacturing sector	USD in million	LIGC	WDI
Service gross value added (SGC)	Representing the service sector	USD in million	LSGC	WDI
Manufacturing gross value added (MGC)	Representing manufacturing sector	USD in million	LMGC	WDI
Export value-added (EXC)	Representing the value of exported goods and services	USD in million	LEXC	WDI
Foreign direct investment (FDI)	Representing the net inflows	USD in million	LFDI	WDI
Trade openness (TRO)	Sum of exports and imports of goods and services	USD in million	LTRO	WDI
Labor force participation (PLP)	Representing the percentage of labor force participation	Percentage of people	LPLP	WDI

3. Results and Discussion

Since obtaining a desirable growth rate is one of the fundamental economic objectives, GDP growth is one of the important macroeconomic factors that determine a country's policies. However, it is impossible to ignore ecological and environmental implications. The link between economic growth and carbon footprint has so lately attracted the attention of policymakers, practitioners, and scholars. An inverted U-shaped link between economic development and carbon footprint is suggested by the Environmental Kuznets Curve (EKC) theory, which has received support from certain recent research. The earliest studies contend that economic development leads to environmental deterioration up until a certain point and that, after that point, environmental quality increases were those [72]. Conceptually, it is true that the majority of nations are attempting to transition from cash crop economies to industrialized economies, and that the carbon footprint is now a very significant concern; nevertheless, this trend began long ago among rich countries following the industrial revolution. A country's entire output of completed goods and services during a certain period of time, often a year or quarter, is measured as its gross domestic product, or GDP. This makes it a measurement of domestic output and a tool for assessing the state of an economy. A country's GDP, which calculates the value added to each industry, is made up of three different sectors: agriculture, industry, and services. In countries where value added is recorded at basic prices, net indirect taxes are reported as a distinct line item. The value-added shares for industry, services, and agriculture are included in the World Development Indicators as a subset of industry, which includes manufacturing. All the information about the variables, observations, mean, standard deviation, minimum and maximum amount is provided in Table 3.

In Table 4, all the variables have a strong positive linear connection, as seen by their correlation coefficients, which are all more than 0.9. Since correlation does not indicate causality, it is imperative to proceed with caution when examining correlations among variables. Correlation does not establish a cause-and-effect link, even if it indicates the direction and strength of a linear relationship between two variables; however, they indicate that they are linked with one another. An increase in agriculture, industry, service, manufacturing, export, FDI, trade openness, labor force participation activities may lead to an increase in carbon footprint levels.

In Table 5 the descriptive statistics conducted with all examined variables, including the carbon footprint, agriculture gross value added, industry gross value added, service gross value added, manufacturing gross value added, export value-added, foreign direct investment, trade openness, and labor force participation percentage, are critically described. All estimations in this model employ the log transformation of all variables. There are a total of 33 observations made during a 33-year period, from 1990 to 2022, with the highest averages in case of dependent variable for the service, industrial, and trade openness. While the minimal range of the standard deviation for the other five variables is less than one, the standard deviation for export, FDI, and trade openness is greater than one. The descriptive statistics conclude that the behaviors of variables are acceptable and reliable.

Table 3

Summary model descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Carbon footprint	33	44174.821	28402.682	10830.76	95944.602
Agriculture	33	20548.157	13059.801	9024.86	51623.512
Industry	33	39285.92	43322.72	6365.68	156100.55
Manufacturing	33	25168.398	27715.994	4183.37	100161.92
Services	33	69854.642	64786.247	13731.91	234877.77
Exports	33	18560.489	16192.267	1866.93	59284.129
FDI	33	944.517	930.199	1.39	2831.15
GDP pc	33	883.218	717.954	283.38	2688.3
Trade openness	33	45354.002	40446.73	5847.82	155455.75
Labor force	33	53.622	11.164	35.66	74.46

Table 4

Correlation equation summary descriptive statistics

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) l_{carbon_foot}	1.000	–	–	–	–	–	–	–	–
(2) $l_{agriculture}$	0.937	1.000	–	–	–	–	–	–	–
(3) $l_{industry}$	0.959	0.994	1.000	–	–	–	–	–	–
(4) $l_{services}$	0.975	0.987	0.996	1.000	–	–	–	–	–
(5) $l_{manufacturing}$	0.955	0.994	1.000	0.994	1.000	–	–	–	–
(6) $l_{exports}$	0.991	0.939	0.959	0.975	0.956	1.000	–	–	–
(7) l_{fdi}	0.905	0.764	0.805	0.847	0.798	0.909	1.000	–	–
(8) $l_{trade\_openness}$	0.990	0.953	0.969	0.982	0.966	0.998	0.893	1.000	–
(9) l_{labor_force}	0.986	0.933	0.961	0.976	0.957	0.982	0.904	0.981	1.000

Table 5

Log summary equation descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
$l_{carbon\ foot}$	33	10.468	0.713	9.29	11.472
$l_{agriculture}$	33	9.763	0.565	9.108	10.852
$l_{industry}$	33	10.065	0.999	8.759	11.958
$l_{services}$	33	10.766	0.888	9.527	12.367
$l_{manufacturing}$	33	9.625	0.991	8.339	11.515
$l_{exports}$	33	9.374	1.036	7.532	10.99
l_{fdi}	33	5.559	2.368	0.329	7.948
$l_{trade\ openness}$	33	10.279	1.005	8.674	11.954
$l_{labor\ force}$	33	3.961	0.212	3.574	4.31

In Table 6, it shows that the coefficient of GDP per capita titled «cgdp_pc2» will represent the curvature of the EKC relationship between «carbon_footprint» and «cgdp_pc» (Fig. 1). For a one-dollar increase in GDP per capita centered «cgdp_pc», the «carbon_footprint» is expected to increase by 58.15 million kg, holding all other variables constant and it is significant at 1 % level (*p-value* < 0.001). This suggests a positive relationship between economic development and carbon footprint. For a one-dollar increase in GDP per capita in the squared «cgdp_pc2», the «carbon_footprint» is expected to decrease by 0.024 million kg, holding all other variables constant and it is significant at 1 % level (*p-value* < 0.001). This suggests a quadratic relationship between GDP per capita and carbon footprint, following an inverted U-shaped environmental Kuznets curve pattern.

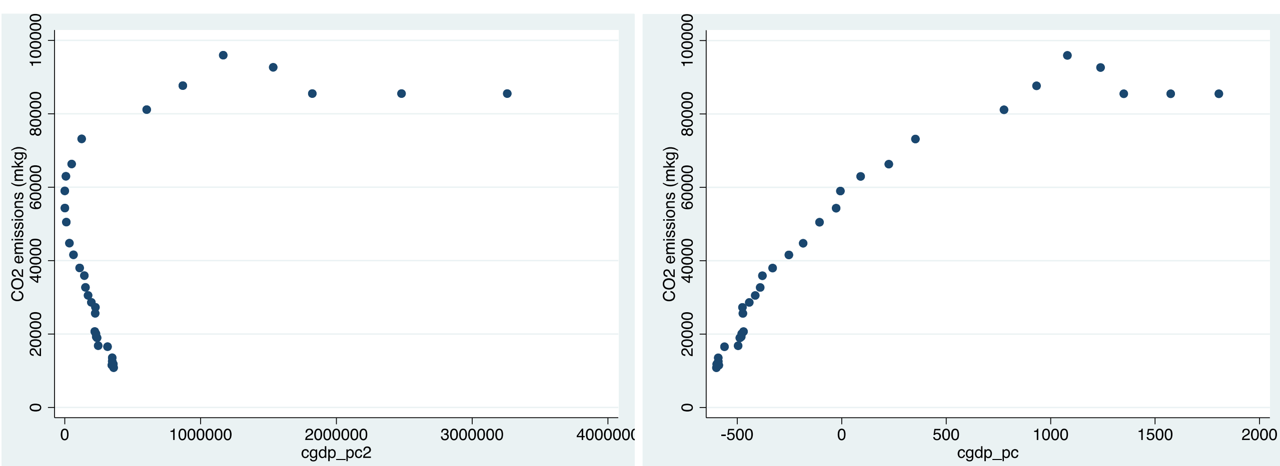
In Table 7, it shows that the coefficient of agriculture squire will represent the curvature of the EKC relationship between «carbon_footprint» and «agriculture» (Fig. 2). For a one million dollar increase in agriculture, the «carbon_footprint» is expected to increase by 2.97 million kg, holding all other variables constant and it is significant at 1 % level (*p-value* < 0.001). This suggests a positive relationship between agricultural development and carbon footprint. For a one-dollar increase in agriculture in the squared, the «carbon_footprint» is expected to decrease by 0.0000646 million kg, holding all other variables constant and it is significant at 1 % level (*p-value* < 0.001). This suggests a quadratic relationship between agriculture and carbon footprint, following an inverted U-shaped environmental Kuznets curve pattern. However, the coefficient of agriculture squire (β_2) is negative and close to zero (–0.0000646) which shows EKC has not a more pronounced inverted U shape affiliation between carbon footprint and agriculture value addition to GDP. The statistical significance of β_2 is crucial to figure out whether the curvature in the relationship is meaningful and not due to random chance. A statistically significant β_2 strengthens the case for the presence of an EKC pattern. The magnitude of β_2 indicates the strength of the curvature in the relationship. A larger absolute value of β_2 suggests a more pronounced U-shaped or inverted U-shaped relationship.

Table 6

Linear regression on environmental Kuznets curve (EKC) equation

carbon_footprint	Coef.	St. Err.	*t-value*	*p-value*	[95 % Conf	Interval]	Sig
c_{gdp_pc}	58.152	1.376	42.26	0	55.342	60.962	***
c_{gdp_pc2}	–0.024	0.001	–18.49	0	–0.027	–0.022	***
Constant	56377.388	846.521	66.60	0	54648.561	58106.214	***
Mean dependent var	44174.821		SD dependent var			28402.682	
R-squared	0.989		Number of obs			33	
F-test	1375.587		Prob > F			0.000	
Akaike crit. (AIC)	625.943		Bayesian crit. (BIC)			630.433	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$



a *b*

Fig. 1. Relationship between GDP per capita and carbon footprint: *a* – c_{gdp_pc2}; *b* – c_{gdp_pc}

Table 7

Linear regression on environmental Kuznets curve (EKC) equation

carbon_footprint	Coef.	St. Err.	*t-value*	*p-value*	[95 % Conf	Interval]	Sig
$c_{agriculture}$	2.975	0.086	34.71	0	2.8	3.15	***
$c_{agriculture2}$	–0.0000646	0	–13.10	0	0	0	***
Constant	54851.94	1034.04	53.05	0	52740.149	56963.731	***
Mean dependent var	44174.821		SD dependent var			28402.682	
R-squared	0.984		Number of obs			33	
F-test	950.176		Prob > F			0.000	
Akaike crit. (AIC)	637.994		Bayesian crit. (BIC)			642.483	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

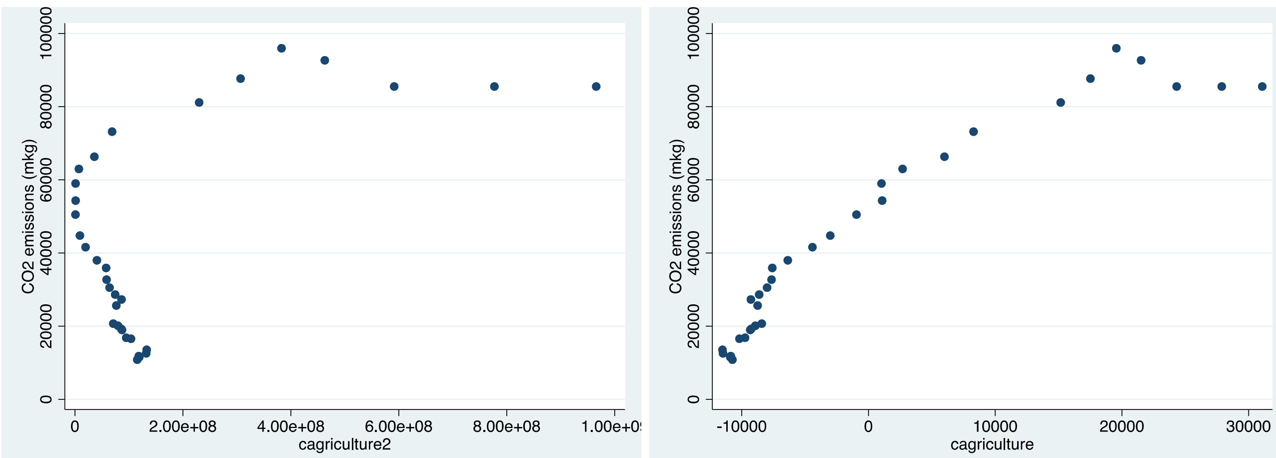


Fig. 2. Relationship between agriculture and carbon footprint: *a* – $c_{agriculture2}$; *b* – $c_{agriculture}$

In Table 8, it shows that the coefficient of industry squire stands for the curvature of the EKC relationship between (Fig. 3). For a one million dollar increase in industry, the «carbon_footprint» is expected to increase by 1.06 million kg, holding all other variables constant and it is significant at 1 % level (*p-value* < 0.001). However, the coefficient of industry squire (β_2) is negative and a larger absolute value (7.7) which shows EKC has a more pronounced inverted U shape affiliation between carbon footprint and industry value addition to GDP. The magnitude of β_2 indicates the strength of the curvature in the relationship and a larger absolute value of β_2 suggests a more pronounced U-shaped or inverted U-shaped relationship.

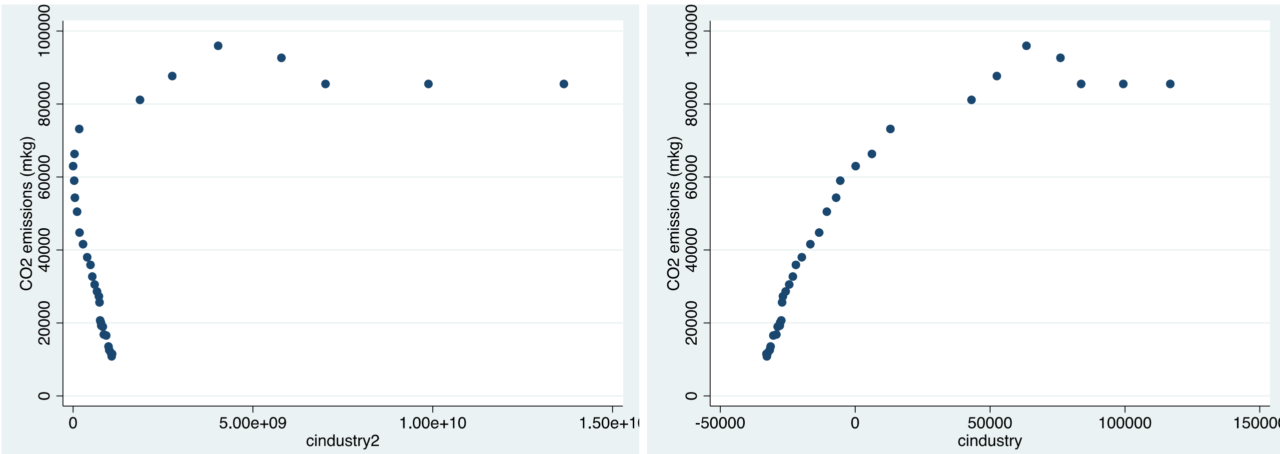
In Table 9, it shows that the coefficient of service squire stands for the curvature of the EKC relationship between (Fig. 4). For a one million dollar increase in service, the «carbon_footprint» is expected to increase by 0.63 million kg, holding all other variables constant and it is significant at 1 % level (*p-value* < 0.001). However, the coefficient of service squire (β_2) is negative and an absolute value (2.8) which shows EKC has a moderate pronounced inverted U shape affiliation between carbon footprint and service value addition to GDP. The magnitude of β_2 indicates the strength of the curvature in the relationship and a larger absolute value of β_2 suggests a more pronounced U-shaped or inverted U-shaped relationship.

Table 8

Linear regression on environmental Kuznets curve (EKC) equation

carbon_footprint	Coef.	St. Err.	*t-value*	*p-value*	[95 % Conf	Interval]	Sig
$c_{industry}$	1.065	0.036	29.71	0	0.992	1.138	***
$c_{industry2}$	–7.79	0	–15.27	0	0	0	***
Constant	58352.072	1197.374	48.73	0	55906.708	60797.435	***
Mean dependent var	44174.821		SD dependent var			28402.682	
R-squared	0.978		Number of obs			33	
F-test	669.295		Prob > F			0.000	
Akaike crit. (AIC)	649.343		Bayesian crit. (BIC)			653.833	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$



a *b*

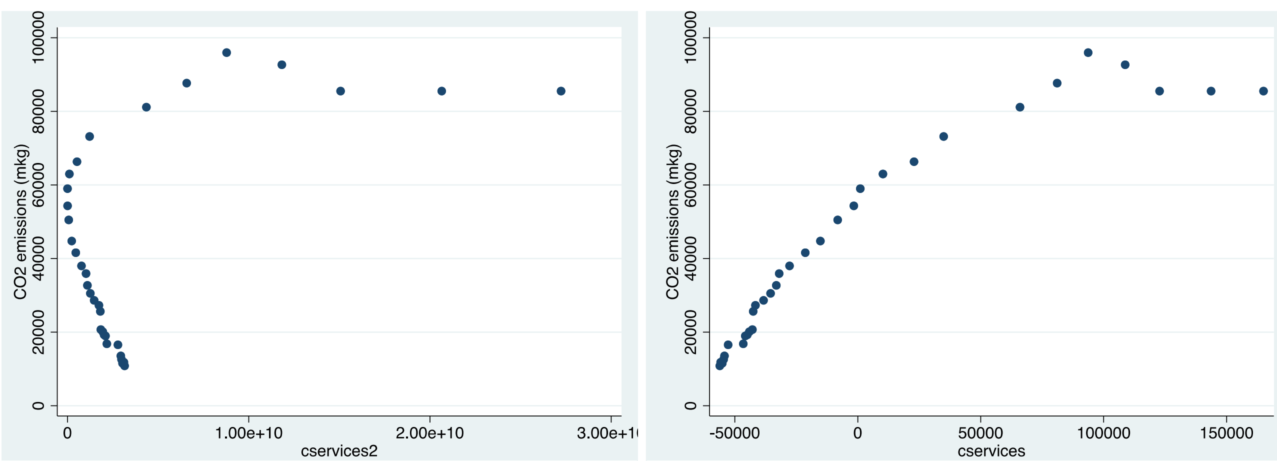
Fig. 3. Relationship between industry and carbon footprint: *a* – $c_{industry2}$; *b* – $c_{industry}$

Table 9

Linear regression on environmental Kuznets curve (EKC) equation

carbon_footprint	Coef.	St. Err.	*t-value*	*p-value*	[95 % Conf	Interval]	Sig
$c_{services}$	0.63	0.012	54.31	0	0.607	0.654	***
$c_{services2}$	–2.83	0	–23.21	0	0	0	***
Constant	55689.205	651.443	85.49	0	54358.781	57019.629	***
Mean dependent var	44174.821		SD dependent var			28402.682	
R-squared	0.993		Number of obs			33	
F-test	2180.345		Prob > F			0.000	
Akaike crit. (AIC)	610.875		Bayesian crit. (BIC)			615.364	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$



a *b*

Fig. 4. Relationship between service and carbon footprint: *a* – $c_{services2}$; *b* – $c_{services}$

In Table 10, it shows that the coefficient of manufacturing squire stands for the curvature of the EKC relationship between (Fig. 5). For a one million dollar increase in manufacturing, the «carbon_footprint» is expected to increase by 1.67 million kg, holding all other variables constant and it is significant at 1 % level (*p-value* < 0.001). However, the coefficient of manufacturing squire (β_2) is close to zero (–0.0000191) which shows EKC has an insignificant inverted U shape affiliation between carbon footprint and manufacturing value addition to GDP. The magnitude of β_2 indicates the strength of the curvature in the relationship and a larger absolute value of β_2 suggests a more pronounced U-shaped or inverted U-shaped relationship. It is noted that manufacturing is belonging to Industry.

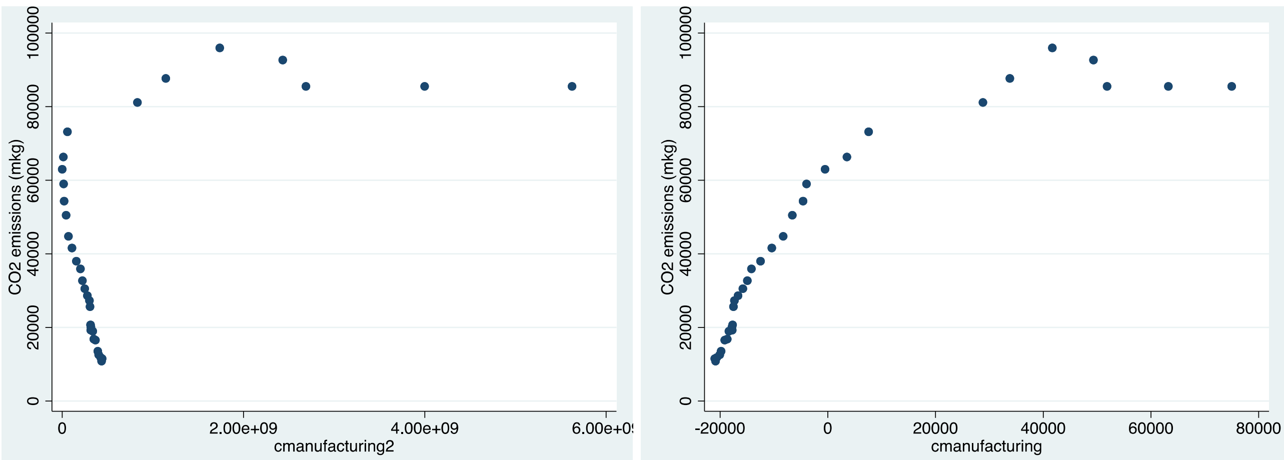
Additionally, Tables 11–15 make it abundantly evident that, with the exception of Agriculture Gross Value-Added (AGC), all other variables have positive, substantial effects on carbon footprint, making each variable individually accountable for carbon footprints and environmental degradation; however, combined results shown in Table 15 are slightly different.

Table 10

Linear regression on environmental Kuznets curve (EKC) equation

carbon_footprint	Coef.	St. Err.	*t-value*	*p-value*	[95 % Conf	Interval]	Sig
$c_{manufacturing}$	1.665	0.06	27.55	0	1.542	1.789	***
$c_{manufacturing2}$	–0.0000191	0	–14.14	0	0	0	***
Constant	58367.069	1289.607	45.26	0	55733.341	61000.797	***
Mean dependent var	44174.821			SD dependent var		28402.682	
R-squared	0.975			Number of obs		33	
F-test	581.430			Prob > F		0.000	
Akaike crit. (AIC)	653.878			Bayesian crit. (BIC)		658.368	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$



a *b*

Fig. 5. Relationship between manufacturing and carbon footprint: *a* – $c_{manufacturing2}$; *b* – $c_{manufacturing}$

Table 11

Linear regression agc model equation summary statistics

l_{carbon_foot}	Coef.	St. Err.	*t-value*	*p-value*	[95 % Conf	Interval]	Sig
l_{gdp_pc}	3.125	0.704	4.44	0	1.687	4.564	***
$l_{agriculture}$	–2.801	0.9	–3.11	0.004	–4.639	–0.963	***
Constant	17.464	4.224	4.13	0	8.838	26.091	***
Mean dependent var	10.468		SD dependent var			0.713	
R-squared	0.927		Number of obs			33	
F-test	189.767		Prob > F			0.000	
Akaike crit. (AIC)	–9.935		Bayesian crit. (BIC)			-5.445	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 12

Linear regression on igc model equation summary statistics

l_{carbon_foot}	Coef.	St. Err.	*t-value*	*p-value*	[95 % Conf	Interval]	Sig
l_{gdp_pc}	–2.459	0.846	–2.91	0.007	–4.188	–0.731	***
$l_{industry}$	2.458	0.611	4.02	0	1.21	3.707	***
Constant	1.736	0.716	2.42	0.022	0.273	3.199	**
Mean dependent var	10.468		SD dependent var			0.713	
R-squared	0.937		Number of obs			33	
F-test	223.216		Prob > F			0.000	
Akaike crit. (AIC)	–14.928		Bayesian crit. (BIC)			-10.438	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 13

Linear regression on SGC model equation summary statistics

l_{carbon_foot}	Coef.	St. Err.	*t-value*	*p-value*	[95 % Conf	Interval]	Sig
l_{gdp_pc}	–1.64	0.213	–7.69	0	–2.076	–1.204	***
$l_{services}$	2.109	0.173	12.16	0	1.755	2.463	***
Constant	–1.561	0.51	–3.06	0.005	–2.602	–0.52	***
Mean dependent var	10.468		SD dependent var			0.713	
R-squared	0.984		Number of obs			33	
F-test	902.429		Prob > F			0.000	
Akaike crit. (AIC)	–59.425		Bayesian crit. (BIC)			–54.935	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 14

Linear regression on mgc model equation summary statistics

l_{carbon_foot}	Coef.	St. Err.	*t-value*	*p-value*	[95 % Conf	Interval]	Sig
l_{gdp_pc}	–1.084	0.923	–1.17	0.249	–2.969	0.801	–
$l_{manufacturing}$	1.476	0.672	2.20	0.036	0.103	2.85	**
Constant	3.317	0.584	5.68	0	2.124	4.51	***
Mean dependent var	10.468		SD dependent var			0.713	
R-squared	0.917		Number of obs			33	
F-test	164.669		Prob > F			0.000	
Akaike crit. (AIC)	–5.620		Bayesian crit. (BIC)			–1.130	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 15

Linear regression on combine model equation summary statistics

l_{carbon_foot}	Coef.	St. Err.	*t-value*	*p-value*	[95 % Conf	Interval]	Sig
l_{gdp_pc}	–4.448	1.75	–2.54	0.018	–8.061	–0.835	**
$l_{agriculture}$	1.017	0.613	1.66	0.11	–0.248	2.282	–
$l_{industry}$	1.058	0.677	1.56	0.131	–0.339	2.455	–
$l_{services}$	2.743	0.942	2.91	0.008	0.8	4.687	***
$l_{exports}$	0.253	0.431	0.59	0.564	–0.0638	1.143	–
l_{fdi}	–0.022	0.027	–0.82	0.421	–0.076	0.033	–
l_{labor_force}	–1.476	1.151	–1.28	0.212	–3.852	0.9	–
$l_{trade\_openness}$	–0.075	0.443	–0.17	0.867	–0.989	0.84	–
Constant	–6.313	3.907	–1.62	0.119	–14.377	1.751	–
Mean dependent var	10.468		SD dependent var			0.713	
R-squared	0.991		Number of obs			33	
F-test	316.440		Prob > F			0.000	
Akaike crit. (AIC)	–65.721		Bayesian crit. (BIC)			–52.252	

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Legal Obligations and Policy Suggestions. The Kyoto Protocol to the UNFCCC was adopted in 1997 to introduce more robust legally binding GHG emission reduction targets and timelines, which were absent from the UNFCCC. The Kyoto Protocol entered into force in 2005 and currently has 192 Parties [66]. The essential tenet of the Kyoto Protocol was that industrialized nations needed to lessen the amount of their CO_2 emissions. Countries that ratified the Kyoto Protocol were assigned maximum carbon footprint levels for specific periods and participated in carbon credit trading. If a country emitted more than its assigned limit, then it would be penalized by receiving a lower emissions limit in the following period [73]. After that, the Paris Agreement became a landmark in the multilateral climate change process because, for the first time, a binding agreement brings all nations together to combat climate change and adapt to its effects. Its overarching goal is to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels [74]. The Paris Agreement is organized to respect state sovereignty with a bottom-up structure of nationally determined contributions (NDCs), which allows Parties to communicate actions taken to reduce their own Green House Gas emissions. To enforce accountability however, there are also structures in place including a transparency system, which contains certain information sharing obligations under Articles 4 and 13; a global stocktake process, which begins in 2023 and involves collective progress tracking and assessment every five years under Article 14; and a compliance mechanism, which designates a committee to facilitate implementation and promotion of compliance under Article 15 [75]. Also, some regional associations of countries, like ASEAN, EU, Pacific countries, and Southeast or South Asian countries have taken regional attempts to reduce carbon footprint based on unified projects. Bangladesh enacted several laws, rules, and policies to address the carbon footprint issue with severe importance but still, there are some loopholes that need to be noticed. Bangladesh should formulate policies regarding sustainable development in the agricultural sector as well as foster industrialization with due care to international legal obligations to mitigate carbon pollution. In the upcoming days, considering the amount of population and the need for development in every sector, such as agriculture, trade, industrialization, service, and manufacture of products, Bangladesh should take appropriate policies which can harmonize all the needs while keeping the carbon footprint at the lowest as possible. Taxation may be imposed on specific trade and business where carbon footprint is at an alarming level. Besides this, the reduction of tax may be provided to those inputs, in agriculture, where carbon footprint is minimal. This strategy may inspire companies to give attention to environmental pollution by reducing carbon footprint. Rigorous research work and analysis are required to determine the execution process of such vast work with the collaboration of government agencies, civil society, NGOs, international communities, local communities as well as educational institutions.

Practical significance of the research. The study's findings have significance far beyond Bangladesh's boundaries since they highlight the beneficial carbon reduction potential inherent in agricultural economies while also highlighting the burden of carbon emissions associated with industrial economies. These results have intrinsic significance for an international audience since they cut beyond geographic barriers to provide a thorough foundation for sustainable development. The paper provides an invaluable reference point for governments around the world struggling with the challenge of balancing economic growth with ecological stewardship by assessing the relative environmental effect of various economic sectors. Policymakers and other stakeholders can use the knowledge gained from this research as a guide to help them pursue growth models that put sustainability first. The study's disclosure of the crucial role of agriculture in carbon footprint reduction provides a revolutionary story in a society grappling with the urgency of climate change and its effects. No matter how different their economies and regions are, all nations may learn from Bangladesh's experience and use what they learn to reevaluate their economic strategies and investment choices. It emphasizes the idea that placing a strategic priority on agriculture may help achieve global climate goals set forth in international accords like the Paris Agreement in addition to spurring economic growth. The study's consequences penetrate the fabric of society awareness and go beyond simple policy issues. A compelling story for lobbying and awareness efforts is the comparison of agriculture's positive carbon footprint impact with the burden of industrial sectors' carbon emissions.

Limitations and prospects for further research. While the study effectively highlights the comparative carbon footprint reduction potential of agricultural economies versus carbon emissions from industrial economies, it might have slightly overlooked the broader environmental impacts of agricultural practices beyond carbon, such as water use and pesticide effects. The prospects for further research are promising, with opportunities to conduct life cycle assessments encompassing environmental impacts, explore technological innovations within both sectors, analyze regional variations, delve into circular economy approaches, understand the social and economic dimensions of sustainable transitions, study consumer behavior, assess policy implications comprehensively, and scrutinize long-term trends in economic transformations. These potential research directions can contribute to a more comprehensive and nuanced understanding of the interplay between economic activities and sustainability, enriching policy recommendations and paving the way for more informed decision-making.

4. Conclusions

This paper uncovers the significance of the impact of carbon footprint due to agriculture, manufacturing products, services, and other trade-related activities. It shows the interrelation between GDP growth and carbon footprint based on several methods and tests. The current study looked at the relationship between carbon footprint and economic value added from manufacturing, services, industry, and agriculture by adding to the body of literature on EKC. The analysis discovered that adding value to agriculture reduces carbon dioxide emissions. In addition, the study discovered that the EKC hypothesis holds true in terms of the value-added to industry, manufacturing, services, and agriculture. Additionally, the economic contributions of industry, services, and manufacturing result in carbon footprints, whereas the economic contribution of agriculture is ecologically preferable. As a result, there is an inverted U-shaped pattern in the association between carbon footprint and each of industry, service, and manufacturing value added; agriculture, however, shows insignificant inverted U-shaped pattern. In addition, we discovered that every dependent variable – aside from the GDP contribution of agriculture – has a positive connection with carbon footprint. The significance of this study is that it provides policy recommendations to the government and the key players in the industry, service, and agriculture industries. In order to avoid the issue of the present trend of environmental sustainability in the sector, the sustainable approach should be broadened in the area of agriculture. In order to do this, on the one hand, tax policy may be a tried-and-true tool for promoting low-carbon energy usage in the sector, while on the other hand, agricultural policy subsidies and deregulation may work as motivating elements for the growth of the cash crop economy. It is possible to see this as a potential development area in the present study that should be of concern to decision-makers.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this study, including financial, personal, authorship, or any other, that could affect the study and its results presented in this article.

Financing

Presentation of research in the form of publication through financial support in the form of a grant «Scientific Developments Applicable to the Reconstruction of Ukraine» from the publisher PC TECHNOLOGY CENTER (Kharkiv, Ukraine).

Data availability

The manuscript has no associated data.

References

1. Baumert, N., Kander, A., Jiborn, M., Kulionis, V., Nielsen, T. (2019). Global outsourcing of carbon emissions 1995–2009: A reassessment. *Environmental Science&Policy, 92,* 228–236. doi: https://doi.org/10.1016/j.envsci.2018.10.010
2. Sachs, J., Schmidt-Traub, G., Kroll, C., Durand-Delacre, D., Teksoz, K. (2017). *SDG index and dashboards report 2017*. New York: Bertelsmann Stiftung and Sustainable Development Solutions Network, 490.
3. Mitić, P., Munitlak Ivanović, O., Zdravković, A. (2017). A Cointegration Analysis of Real GDP and CO_2 Emissions in Transitional Countries. *Sustainability, 9 (4),* 568. doi: https://doi.org/10.3390/su9040568
4. *Overview of Greenhouse Gases. US EPA*. Us Epa. Available at: https://www.epa.gov/ghgemissions/overview-greenhouse-gases
5. *Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (2014). Geneva IPCC, 151.
6. Grossman, G. M., Krueger, A. B. (1995). Economic Growth and the Environment. *The Quarterly Journal of Economics, 110 (2),* 353–377. doi: https://doi.org/10.2307/2118443
7. Hasan, M. M., Chongbo, W. (2020). Estimating energy-related CO_2 emission growth in Bangladesh: The LMDI decomposition method approach. *Energy Strategy Reviews, 32,* 100565. doi: https://doi.org/10.1016/j.esr.2020.100565
8. Bouznit, M., Pablo-Romero, M. del P. (2016). CO_2 emission and economic growth in Algeria. *Energy Policy, 96,* 93–104. doi: https://doi.org/10.1016/j.enpol.2016.05.036
9. Aftab, S., Ahmed, A., Chandio, A. A., Korankye, B. A., Ali, A., Fang, W. (2021). Modeling the nexus between carbon emissions, energy consumption, and economic progress in Pakistan: Evidence from cointegration and causality analysis. *Energy Reports, 7,* 4642–4658. doi: https://doi.org/10.1016/j.egyr.2021.07.020
10. Cai, Y., Sam, C. Y., Chang, T. (2018). Nexus between clean energy consumption, economic growth and CO_2 emissions. *Journal of Cleaner Production, 182,* 1001–1011. doi: https://doi.org/10.1016/j.jclepro.2018.02.035
11. Salari, M., Javid, R. J., Noghanibehambari, H. (2021). The nexus between CO_2 emissions, energy consumption, and economic growth in the U.S. *Economic Analysis and Policy, 69,* 182–194. doi: https://doi.org/10.1016/j.eap.2020.12.007
12. Wasti, S. K. A., Zaidi, S. W. (2020). An empirical investigation between CO_2 emission, energy consumption, trade liberalization and economic growth: A case of Kuwait. *Journal of Building Engineering, 28,* 101104. doi: https://doi.org/10.1016/j.jobe.2019.101104
13. Valadkhani, A., Smyth, R., Nguyen, J. (2019). Effects of primary energy consumption on CO_2 emissions under optimal thresholds: Evidence from sixty countries over the last half century. *Energy Economics, 80,* 680–690. doi: https://doi.org/10.1016/j.eneco.2019.02.010
14. Rahman, M. M. (2017). Do population density, economic growth, energy use and exports adversely affect environmental quality in Asian populous countries? *Renewable and Sustainable Energy Reviews, 77,* 506–514. doi: https://doi.org/10.1016/j.rser.2017.04.041
15. Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., Leitão, N. C. (2013). Economic growth, energy consumption, financial development, international trade and CO_2 emissions in Indonesia. *Renewable and Sustainable Energy Reviews, 25,* 109–121. doi: https://doi.org/10.1016/j.rser.2013.04.009
16. Ang, J. B. (2008). Economic development, pollutant emissions and energy consumption in Malaysia. *Journal of Policy Modeling, 30 (2),* 271–278. doi: https://doi.org/10.1016/j.jpolmod.2007.04.010
17. Islam, F., Muhammad Adnan Hye, Q., Shahbaz, M. (2012). Import-economic growth nexus: ARDL approach to cointegration. *Journal of Chinese Economic and Foreign Trade Studies, 5 (3),* 194–214. doi: https://doi.org/10.1108/17544401211263964
18. Saint Akadiri, S., Alola, A. A., Akadiri, A. C., Alola, U. V. (2019). Renewable energy consumption in EU-28 countries: Policy toward pollution mitigation and economic sustainability. *Energy Policy, 132,* 803–810. doi: https://doi.org/10.1016/j.enpol.2019.06.040
19. You, W., Lv, Z. (2018). Spillover effects of economic globalization on CO_2 emissions: A spatial panel approach. *Energy Economics, 73,* 248–257. doi: https://doi.org/10.1016/j.eneco.2018.05.016
20. Heydari, A., Garcia, D. A., Keynia, F., Bisegna, F., Santoli, L. D. (2019). Renewable Energies Generation and Carbon Dioxide Emission Forecasting in Microgrids and National Grids using GRNN-GWO Methodology. *Energy Procedia, 159,* 154–159. doi: https://doi.org/10.1016/j.egypro.2018.12.044
21. Hosseini, S. M., Saifoddin, A., Shirmohammadi, R., Aslani, A. (2019). Forecasting of CO_2 emissions in Iran based on time series and regression analysis. *Energy Reports, 5,* 619–631. doi: https://doi.org/10.1016/j.egyr.2019.05.004
22. Amarpuri, L., Yadav, N., Kumar, G., Agrawal, S. (2019). Prediction of CO_2 emissions using deep learning hybrid approach: A Case Study in Indian Context. *2019 Twelfth International Conference on Contemporary Computing (IC3)*. doi: https://doi.org/10.1109/ic3.2019.8844902
23. Moutinho, V., Madaleno, M., Elheddad, M. (2020). Determinants of the Environmental Kuznets Curve considering economic activity sector diversification in the OPEC countries. *Journal of Cleaner Production, 271,* 122642. doi: https://doi.org/10.1016/j.jclepro.2020.122642
24. Sohag, K., Kalugina, O., Samargandi, N. (2019). Re-visiting environmental Kuznets curve: role of scale, composite, and technology factors in OECD countries. *Environmental Science and Pollution Research, 26 (27),* 27726–27737. doi: https://doi.org/10.1007/s11356-019-05965-7
25. Murshed, M., Nurmakhanova, M., Elheddad, M., Ahmed, R. (2020). Value addition in the services sector and its heterogeneous impacts on CO_2 emissions: revisiting the EKC hypothesis for the OPEC using panel spatial estimation techniques. *Environmental Science and Pollution Research, 27 (31),* 38951–38973. doi: https://doi.org/10.1007/s11356-020-09593-4
26. Moutinho, V., Varum, C., Madaleno, M. (2017). How economic growth affects emissions? An investigation of the environmental Kuznets curve in Portuguese and Spanish economic activity sectors. *Energy Policy, 106,* 326–344. doi: https://doi.org/10.1016/j.enpol.2017.03.069
27. Ramos, A. H., Madaleno, M., Amorim Varum, C. (2018). An Analysis of the Environmental Kuznets Curve (EKC) Hypothesis in Portugal: Sector Data and Innovation Effects. *2018 15th International Conference on the European Energy Market (EEM)*. doi: https://doi.org/10.1109/eem.2018.8469919
28. Asumadu-Sarkodie, S., Owusu, P. A. (2016). The causal nexus between carbon dioxide emissions and agricultural ecosystem – an econometric approach. *Environmental Science and Pollution Research, 24 (2),* 1608–1618. doi: https://doi.org/10.1007/s11356-016-7908-2
29. Liu, X., Zhang, S., Bae, J. (2017). The impact of renewable energy and agriculture on carbon dioxide emissions: Investigating the environmental Kuznets curve in four selected ASEAN countries. *Journal of Cleaner Production, 164,* 1239–1247. doi: https://doi.org/10.1016/j.jclepro.2017.07.086

30. Appiah, K., Du, J., Poku, J. (2018). Causal relationship between agricultural production and carbon dioxide emissions in selected emerging economies. *Environmental Science and Pollution Research, 25 (25),* 24764–24777. doi: https://doi.org/10.1007/s11356-018-2523-z
31. Waheed, R., Chang, D., Sarwar, S., Chen, W. (2018). Forest, agriculture, renewable energy, and CO_2 emission. *Journal of Cleaner Production, 172,* 4231–4238. doi: https://doi.org/10.1016/j.jclepro.2017.10.287
32. Ben Jebli, M., Ben Youssef, S. (2019). Combustible renewables and waste consumption, agriculture, CO_2 emissions and economic growth in Brazil. *Carbon Management, 10 (3),* 309–321. doi: https://doi.org/10.1080/17583004.2019.1605482
33. Ngarava, Zhou, Ayuk, Tatsvarei. (2019). Achieving Food Security in a Climate Change Environment: Considerations for Environmental Kuznets Curve Use in the South African Agricultural Sector. *Climate, 7 (9),* 108. doi: https://doi.org/10.3390/cli7090108
34. Olanipekun, I. O., Olasehinde-Williams, G. O., Alao, R. O. (2019). Agriculture and environmental degradation in Africa: The role of income. *Science of The Total Environment, 692,* 60–67. doi: https://doi.org/10.1016/j.scitotenv.2019.07.129
35. Qiao, H., Zheng, F., Jiang, H., Dong, K. (2019). The greenhouse effect of the agriculture-economic growth-renewable energy nexus: Evidence from G20 countries. *Science of The Total Environment, 671,* 722–731. doi: https://doi.org/10.1016/j.scitotenv.2019.03.336
36. Sarkodie, S. A. (2018). The invisible hand and EKC hypothesis: what are the drivers of environmental degradation and pollution in Africa? *Environmental Science and Pollution Research, 25 (22),* 21993–22022. doi: https://doi.org/10.1007/s11356-018-2347-x
37. Gokmenoglu, K. K., Taspinar, N. (2018). Testing the agriculture-induced EKC hypothesis: the case of Pakistan. *Environmental Science and Pollution Research, 25 (23),* 22829–22841. doi: https://doi.org/10.1007/s11356-018-2330-6
38. Agboola, M. O., Bekun, F. V. (2019). Does agricultural value added induce environmental degradation? Empirical evidence from an agrarian country. *Environmental Science and Pollution Research, 26 (27),* 27660–27676. doi: https://doi.org/10.1007/s11356-019-05943-z
39. Aydoğan, B., Vardar, G. (2019). Evaluating the role of renewable energy, economic growth and agriculture on CO_2 emission in E7 countries. *International Journal of Sustainable Energy, 39 (4),* 335–348. doi: https://doi.org/10.1080/14786451.2019.1686380
40. Gurbuz, I. B., Nesirov, E., Ozkan, G. (2021). Does agricultural value-added induce environmental degradation? Evidence from Azerbaijan. *Environmental Science and Pollution Research, 28 (18),* 23099–23112. doi: https://doi.org/10.1007/s11356-020-12228-3
41. Alam, J. (2015). Impact of agriculture, industry and service sector's value added in the GDP on CO_2 emissions of selected South Asian countries. *World Review of Business Research, 5 (2),* 39–59.
42. Hove, S., Tursoy, T. (2019). An investigation of the environmental Kuznets curve in emerging economies. *Journal of Cleaner Production, 236,* 117628. doi: https://doi.org/10.1016/j.jclepro.2019.117628
43. Pata, U. K. (2017). The effect of urbanization and industrialization on carbon emissions in Turkey: evidence from ARDL bounds testing procedure. *Environmental Science and Pollution Research, 25 (8),* 7740–7747. doi: https://doi.org/10.1007/s11356-017-1088-6
44. Adedoyin, F. F., Alola, A. A., Bekun, F. V. (2021). The alternative energy utilization and common regional trade outlook in EU-27: Evidence from common correlated effects. *Renewable and Sustainable Energy Reviews, 145,* 111092. doi: https://doi.org/10.1016/j.rser.2021.111092
45. Adedoyin, F. F., Nathaniel, S., Adeleye, N. (2020). An investigation into the anthropogenic nexus among consumption of energy, tourism, and economic growth: do economic policy uncertainties matter? *Environmental Science and Pollution Research, 28 (3),* 2835–2847. doi: https://doi.org/10.1007/s11356-020-10638-x
46. Adedoyin, F. F., Ozturk, I., Agboola, M. O., Agboola, P. O., Bekun, F. V. (2021). The implications of renewable and non-renewable energy generating in Sub-Saharan Africa: The role of economic policy uncertainties. *Energy Policy, 150,* 112115. doi: https://doi.org/10.1016/j.enpol.2020.112115
47. Alola, A. A., Alola, U. V. (2018). Agricultural land usage and tourism impact on renewable energy consumption among Coastline Mediterranean Countries. *Energy & Environment, 29 (8),* 1438–1454. doi: https://doi.org/10.1177/0958305x18779577
48. Adedoyin, F. F., Bekun, F. V. (2020). Modelling the interaction between tourism, energy consumption, pollutant emissions and urbanization: renewed evidence from panel VAR. *Environmental Science and Pollution Research, 27 (31),* 38881–38900. doi: https://doi.org/10.1007/s11356-020-09869-9
49. Latif, K., Raza, M. Y., Shahid Adil, Rehana Kouser. (2020). Nexus between Economy, Agriculture, Population, Renewable Energy and CO_2 Emissions: Evidence from Asia-Pacific Countries. *Journal of Business and Social Review in Emerging Economies, 6 (1),* 261–276. doi: https://doi.org/10.26710/jbsee.v6i1.1072
50. Çoban, O., Kılınç, N. Ş. (2015) Yenilenebilir enerji tüketimi ve karbon emisyonuilişkisi: TR örneği. *Sosyal Bilimler Enstitüsü Dergisi, 38,* 195–208.
51. Khan, Z., Ali, S., Umar, M., Kirikkaleli, D., Jiao, Z. (2020). Consumption-based carbon emissions and International trade in G7 countries: The role of Environmental innovation and Renewable energy. *Science of The Total Environment, 730,* 138945. doi: https://doi.org/10.1016/j.scitotenv.2020.138945
52. Safi, A., Chen, Y., Wahab, S., Ali, S., Yi, X., Imran, M. (2021). Financial Instability and Consumption-based Carbon Emission in E-7 Countries: The Role of Trade and Economic Growth. *Sustainable Production and Consumption, 27,* 383–391. doi: https://doi.org/10.1016/j.spc.2020.10.034
53. Wang, Q., Zhang, F. (2021). The effects of trade openness on decoupling carbon emissions from economic growth – Evidence from 182 countries. *Journal of Cleaner Production, 279,* 123838. doi: https://doi.org/10.1016/j.jclepro.2020.123838
54. Çetin, M., Saygin, S., Demir, H. (2020). Tarım Sektörünün Ç evre Kirliliği Üzerindeki Etkisi: Türkiye Ekonomisi İçin Bir Eşbütünleşme ve Nedensellik Analizi. *Tekirdağ Ziraat Fakültesi Dergisi, 17 (3),* 329–345. doi: https://doi.org/10.33462/jotaf.678764
55. Uddin, M. M. M. (2020). What are the dynamic links between agriculture and manufacturing growth and environmental degradation? Evidence from different panel income countries. *Environmental and Sustainability Indicators, 7,* 100041. doi: https://doi.org/10.1016/j.indic.2020.100041
56. Jiang, Q., Khattak, S. I., Ahmad, M., Lin, P. (2021). Mitigation pathways to sustainable production and consumption: Examining the impact of commercial policy on carbon dioxide emissions in Australia. *Sustainable Production and Consumption, 25,* 390–403. doi: https://doi.org/10.1016/j.spc.2020.11.016
57. Lv, M., Bai, M. (2020). Evaluation of China's carbon emission trading policy from corporate innovation. *Finance Research Letters, 39,* 101565. doi: https://doi.org/10.1016/j.frl.2020.101565
58. Ridzuan, N. H. A. M., Marwan, N. F., Khalid, N., Ali, M. H., Tseng, M.-L. (2020). Effects of agriculture, renewable energy, and economic growth on carbon dioxide emissions: Evidence of the environmental Kuznets curve. *Resources, Conservation and Recycling, 160,* 104879. doi: https://doi.org/10.1016/j.resconrec.2020.104879
59. Strapasson, A., Woods, J., Meessen, J., Mwabonje, O., Baudry, G., Mbuk, K. (2020). EU land use futures: modelling food, bioenergy and carbon dynamics. *Energy Strategy Reviews, 31,* 100545. doi: https://doi.org/10.1016/j.esr.2020.100545
60. Xu, X., Wang, Q., Ran, C., Mu, M. (2021). Is burden responsibility more effective? A value-added method for tracing worldwide carbon emissions. *Ecological Economics, 181,* 106889. doi: https://doi.org/10.1016/j.ecolecon.2020.106889
61. Apaydın, Ş., Taşdoğan, C. (2019). Türkiye'de iktisadi büyüme ve birincil enerji tüketiminin karbon salınımı üzerindeki etkisi: Yapısal VAR yaklaşımı. *Akademi Sosyal Bilimler Dergisi, 6 (16),* 19–35.
62. Wang, G., Han, Q., de Vries, B. (2019). Assessment of the relation between land use and carbon emission in Eindhoven, the Netherlands. *Journal of Environmental Management, 247,* 413–424. doi: https://doi.org/10.1016/j.jenvman.2019.06.064
63. Khan, M. T. I., Ali, Q., Ashfaq, M. (2018). The nexus between greenhouse gas emission, electricity production, renewable energy and agriculture in Pakistan. *Renewable Energy, 118,* 437–451. doi: https://doi.org/10.1016/j.renene.2017.11.043
64. Başar, S. (2018). Enerji tüketimi ve karbon emisyonu ile iktisadi büyüme arasindaki ilişkinin tesp. *Gumushane Universitesi Sosyal Bilimler Elektronik Dergisi, 9 (23),* 332–347. doi: https://doi.org/10.17823/gusb.2636

ISSN 2664-9969

65. Çetin, M., Yüksel, Ö. (2018). The impact of energy consumption on carbon emissions in Turkish economy. *Mehmet Akif Ersoy Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 5 (2),* 169–186. doi: https://doi.org/10.30798/makuiibf.409119
66. Antonakakis, N., Chatziantoniou, I., Filis, G. (2017). Energy consumption, CO_2 emissions, and economic growth: An ethical dilemma. *Renewable and Sustainable Energy Reviews, 68,* 808–824. doi: https://doi.org/10.1016/j.rser.2016.09.105
67. Şimşek, T., Yiğit, E. (2017). BRICT Ülkelerinde Yenilenebilir Enerji Tüketimi, Petrol Fiyatları, CO_2 Emisyonu, Kentleşme ve Ekonomik Büyüme Üzerine Nedensellik Analizi. *Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi, 12 (3),* 117–136. doi: https://doi.org/10.17153/oguiibf.335630
68. Güllü, M., Yakişik, H. (2017). Karbon Emisyonu Ve Enerji Tüketiminin Büyüme Üzerindeki Etkileri: MIST Ülkeleri Karşılaştırması. *Sosyoekonomi, 25 (32),* 239–239. doi: https://doi.org/10.17233/sosyoekonomi.289930
69. Cerdeira Bento, J. P., Moutinho, V. (2016). CO_2 emissions, non-renewable and renewable electricity production, economic growth, and international trade in Italy. *Renewable and Sustainable Energy Reviews, 55,* 142–155. doi: https://doi.org/10.1016/j.rser.2015.10.151
70. Saidi, K., Hammami, S. (2015). The impact of CO_2 emissions and economic growth on energy consumption in 58 countries. *Energy Reports, 1,* 62–70. doi: https://doi.org/10.1016/j.egyr.2015.01.003
71. Bölük, G., Mert, M. (2015). The renewable energy, growth and environmental Kuznets curve in Turkey: An ARDL approach. *Renewable and Sustainable Energy Reviews, 52,* 587–595. doi: https://doi.org/10.1016/j.rser.2015.07.138
72. Ridzuan, N. H. A. M., Marwan, N. F., Khalid, N., Ali, M. H., Tseng, M.-L. (2020). Effects of agriculture, renewable energy, and economic growth on carbon dioxide emissions: Evidence of the environmental Kuznets curve. *Resources, Conservation and Recycling, 160,* 104879. doi: https://doi.org/10.1016/j.resconrec.2020.104879
73. *Climate change and sustainability disputes: The international legal framework* (2021). Norton Rose Fulbright. Available at: https://www.nortonrosefulbright.com/en/knowledge/publications/aec10a3b/climate-change-and-sustainability-disputes-the-international-legal-framework
74. Tardi, C. (2022). *What is the Kyoto Protocol? Definition, History, Timeline, Status.* Available at: https://www.investopedia.com/terms/k/kyoto.asp
75. *The Paris Agreement What is the Paris Agreement?* UNFCCC website. Available at: https://unfccc.int/process-and-meetings/the-paris-agreement

✉***Md. Rony Masud,*** *Department of International Business, Rikkyo University, Tokyo, Japan, ORCID: https://orcid.org/0000-0002-4474-3928, e-mail: rony1duuu@gmail.com*

Jihan Binte Enam, *Law Department, Keio University, Tokyo, Japan, ORCID: https://orcid.org/0009-0008-1143-6025*

✉*Corresponding author*