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GREEN ECONOMY WITH ECONOMIC GROWTH AND PER CAPITA INCOME IN VIETNAM

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ABSTRACT

Objective: The objective of this study is to investigate the green economy with economic growth and per capita income in Vietnam, to analyze the quantitative relationship among those factors, and to improve long-term green economic development in Vietnam towards sustainable national economic growth.

Theoretical Framework: In this topic, the main concepts and theories that underpin the research are presented. The inverted U-shaped model of Kuznets; Green economy concept and regression model stand out, providing a solid basis for understanding the context of the investigation.

Method: The methodology adopted for this research comprises desk research methods to clarify the theoretical basis of green economy, economic growth, and per capita income; qualitative research methods; and quantitative research methods. Data collection was carried out through the collection of time-series data: Real Gross Domestic Product (GDP), Gross Domestic Product per capita (GDPP), and CO2 emissions from 1995 to 2022 from the World Bank website.

Results and Discussion: The results obtained revealed the positive relationship between economic growth, CO2 emissions, and per capita income in the short term; however, in the long term, when GDP as well as per capita income reach a certain threshold. The level of waste gradually decreases and environmental quality improves. In the discussion section, these results are contextualized in light of the theoretical framework, highlighting the implications and relationships identified. Possible discrepancies and limitations of the study are also considered in this section.

Research Implications: The practical and theoretical implications of this research are discussed, providing insights into how the results can be applied or influence practices in the field of development economics. These implications could encompass many sectors, especially the processing industry.

Originality/Value: This study contributes to the literature by Simon Kuznets - economic growth is not a threat, but rather a means to improve the environment in the future. The relevance and value of this research are evidenced by contributing one more case in Vietnam which approves Kuznets curve on the environment and thus is the basis for future research on this urgent problem all over the world.

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ECONOMIA VERDE COM CRESCIMENTO ECONÔMICO E RENDA PER CAPITA NO VIETNÃ

RESUMO

Objetivo: O objetivo deste estudo é investigar a economia verde com o crescimento econômico e a renda per capita no Vietnã, analisar a relação quantitativa entre esses fatores e melhorar o desenvolvimento econômico verde de longo prazo no Vietnã em direção ao crescimento econômico nacional sustentável.

Estrutura teórica: Neste tópico, são apresentados os principais conceitos e teorias que sustentam a pesquisa. Destacam-se o modelo em forma de U invertido de Kuznets, o conceito de economia verde e o modelo de regressão, que fornecem uma base sólida para a compreensão do contexto da pesquisa.

Método: A metodologia adotada para esta pesquisa inclui métodos de pesquisa documental para esclarecer a base teórica da economia verde, do crescimento econômico e da renda per capita; métodos de pesquisa qualitativa; e métodos de pesquisa quantitativa. A coleta de dados foi realizada por meio da coleta de dados de séries temporais: Produto Interno Bruto (PIB) real, Produto Interno Bruto per capita (PIBP) e emissões de CO2 de 1995 a 2022 do site do Banco Mundial.

Resultados e Discussão: Os resultados obtidos revelaram a relação positiva entre crescimento econômico, emissões de CO2 e renda per capita no curto prazo; no entanto, no longo prazo, quando o PIB e a renda per capita atingem um determinado limite. O nível de resíduos diminui gradualmente e a qualidade ambiental melhora. Na seção de discussão, esses resultados são contextualizados à luz da estrutura teórica, destacando as implicações e os relacionamentos identificados. As possíveis discrepâncias e limitações do estudo também são consideradas nessa seção.

Implicações da Pesquisa: As implicações práticas e teóricas desta pesquisa são discutidas, fornecendo percepções sobre como os resultados podem ser aplicados ou influenciar as práticas no campo da economia do desenvolvimento. Essas implicações podem abranger muitos setores, especialmente o setor de processamento.

Originalidade/Valor: Este estudo contribui para a literatura de Simon Kuznets - o crescimento econômico não é uma ameaça, mas sim um meio de melhorar o meio ambiente no futuro. A relevância e o valor desta pesquisa são evidenciados pela contribuição de mais um caso no Vietnã que aprova a curva de Kuznets sobre o meio ambiente e, portanto, é a base para futuras pesquisas sobre esse problema urgente em todo o mundo.

Palavras-chave: Economia Verde, Poluição Ambiental, Crescimento Econômico, Renda Per Capita, Vietnã.

LA ECONOMÍA VERDE CON EL CRECIMIENTO ECONÓMICO Y LA RENTA PER CÁPITA EN VIETNAM

RESUMEN

Objetivo: El objetivo de este estudio es investigar la economía verde con el crecimiento económico y la renta per cápita en Vietnam, analizar la relación cuantitativa entre esos factores y mejorar el desarrollo económico verde a largo plazo en Vietnam hacia un crecimiento económico nacional sostenible.

Marco Teórico: En este tema se presentan los principales conceptos y teorías que sustentan la investigación. Destacan el modelo en forma de U invertida de Kuznets; el concepto de economía verde y el modelo de regresión, que proporcionan una base sólida para comprender el contexto de la investigación.

Metodología: La metodología adoptada para esta investigación comprende métodos de investigación documental para aclarar las bases teóricas de la economía verde, el crecimiento económico y la renta per cápita; métodos de investigación cualitativa; y métodos de investigación cuantitativa. La recogida de datos se llevó a cabo mediante la recopilación de datos de series temporales: Producto Interior Bruto (PIB) real, Producto Interior Bruto per cápita (PIBP) y emisiones de CO2 de 1995 a 2022 de la página web del Banco Mundial.

Resultados y Discusión: Los resultados obtenidos revelaron la relación positiva entre el crecimiento económico, las emisiones de CO2 y la renta per cápita a corto plazo; sin embargo, a largo plazo, cuando tanto el PIB como la renta per cápita alcanzan un determinado umbral. El nivel de residuos disminuye gradualmente y mejora la calidad del medio ambiente. En la sección de discusión, estos resultados se contextualizan a la luz del marco teórico, destacando las implicaciones y relaciones identificadas. También se consideran en esta sección las posibles discrepancias y limitaciones del estudio.

Implicaciones de la investigación: Se discuten las implicaciones prácticas y teóricas de esta investigación, aportando ideas sobre cómo pueden aplicarse los resultados o influir en las prácticas en el campo de la economía del desarrollo. Estas implicaciones podrían abarcar muchos sectores, especialmente la industria de transformación.

Originalidad/Valor: Este estudio contribuye a la literatura de Simon Kuznets: el crecimiento económico no es una amenaza, sino un medio para mejorar el medio ambiente en el futuro. La pertinencia y el valor de esta investigación se ponen de manifiesto al aportar un caso más en Vietnam que aprueba la curva de Kuznets sobre el medio ambiente y constituye así la base de futuras investigaciones sobre este problema urgente en todo el mundo.

Palabras clave: Economía Verde, Contaminación Ambiental, Crecimiento Económico, Renta Per Cápita, Vietnam.

1 INTRODUCTION

In the context of globalization, economic development and changes in production and consumption behavior have led to numerous challenges for the environment. Economic growth, alongside positive impacts such as improving living standards, poverty reduction, and infrastructure development, also brings negative effects and imposes significant pressure, with a tendency to increase environmental pollution, including air and water pollution, biodiversity loss, and climate change. However, both in Vietnam and globally, there have been considerable and positive changes in production and consumption behaviors in response to negative impacts from climate change and environmental pollution. There is an increasing number of practical actions contributing to the development of a green economy. People's lives continue to improve, with many new urban areas emerging, particularly in the formation of new rural areas. The term “green economy” is frequently mentioned at summit conferences on economic, social, and environmental issues. The development of a green economy not only addresses urgent environmental issues but also solves long-term problems, including promoting sustainable economic development. The reason is that the development of a green economy will encourage businesses to efficiently use natural resources, minimize emissions, and establish a foundation for sustainable economic development in the future. Moreover, the green economy helps increase per capita income by creating high-income jobs in green industries, and high per capita income promotes green economic development by increasing demand for green products and services.

The current situation of Vietnam's economy and other countries worldwide has demonstrated the role of green economic development in economic growth and per capita income, and vice versa. Green economic development contributes to economic growth and raises per capita income, while high economic growth and per capita income provide the basis for sustainable development. In order to gain a deeper understanding of the relationship between economic growth, per capita income, and environmental factors, the research team has decided to conduct the study “Green economy with economic growth and per capita income in Vietnam”. The article focuses on analyzing the quantitative relationship between environmental factors and the speed of economic growth and per capita income nationwide. The research team utilizes a combination of qualitative and quantitative research methods by searching and synthesizing documents from electronic portals and data from IFS and World Bank websites. Data collected from 1995 to 2022 are then aggregated, cleaned, and regression models are run using Excel and Eviews12 software.

2 THEORETICAL BASIS AND RESEARCH OVERVIEW

2.1 GREEN ECONOMY

The term "green economy" has been widely used since 2008 in the context of the financial crisis and the necessity for "green economy stimulus" with various definitions. The United Nations Environment Programme (UNEP, 10/2008) introduced the "Green economy initiative". In 2011, the report "Towards a green economy: pathways to sustainable development and poverty eradication" provided a widely used definition of the green economy, stating that "A green economy improves living standards and social equity while significantly reducing environmental risks and ecological scarcities. A green economy can be seen as low carbon, resource-efficient, and socially inclusive". (Pong, 2021)

The nature of the green economy is ensuring economic growth while simultaneously protecting the environment for clean and sustainable living.

The World Bank (WB, 2012b) defines the green economy as: "Economic development that efficiently utilizes natural resources, minimizes pollution and environmental impacts, enhances resilience to natural disasters, and strengthens the role of state environmental and natural resource management in disaster prevention".

According to the United Nations, the green economy is an economic model that provides a future with a new growth pattern that is friendly to the earth's ecosystems and contributes to solving the employment problem for workers. Based on economic production, the green economy helps reduce emissions, resource consumption, and environmental costs (Matthews, 2013).

The green economy can also be understood as a dynamic economic transformation process, aiming for low carbon, increasing resource efficiency, and enhancing welfare by using technology and creating new jobs, while minimizing long-term environmental degradation (Frone & Simona, 2015).

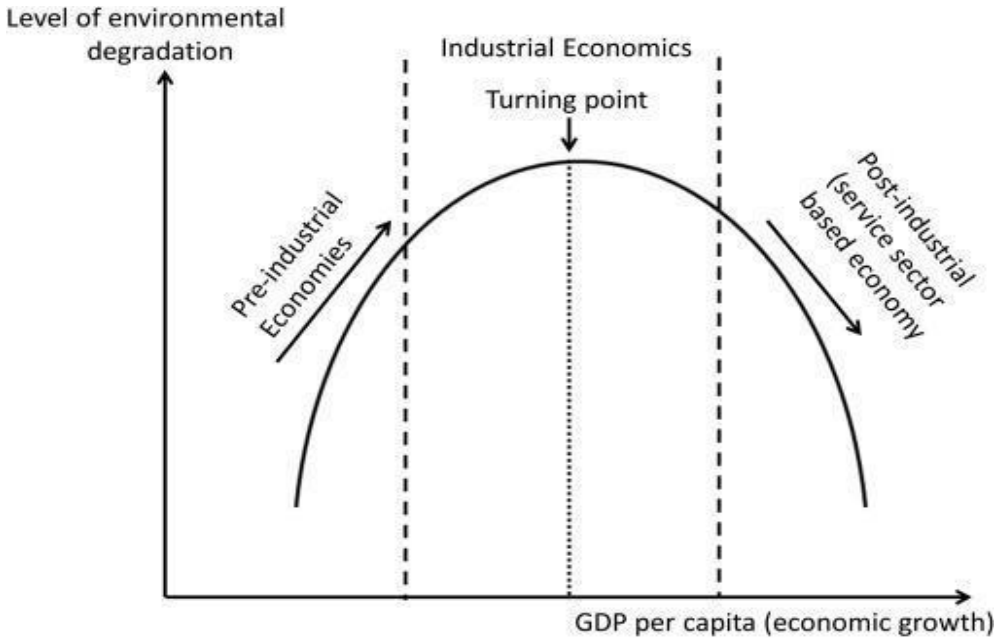
2.2 THE KUZNETS CURVE ON THE ENVIRONMENT

The concept of the Kuznets curve, proposed by Simon Kuznets, was first published at the 67th annual meeting of the American Economic Association in December 1954. This theory initially described the relationship between economic development and income inequality, where income inequality increases during the early stages of economic growth and decreases

as income reaches a certain threshold due to redistribution. The Kuznets curve theory began to be applied in analyses related to environmental economics in the early 1990s. Grossman and Krueger's (1993) study on the potential impacts of the North American Free Trade Agreement (NAFTA) contributed to the widespread adoption of the EKC terminology in the World Bank's 1992 Development Report. According to this, economic growth is not a threat, but rather a means to improve the environment in the future. Specifically, environmental pollution increases in the early stages of economic development; however, beyond a certain income threshold, environmental quality improves, and the level of waste gradually decreases. Thus, the relationship between economic development variables and declining environmental quality takes on an inverted U shape when represented in Figure 1.

Figure 1

Relationship between economic growth and environment



Source: Uchiyama, K. (2016)

2.3 RESEARCH OVERVIEW

Recent experimental studies have shown that certain types of emissions follow an inverted U-shaped curve or Environmental Kuznets Curve (EKC) as income increases. Saboori et al. (2012) demonstrated the relationship between economic growth and carbon emissions in Malaysia. Using data from 1980 to 2009, the Environmental Kuznets Curve (EKC) hypothesis was tested using the Autoregressive Distributed Lag (ARDL) method. The experimental

research results showed the existence of a long-term relationship between per capita CO2 emissions and per capita real GDP when CO2 emissions were the dependent variable. The article identified an inverted U-shaped relationship between CO2 emissions and GDP in both the short and long term, thus supporting the EKC hypothesis. The research results indicated a unidirectional relationship from economic growth to CO2 emissions in the long run. The increasing threat of global warming and climate change has called for more attention and discussion on global environmental issues. Rising global average air and ocean temperatures, widespread melting of snow cover, and increasing global sea levels are compelling evidence of global warming. Akbostancı et al. (2009) studied the relationship between income and environmental quality in Turkey at two levels. The article used data from the period 1992–2001 from 58 provinces of Turkey. The research results revealed a steadily increasing relationship between CO2 and income and an N-shaped relationship with SO2 and PM10 emissions.

Bruyn et al. (1998) based on the analysis of "resource use intensity" in resource economics, identified and estimated a substitute growth model for three types of emissions (CO2, NOx, and SO2) in four countries (the Netherlands, the UK, the US, and West Germany). The research results showed a time model of these emissions positively correlated with economic growth and that emission reduction could be achieved through structural and technological changes in the economy, leading to increased emissions. This ratio was calculated for each type of emission and country based on estimated parameter values. The indices obtained reflected the balance between the positive impact of growth and the negative impact of structural changes and technological progress on emissions. Ang (2008) studied the long-term relationship between output, pollution emissions, and energy consumption in Malaysia during the period 1971–1999. The article assessed the causal relationship between variables using recent available causality tests in the literature. The results indicated a positive relationship between pollution and energy consumption with output in the long run. Strong support was found for the causal relationship from economic growth to energy consumption growth, both in the short and long run.

Azomahou et al. (2006) examined the empirical relationship between per capita CO2 emissions and per capita GDP during the period 1960–1996, using a data set comprising 100 countries. Based on Baltagi and colleagues' (1996) nonparametric pooled test. The estimation results showed an upward sloping relationship. The nonparametric specification tests did not reject monotonicity but rejected polynomial form leading to the Environmental Kuznets Curve in some studies. Anser, MK, Usman, M., Godil, D.I. et al. (2021) analyzed the relationship

between globalization, energy consumption, and economic growth among selected South Asian countries to promote green economy and environment. The study also found a causal relationship between energy growth and the relationship between CO2 emissions and the premises of the EKC framework. Using annual time series analysis method, starting from 1985 to 2019. The dataset was collected from the World Development Indicators (WDI). The results of the Fully Modified Ordinary Least Squares (FMOLS) method modified the description of the environment as significantly worse in the South Asian region. Individual countries such as Bangladesh showed a significant positive impact on CO2 emissions and environmental degradation related to globalization and non-renewable energy. However, the negative and positive growth rates (GDP) and GDP square confirmed the EKC hypothesis in this region. The study identified a causal relationship between GDP growth and carbon emissions and found a two-way causal relationship between economic growth and energy use.

Hien et al. (2017) based on the studies of Shafik and Bandyopadhyay (1992), Holtz-Eakin and Selden (1995), Roberts and Grimes (1997), Galeotti and Lanza (1999), Pao and Tsai (2010) used per capita income variable (logINC) to examine the impact of economic growth on the environment. Hien et al. (2017) used the square of log (INC) (the logarithm of per capita income) to test the graph representing the relationship between per capita income and CO2 emissions in the form of a curve as proposed by the EKC theory. Regression results indicated close consistency of research results across estimation techniques. Except for the FDI variable (Foreign Direct Investment), most explanatory variables in the model (including ln(ENI)-logarithm of per capita income, ln(INC2)-Square of the logarithm of per capita income, ln(ENC)-logarithm of per capita energy consumption) were statistically significant at the 1% significance level. It is noteworthy that the impact of economic growth (measured through the per capita income metric) on environmental quality follows the Kuznets curve theory. Specifically, in the initial stage when the income of the economy increases, it will lead to an increase in CO2 emissions and environmental pollution become more severe. This is reflected in the positive correlation between the ln(INC) and ln(CO2) variables. However, when income reaches a certain threshold, the level of waste gradually decreases, and environmental quality improves. This is confirmed when the study identifies the inverse impact of the ln(INC2) variable on the ln(CO2) variable. Once again, this study, along with previous studies, has contributed to reinforcing the sustainability of the Kuznets curve theory.

3 RESEARCH METHODOLOGY

3.1 THEORETICAL RESEARCH METHODS

The research team employed desk research methods to clarify the theoretical basis of green economy, economic growth, per capita income, and green economy to economic growth and per capita income.

The study provides an overview of research through academic databases including Researchgate, Scien Direct, IEEE Xplore, Scopus, Emerald, Insight, Taylor and Francis, and online sources alongside Google Scholar and websites related to a green economy, economic growth, per capita income, and environmental issues with economic growth and per capita income. This helps identify the research problem's theoretical basis and determine the research model.

3.2 DATA COLLECTION AND PROCESSING

+ Collection of time-series data: Real Gross Domestic Product (GDP), Gross Domestic Product per capita (GDPP), and CO2 emissions from 1995 to 2022 from the World Bank website.

+ The research team based on the inverted U-shaped model of Kuznets, constructed equations to depict the relationship between GDP and CO2, and GDPP and CO2 through two general models:

$$LCO2 = C(1)*LGDPR^2 + C(2)*LGDPR + C(3) + e \quad \text{(model 1)}$$

In which:

LCO2 is the logarithm of CO2 emissions.
LGDPR is the logarithm of GDP.
LGDPR^2 is the square of the logarithm of GDP.
With ε representing random noise.

$$LCO2 = C(4)*LGDPP^2 + C(5)*LGDPP + C(6) + \varepsilon \quad \text{(model 2)}$$

In which:

LGDPP is the logarithm of GDPP.

LGDPP^2 is the square of the logarithm of GDPP.

With ε representing random noise.

To build two second-degree equations representing the relationship between economic growth (represented by real Gross Domestic Product - GDPR) and CO2 emissions and the relationship between per capita income (GDPP) and CO2 emissions, the steps are as follows:

Step 1: Use Eviews12 software to run the model with the collected secondary data.

Step 2: Check the statistical significance of the regression coefficients corresponding to the explanatory variables and the statistical significance of the model.

A coefficient is considered statistically significant if:

- Prob < 0.0α (significance level α%) with 0% < α < 10%.
- Prob(F-statistic) < 0.0α (significance level α%) with 0% < α < 10%.

Step 3: Check the explanatory power of the model through the R-squared and Adjusted R-squared coefficients.

A model is considered explanatory (appropriate) if:

- R-squared > 0.6.
- Adjusted R-squared > 0.6.

Step 4: Check for model flaws.

A model is considered good (suitable for analysis) if, besides the regression coefficients and statistical significance, the R-squared coefficient and adjusted R-squared coefficient, do not suffer from autocorrelation flaws; the residual variance changes. Additionally, the model residuals must follow a normal distribution.

In the study, the authors used the tools in Eviews8 to check these flaws. Specifically:

- Use the Breusch-Godfrey test to check for autocorrelation flaws. The model does not suffer from autocorrelation flaws at a certain degree p if Prob (F-statistic) and Prob (Obs * R-squared) > 0.0α (significance level α%) with 0% < α < 10%.
- Use the Breusch-Pagan-Godfrey test to check for heteroscedasticity flaws. The model does not suffer from heteroscedasticity flaws if Prob (F-statistic) and Prob (Obs * Chi-squared) > 0.0α (significance level α%) with 0% < α < 10%.

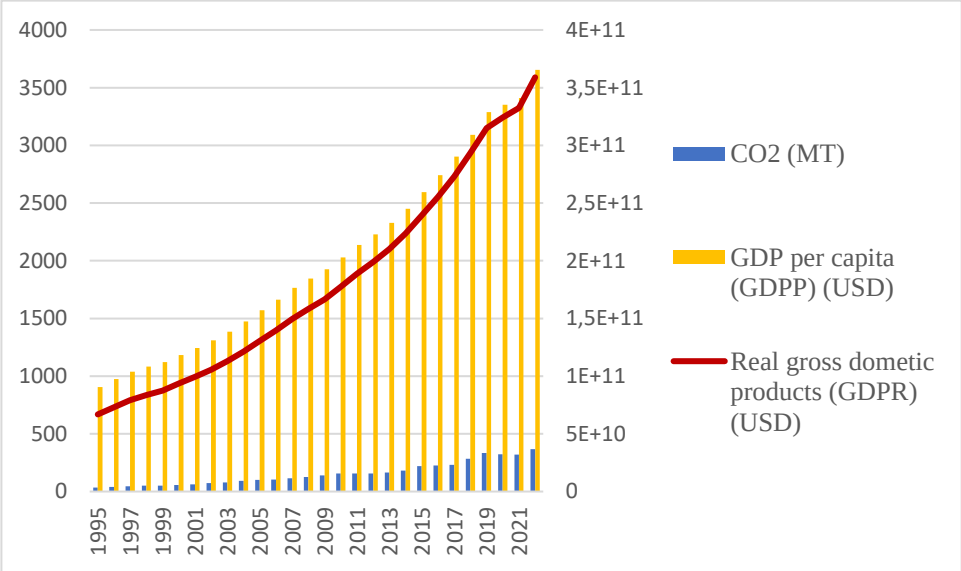
- Use the Jarque-Bera Test to check whether the model residuals follow a normal distribution. The model residuals follow a normal distribution if Prob (Jarque-Bera) > 0.0α (significance level α%) with 0% < α < 10%.

When the above conditions are met, estimate ion and analysis of the model results will be conducted.

4 RELATIONSHIP BETWEEN ECONOMIC GROWTH, PER CAPITA INCOME, AND CO2 EMISSIONS IN VIETNAM DURING THE PERIOD

Figure 2

Relationship between real gross domestic product (GDPR), per capita income (GDPP), and CO2 emissions



Source: Compiled from WB and IFS (2023)

Figure 2 illustrates the relationship between real gross domestic product (GDPR), per capita income (GDPP), and CO2 emissions. CO2 emissions during the period 1995 – 2022 show an increasing trend over the years. In 1995, CO2 emissions were at 34,295 metric tons, with a positive growth rate averaging 6.43% during the period under review (WB, 2023), reaching 368 metric tons in 2022. Although the growth rate fluctuated during the period, there was no significant variation, and the growth rate remained positive over the years. This indicates that the level of CO2 emissions fluctuates over the years, but the positive growth rate suggests a close association between CO2 emissions and economic development activities.

Regarding real gross domestic product (GDP), the period from 1995 to 2008 showed positive growth and an increasing trend. In 1995, the real GDP reached 66,835,360,716 USD, with an average growth rate of 10.09% during the period from 1995 to 2007. The positive growth rate continued until 2008 when there was a slight decline in real GDP. The reason for this was the impact of the global financial crisis. However, in 2009, the real GDP began to increase again, reaching 358,918,378,057.646 USD in 2022, despite a decline in the period from 2020 to 2021 due to the negative effects of the Covid-19 pandemic (IFS, 2023).

Regarding per capita income, in 1995, the per capita income was at 906.13 USD per person per year, with a gradually increasing trend over the years and a strong growth rate during the period from 1995 to 2019. However, the period from 2020 to 2021 showed a slowdown in the growth rate of per capita income (1.93% and 1.69% compared to the same period in the previous year), despite remaining positive. The reason for this was the impact of the COVID-19 pandemic, which negatively affected the economy, leading to a decrease in per capita income. In 2022, the economy began to recover, with per capita income reaching 3,655 USD per person per year, a 7.22% increase compared to the previous year (IFS, 2023).

Thus, Chart 1 depicts the increasing trend over the years of total CO2 emissions into the environment, real Gross Domestic Product, and per capita income. The chart also indicates a positive correlation between economic growth, per capita income, and total CO2 emissions. This is because the high short-term economic growth leads to increased economic activities and production, resulting in increased CO2 emissions into the environment. Therefore, the current situation necessitates solutions to minimize CO2 emissions into the environment and move towards sustainable economic growth and development.

5 ANALYSIS RESULTS OF THE QUANTITATIVE RELATIONSHIP BETWEEN GDPR, GDPP, AND CO2

5.1 DESCRIPTIVE STATISTICS OF RESEARCH DATA

Using the collected data, the research team conducted descriptive statistics using Eviews12 software, as shown in Table 1.

Table 1

Analysis Data

	LCO2	LGDPP	LGDPP2	LGDPR	LGDPR2
Mean	4.805686	7.527992	56.84547	25.79769	665.7729
Median	4.891010	7.542385	56.88802	25.81270	666.2960
Maximum	5.908083	8.203978	67.30525	26.60636	707.8984
Minimum	3.535000	6.809183	46.36497	24.92550	621.2805
Sum	134.5592	210.7838	1591.673	722.3353	18641.64
Observations	28	28	28	28	28

Source: Data analysis results

The collected data is time series data from 1995 to 2022 with 28 observations. Table 1 shows the minimum value, maximum value, mean value, and total value of the observed data series.

The research team conducted an estimation of 2 research models regarding the relationship between GDPR and CO2, and GDPP and CO2, based on the general model built above. This was done to examine the relationship between variables in a curved (inverted U) shape, as proposed by the Environmental Kuznets Curve (EKC) theory.

5.2 MODEL 1

The results of estimating the relationship between real domestic product (GDPR) and CO2 emissions in the period 1995-2022 are shown in Table 2.

Table 2

Relationship between real domestic product (GDPR) and CO2 emissions in the period 1995-2022

Dependent Variable: LCO2
Method: Least Squares
Date: 02/23/24 Time: 21:50
Sample: 1995 2022
Included observations: 28

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDPR^2	-0.117421	0.044916	-2.614255	0.0149
LGDPR	7.438198	2.316333	3.211195	0.0036
C	-108.9068	29.85461	-3.647905	0.0012

R-squared	0.994812	Mean dependent var	4.805686
Adjusted R-squared	0.994397	S.D. dependent var	0.709454
S.E. of regression	0.053105	Akaike info criterion	-2.932128

Sum squared resid	0.070504	Schwarz criterion	-2.789392
Log likelihood	44.04979	Hannan-Quinn criter.	-2.888492
F-statistic	2396.897	Durbin-Watson stat	1.165123
Prob(F-statistic)	0.000000		

Source: Model estimation results

5.2.1 Check the model fit

The results in Table 2 show that the regression coefficients are all statistically significant because the coefficient Prob (LGDPR^2) = 0.0149 < 0.02; Prob (LGDPR) = 0.0036 < 0.02; Prob (C) = 0.0012 < 0.02. The regression model is suitable because the coefficient Prob(F-statistic) = 0.000000 < 0.02

The coefficient of determination of the model R-squared = 0.994812 > 0.6; Adjusted R-squared = 0.994397 > 0.6.

5.2.2 Autocorrelation test

Table 3

Breusch- Godfrey Serial Correlation LM Test (lags = 2)

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	4.301659	Prob. F(2,23)	0.0259
Obs*R-squared	7.622393	Prob. Chi-Square(2)	0.0221

Source: The model testing result

According to the results of Table 3, the coefficient Prob. F(2.23) = 0.0259 > 0.02; Prob. Chi-Square(2) = 0.0221 > 0.02. The model does not suffer from autocorrelation defects.

5.2.3 Test for heteroskedasticity

Table 4

Heteroskedasticity Test (White)

Heteroskedasticity Test: White

F-statistic	2.627582	Prob. F(2,25)	0.0921
Obs*R-squared	4.863454	Prob. Chi-Square(2)	0.0879
Scaled explained SS	3.189975	Prob. Chi-Square(2)	0.2029

Source: The model testing result

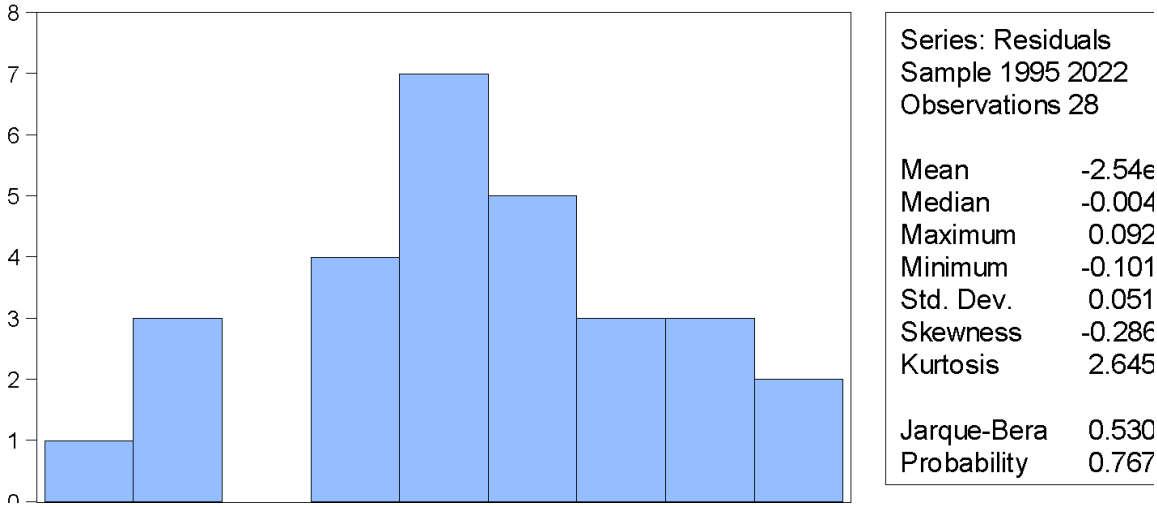
The results in Table 4 show that the coefficient Prob. F(2,25)=0.0921 > 0.02; Prob. Chi-Square(2) = 0.0879 > 0.02; Prob. Chi-Square(2) = 0.2029 > 0.02. The model does not have heteroskedasticity.

5.2.4 Test for normally distributed residuals

The residual of the model follows a normal distribution Prob (Jarque – Bera) = 0.767199 > 0.02 (According to Figure 3)

Figure 3

Normally distributed residuals



Source: The model testing result

5.2.5 Model 1 and analysis of model 1 results:

The results of regression data analysis using Eviews8 software in Table 2 show that the relationship between real gross domestic product (GDPR) and CO2 emissions in the period 1995-2022 is shown in the following equation:

LCO2= - 0.117421*LGDPR^2 0.7438198*LGDPR -108.9068

From the results of the regression model, it shows:

The explanatory variables in the model are all statistically significant at the 2% significance level. It is worth noting that the impact of economic growth (measured in the study through the real gross domestic product measure - GDPR) on environmental quality follows the Kuznets curve theory. Specifically, in the early stages when the real gross domestic product of the economy increases, CO2 emissions will increase and environmental pollution will become more serious. This is shown in the positive correlation between LGDPR and LCO2 variables. However, when GDPR increases to a certain threshold, the level of waste gradually decreases and environmental quality improves. This is confirmed when the study shows the negative impact of the LGDPR^2 variable on the LCO2 variable.

The significance of the R-squared coefficient = 0.994812 shows that Model 1 explains 99.4812% of the variation in CO2 emissions in the period 1995-2022.

5.3 MODEL 2

Table 5

The relationship between income per capita (GDPP) and CO2 emissions in the period 1995-2022

Dependent Variable: LCO2
Method: Least Squares
Date: 02/23/24 Time: 21:51
Sample: 1995 2022
Included observations: 28

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDPP^2	-0.183742	0.064162	-2.863728	0.0084
LGDPP	4.423771	0.965133	4.583587	0.0001
C	-18.05153	3.620414	-4.986041	0.0000
R-squared	0.994974	Mean dependent var		4.805686

Adjusted R-squared	0.994572	S.D. dependent var	0.709454
S.E. of regression	0.052267	Akaike info criterion	-2.963951
Sum squared resid	0.068296	Schwarz criterion	-2.821215
Log likelihood	44.49532	Hannan-Quinn criter.	-2.920316
F-statistic	2474.805	Durbin-Watson stat	1.153668
Prob(F-statistic)	0.000000		

Source: Model estimation results

5.3.1 Check the model fit

The results in Table 5 show that the regression coefficients are all statistically significant because the coefficient Prob (LGDPP^2) = 0.0084 < 0.02; Prob (LGDPP) = 0.0001 < 0.02; Prob (C) = 0.0000 < 0.02. The regression model is suitable because the coefficient Prob(F-statistic) = 0.000000 < 0.02

The coefficient of determination of the model R-squared = 0.99494 > 0.6; Adjusted R-squared = 0.994572 > 0.6.

5.3.2 Autocorrelation test

Table 6

Breusch- Godfrey Serial Correlation LM Test (lags = 2)

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	4.371698	Prob. F(2,23)	0.0246
Obs*R-squared	7.712315	Prob. Chi-Square(2)	0.0211

Source: The model testing result

According to the results of Table 6, the coefficient Prob. F(2.23) = 0.0246 > 0.02; Prob. Chi-Square(2) = 0.0211 > 0.02. The model does not suffer from autocorrelation defects.

5.3.3 Test for heteroskedasticity

Table 7

Heteroskedasticity Test (White)

Heteroskedasticity Test: White

F-statistic	2.218254	Prob. F(3,24)	0.1120
Obs*R-squared	6.078446	Prob. Chi-Square(3)	0.1079
Scaled explained SS	3.847331	Prob. Chi-Square(3)	0.2784

Source: The model testing result

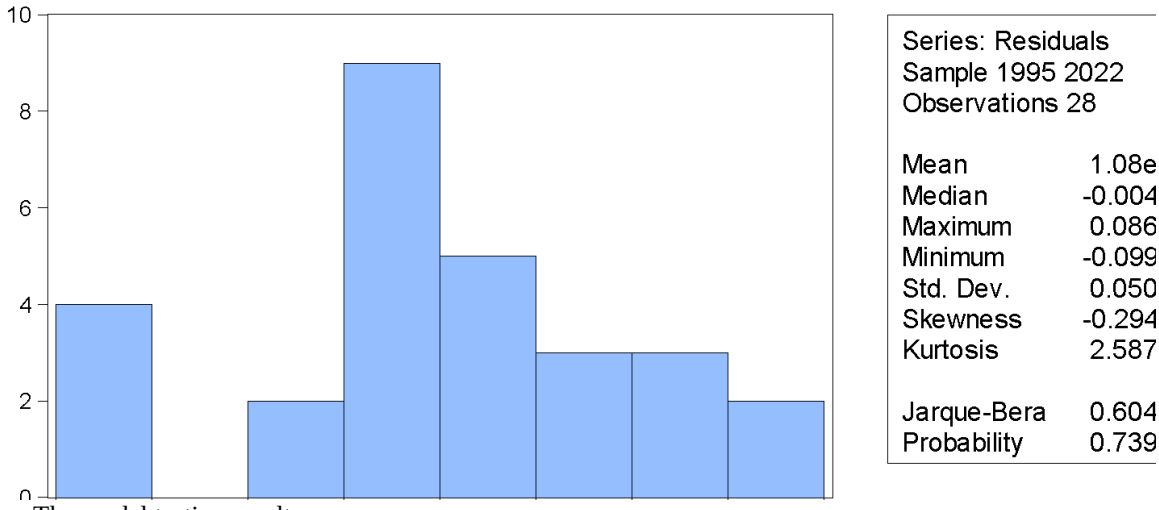
The results in Table 7 show that the coefficient Prob. F(3,24)=0.1120 > 0.02; Prob. Chi-Square(3) = 0.1079 > 0.02; Prob. Chi-Square(3) = 0.2784 > 0.02. The model does not have heteroskedasticity.

5.3.4 Test for normally distributed residuals

The residual of the model follows a normal distribution Prob (Jarque – Bera) = 0.739239 > 0.02 (According to Figure 4)

Figure 4

Normally distributed residuals



Source: The model testing result

5.3.5 Model 2 and analysis result

The results of regression data analysis using Eviews8 software in Table 5 show that the relationship between income per capita (GDPP) and CO2 emissions in the period 1995-2022 is shown in the following equation:

LCO2= - 0.183742*LGDPP^2 + 4.423771*LGDPP -18.05153

From the results of the regression model, it shows:

The explanatory variables in the model are all statistically significant at the 2% significance level. It is worth noting that the impact of increased per capita income on environmental quality also follows Kuznets' (inverted U) curve theory. Specifically, in the early stages, when per capita income increases, CO2 emissions will increase and environmental pollution will become more serious. This is shown in the positive correlation between the variables LGDPP and LCO2. However, when GDP per capita income increases to a certain threshold, the level of waste gradually decreases and environmental quality improves. This is confirmed when the study shows the negative impact of the LGDPP^2 variable on the LCO2 variable.

The significance of the coefficient R-squared = 0.994974 shows that model 2 explains 99.4974% of the variation in CO2 emissions in the period 1995-2022.

6 SOME EXCHANGES AND DISCUSSIONS TO PROMOTE GREEN ECONOMY IN VIET NAM

Green economic growth plays an important role in sustainable economic development in Vietnam. Through the research results, it can be seen that economic growth has a positive relationship with the level of environmental pollution in the short term. However, when a certain threshold is reached, the level of waste gradually decreases and environmental quality improves. To reach that threshold, economic growth needs to be associated with environmental protection, and solutions to promote green economic growth play an important role. Therefore, the research team proposes a number of solutions to promote green economic growth in Vietnam as follows:

The *first*, the Government needs to have tax and incentive policies. The government needs to establish reasonable tax policies to encourage businesses and individuals to switch to environmentally friendly activities and products, providing tax incentives and financial support for businesses and individuals. The project has the goal of protecting the environment and using renewable raw materials. At the same time, the Government needs to have supportive policies such as support funds, attractive electricity purchase prices for renewable energy sources, creating favorable conditions for the development and implementation of renewable energy projects across the country with large and small scales

The second, the Government needs to promote investment in clean and green infrastructure. The state needs to focus on developing green infrastructure including wind power projects, solar power projects, smart power systems and public transportation. In addition, it is necessary to encourage the use of energy-saving technology in construction projects and transportation infrastructure. Promote recycling and use of resources to reduce the amount of waste produced. At the same time, build effective waste management systems and encourage recycling and sustainable waste treatment.

The third, there should be policies to promote the application of environmental protection policies such as reducing emissions, controlling pollution and preserving important ecological areas. Focus on developing environmental restoration projects such as reforestation, restoring marine ecosystems and protecting wetland areas.

The fourth, the Government needs to focus on educating and increasing public awareness through organizing educational campaigns and increasing public awareness of environmental issues and its impact on the economy. Encourage participation in environmental protection activities, participate in recycling and environmental cleaning projects.

The fifth, businesses need to associate growth goals with environmental protection. Promote production growth and increase revenue but need to comply with environmental regulations. On the other hand, businesses need to actively participate in investment and green development projects for stable and sustainable growth.

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ANNEX

Table 8

Model data

	CO2(MT)	GDP per capita (2015) (USD/people)	GDPr (2015) (USD)
1995	34.295	906.1302491	66835360716
1996	38.609	975.0668251	73077795100
1997	44.554	1039.135027	79035158447
1998	49.84	1083.791171	83591104956
1999	51.081	1121.060375	87581398976
2000	56.523	1183.854097	93525825639
2001	62.102	1244.306519	99317780240
2002	73.095	1309.430272	1.05595E+11
2003	77.646	1385.448733	1.12881E+11
2004	91.905	1474.740771	1.21388E+11
2005	100.432	1570.193228	1.30549E+11
2006	103.153	1663.559513	1.39659E+11
2007	114.043	1765.122605	1.49616E+11
2008	126.03	1846.866784	1.58087E+11
2009	140.541	1926.623818	1.6662E+11
2010	156.838	2028.605534	1.77322E+11
2011	157.193	2135.782152	1.88694E+11
2012	156.688	2229.320092	1.99081E+11
2013	164.32	2327.932657	2.10137E+11
2014	180.429	2451.159232	2.23633E+11
2015	221.188	2595.234979	2.39258E+11
2016	226.555	2741.052937	2.55265E+11
2017	231.261	2903.02829	2.72981E+11
2018	282.784	3090.772241	2.93359E+11
2019	333.508	3288.353073	3.14948E+11
2020	322.018	3352.060157	3.23972E+11
2021	321.413	3409.024717	3.32271E+11
2022*	368	3655.462581	3.58918E+11

Source: Compiled from WB and IFS (2023)