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THE MANUFACTURE ECOSYSTEM TOWARDS GREEN ECONOMIC GROWTH: A PER CAPITA INCOME PERSPECTIVE IN VIETNAM

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ABSTRACT

This study examines and evaluates the interaction between the production ecosystem, green growth and the per capita income during Vietnam's economic transition toward a green economy. To ensure the accuracy of the result, annual time-series data include GDP per capita (USD), agricultural production value (million VND), and carbon dioxide emissions (metric tons) from 2000 to 2022 are taken from reliable secondary source like World Bank. The study effectively applied quantile-quantile regression model, giving the most comprehensive results that when the per capita GDP increases by 1 unit, CO_2 emissions increase by approximately 0.3864 metric tons and when agricultural output increases by 1 unit, CO_2 emissions increase by about 0.37 metric tons. Although Vietnam has made significant progress toward economic growth, this development has been accompanied by increasing CO_2 emissions and environmental pollution. Also, there are limited empirical evidence exists for Vietnam that integrates per capita income, agricultural production, and carbon emissions within a green growth framework. In addition, it is necessary to balance maintaining the annual growth rate of per capita income and finding a model suitable for Vietnam's production ecosystem to achieve the set goals in the global integration period.

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1. Introduction

As people and governments place a higher priority on preserving the environment, environmental issues have drawn attention from all around the world in recent years. Since industrial output still contributes significantly to pollution, green growth and sustainable development are important global goals. Green economic methods have been actively adopted by numerous nations, including South Korea, Singapore, Germany, the United Kingdom, and France. Similar to this, Vietnam has realized the value of sustainability and is progressively creating a green manufacturing ecosystem to strike a balance between environmental preservation and long-term economic stability.

The idea of a "green economy" is still relatively new in Vietnam. A significant turning point in the nation's transition to sustainable development was in 2012, when the government formally incorporated green growth into its national policy. Since then, industrial CO_2 emissions have been greatly decreased by the use of greener energy sources. Vietnam has made an effort to follow the "green economy" trend by issuing the National Green Growth Strategy under Decision No. 1658/QD-TTg with the main aims of reducing the GHG emissions per unit of GDP and greening economic sectors (Công, 2022).

Many studies have considered the implementation of green growth originating from the production ecosystem (Su & Yao, 2017; Jänicke, 2012). Studies have shown that the production ecosystem, especially in developing countries, depends heavily on the agricultural production sector. Green growth is the result of a process focusing on investing in modern technological systems to create environmentally friendly products and not using many chemicals that are toxic to humans and the environment. The production ecosystem initiated from the agricultural sector aims at a low-carbon production economy, does not cause damage to the environment and does not create climate degradation.

Since Vietnam's economy has only recently begun its transition toward a green economy, previous studies have not incorporated the concept of a production ecosystem as a determinant of green growth and per capita income in the Vietnamese context. Most studies in Vietnam have remained at a descriptive level or employed basic linear models such as OLS, ARDL, or EKC, without considering the role and impact of the manufacturing ecosystem on green growth. This research has conducted a study using Quantile-on-Quantile Regression (QQR) methodology to examine the nonlinear interaction on the relationship between GDP growth, agricultural activities and CO_2 emissions. Therefore, to achieve the goal of sustainable development with green growth as the foundation, the Government needs to create conditions for the development of the green economy through policies and actions.

2. Theoretical background

2.1. Foundational theories

The Triple Bottom Line (3P) Framework

The Triple Bottom line (3P) theory suggests that a company's performance should be measured equally on the following criteria: social issues, environmental goals, and company profits (John, 1994). Theory evaluates a company or country on three main goals: People, Planet, and Profit. At the Profit pillar, businesses can create positive change for society while still ensuring financial efficiency. Sustainable initiatives can also boost the business of the enterprise. The People Pillar emphasizes the social responsibility of businesses to employees, partners and stakeholders. In the Planet pillar, businesses hold the key to positive environmental change, reducing ecological impact by reducing carbon

emissions, changing raw materials, managing waste and conserving natural resources. The Triple Bottom Line theory plays a role in rebalancing the criteria for success, businesses can create profits, strengthen social welfare and protect the environment.

Green economy

Green economy is one that delivers human well-being, social equity, and reduces environmental risks and ecological degradation. A green economy is characterized by low carbon emissions, resource efficiency, and socially inclusive (UNEP, 2011). A green economy aims to develop the economy by ensuring efficient use of natural resources, minimizing pollution and environmental impacts, enhancing resilience to natural change, and promoting the role of state management of the environment and natural resources in preventing natural disasters (World Bank, 2012).

Systems management theory

Systems management theory views organizations as a collection of interconnected systems that work toward a common goal (Von, 1968). The components of systems management theory include Environment, inputs, processes, outputs, and feedback. According to the theory, departments such as finance, sales, and production are interconnected and influence each other. There are three basic types of systems. Open system: a system that continuously interacts with its environment. Closed system: A system that is independent of its environment. Subsystem: A part of a larger system. The manufacturing ecosystem is an open system, in which businesses, suppliers and stakeholders interact with each other, forming green value.

2.2. The relationship between per capita income, agriculture, and the green economy

The relationship between per capita income and the green economy

Per capita income measures the economy and wealth of a country. In addition to its positive effects, income growth also has a negative impact on the environment by depleting non-renewable natural resources. However, according to the Kuznets environmental curve theory, environmental pollution will increase in the early stages of economic growth, then decrease when reaching a certain threshold (Simon, 1954). Accordingly, economic growth is not a threat but a factor to improve the environment later.

The relationship between agriculture and the green economy

In agriculture, green economy emphasizes sustainable elements such as agroforestry, agricultural cultivation, use of renewable energy and water conservation to withstand natural disasters, helping economic growth and food security. Agriculture and green economy work together. Sustainable agriculture will provide green economy by protecting resources, reducing pollution to a minimum. When applying green economy policies, it can provide agricultural capacity and improve people's lives, especially in developing countries. Sustainable agricultural development together with green economy helps Sustainable economic development and long-term development.

2.3. Empirical studies related to the production ecosystem, green growth, and per capita income

Global empirical studies

In another study by D'Adamo et al. (2022) on 27 EU countries between 2000 and 2007 used the DOLS methodology and the results showed that a 1% increase in GDP would lead to an increase in CO_2 emissions of 0.072%, although it was reduced in part thanks to renewable energy policies. Another study by Chavez and Silveira (2017) based on 20 Latin American and Caribbean countries between 1971 and 2011 confirmed the Kuznets curve: CO_2 emissions

initially increase with income but decrease after reaching a certain income level. In the United States, Li et al. (2020) reported that between 2007 and 2016, GDP grew by about 19% while CO_2 emissions decreased by about 12%, due to the shift to low-emission sectors such as technology. In Southeast Asia, Su et al. (2019) studied ASEAN-5 countries from 1980 to 2016 and found that GDP growth has different impacts on CO_2 emissions and energy use between countries, requiring appropriate policies. In addition, this conclusion is similar to that of Olanrele et al. (2022) in sub-Saharan Africa. In it, they concluded that economic growth, energy use and tourism as well as population growth all affect the increase in CO2 emissions in a positive direction.

Empirical studies relevant to Vietnam

In Vietnam, there are many similar research topics. For example, the study on the relationship between economic growth, CO_2 emissions and per capita income in Vietnam by Nguyen et al. (2024) is based on the Environmental Kuznets Curve (EKC) framework method with data sources taken from 1990 to 2020. There has been a positive effect between economic growth and environmental pollution, but when per capita income exceeds $5,000 per year, CO_2 emissions begin to decline again, just like the EKC hypothesis suggests. In the research of Nguyen et al. (2023), learn about the green economy in the context of digital transformation in Vietnam using popular methods such as surveys, interviews, and snow regression analysis. Since then, the research has made progress in the use of renewable energy as well as the application of the right sustainable policies. But there are still limitations in technology and capital used, making it difficult to expand and exploit for the long term.

In addition, in a recent study by Le et al. (2023), research on the interaction between CO_2 emissions and economic growth, FDI, renewable energy, and urbanization in Vietnam from the 1990s to 2018. The use of the ARDL model helps them validate EKC trends, detect the influence of variables on each other, and reflect on the environmental costs of urbanization. FDI and renewable energy have helped reduce harmful emissions into the environment.

3. Research methodology and data

3.1. Research methodology

The quantitative method is the method used by the team to analyze the relationship between Gross Domestic Product (GDP) and per capita along with the value of agricultural, forestry and fishery production (AGR) to CO_2 emissions in Vietnam.

To ensure high accuracy of the results, the team used a Percentile Regression (QQR) model instead of the traditional linear regression. It is also for the use of reputable official information sources such as sources from the General Statistics Office of Vietnam, the World Bank (WB) and socio-economic reports related to the topic in the period from 2000 to 2022, to bring high accuracy. The results show that the impact of per capita income and agricultural activities on CO_2 emissions at different levels. From there, it is possible to better assess the general trend and observe the fluctuation of CO^2 emissions corresponding to specific economic variables.

3.2. Data collection, processing, and analysis methods

In order to maintain accuracy and reliability, data was collected from a variety of reliable sources through document analysis. These sources include research reports, statistics from government agencies as well as businesses, along with any available data warehouse used to build the model. The main sources include the General Statistics Office of Vietnam (GSO), the World Bank. After collecting, the data was filtered, processed and standardized using MS

Excel to ensure consistency and suitability to the requirements of the research model.

Data processing and analysis methods

Step 1: Data on GDP per capita (GDP), agricultural production value (AGR) and CO_2 emissions (CO_2) were collected from reliable sources such as the World Bank for the period 2000 to 2022 in Vietnam. To ensure that the input data are normally distributed, the study conducted a logarithm of the input research data.

Step 2: Descriptive statistics were computed to analyze the basic features of the data, i.e., mean, variance, standard deviation, maximum, and minimum values attained by each variable. Scatter plots were also used as a pictorial representation of AGR, GDP, and CO_2 to view which variables are correlated. A trend analysis of CO_2 emissions over the years was also done to see how much strength per capita income and agricultural activities have in explaining variations in emission levels.

Step 3: The R-based Quantile-on-Quantile Regression (QQR) approach was thus developed to estimate the influence of AGR and GDP on CO_2 emissions at different quantile levels. What accrues is not a simple mean effect but rather an understanding of how different quantiles of AGR and GDP affect different quantiles of CO_2 (for instance, 0.25, 0.5, 0.75). The analysis reflects in more detail the relations between variables under various states of the economy as per the comprehensive understanding that emerged regarding how income per capita and production in agriculture, forestry, and fisheries influence CO_2 emissions.

Step 4: The model was estimated, and an analysis of the significance of the regression coefficients was carried out. With statistical significance, those regression coefficients that were evaluated describe to which independent variable has an effect on CO_2 emissions. Results across different quantiles were finally compared to see how AGR and GDP effects vary with CO_2 emissions at different quantiles of distribution - i.e., at different stages of economic development.

Step 5: When necessary, different methods can be compared to evaluate accuracy and effectiveness. Based on the analysis results, the impact of AGR and GDP on CO_2 emissions is examined to propose appropriate policies aimed at reducing greenhouse gas emissions while fostering societal development, increasing people's income, and promoting sustainable agriculture.

3.3. Research model: Quantile on Quantile (QQR)

The Quantile-on-Quantile Regression (QQR) methodology, first introduced by Sim and Zhou (2015), extends the traditional conditional quantile regression approach by enabling a more comprehensive examination of relationships among economic variables. Specifically, by integrating quantile regression with nonparametric estimation techniques, the QQR framework allows researchers to explore how a specific quantile of an explanatory variable influences all quantiles of a dependent variable. This approach provides a deeper understanding of the heterogeneity and asymmetry inherent in economic relationships that conventional methods may overlook.

The research applies QQR to study how GDP per capita and agricultural production value affect carbon dioxide emissions. Local linear regression serves as the method to determine variable effects at specific locations according to Cleveland (1979) and Stone (1977). QQR provides superior analysis compared to traditional quantile regression (QR) because it shows both average effects and variable relationships at different quantile points, which helps researchers study how independent and dependent variable quantiles affect each other.

The QQR model benefits from the strengths of local linear regression, which mitigates the curse of dimensionality often encountered in nonparametric models, thereby enhancing its flexibility and applicability relative to standard linear regression techniques. The integration of quantile regression with locally weighted estimation allows for an improved assessment of nonlinear and asymmetric relationships within economic–environmental contexts. Recent empirical studies have demonstrated the efficiency, robustness, and explanatory power of the QQR method in economics and finance, validating its effectiveness in capturing complex, nonlinear dynamics among variables.

$$CO_{2t} = \beta^{\theta}(OP_t) + \mu_t^{\theta} \quad (1)$$

In this study, CO_{2t} represents the level of CO_2 emissions at time t. We consider two key factors that influence CO_2 emissions over a given period, including per capita income (GDP_t) and production in the agriculture, forestry, and fisheries sector AGR_t). Specifically, X_t denotes two independent variables: GDP_t, which represents the global GDP value at time t, while AGR_t reflects the production value of the agriculture, forestry, and fisheries sector during the same period.

The coefficient β_θ is an unknown parameter due to the lack of prior information on the relationship between per capita income, agricultural production, and carbon dioxide emissions. Here, θ represents the θ quantile of the conditional distribution of CO_2, and μ_t^{θ} is the corresponding quantile error term.

It is recognized that quantile regression has significant limitations. The regression model is particularly improved by applying the first-order Taylor expansion of X_t to assess the impact of the θ quantile of GDP and the τ quantile of AGR on CO_2 emissions, denoted as $CO_{2\tau}$. Equation (1) can be decomposed into separate equations to reflect the influence of each factor. Therefore, Equation (1) can be adjusted as follows:

$$\beta^{\theta}(GDP_t) \approx/ \beta^{\theta}(GDP^{\tau}) + \beta^{\theta'}(GDP^{\tau})(GDP_t - GDP^{\tau}) \quad (i)$$

$$\beta^{\theta}(AGR_t) \approx/ \beta^{\theta}(AGR^{\tau}) + \beta^{\theta'}(AGR^{\tau})(AGR_t - AGR^{\tau}) \quad (i)$$

In this analysis, $\beta^{\theta'}$ represents the partial derivatives of $\beta^{\theta}(GDP^{\tau})$ and $\beta^{\theta}(AGR^{\tau})$ concerning per capita income and the output value of the agriculture, forestry, and fishery sectors. These values can be interpreted as marginal effects, reflecting the degree of influence each factor has on CO_2 emissions, similar to the slope in a standard linear regression model.

A key advantage of equations (i, ii & iii) is that the slopes of $\beta^{\theta}(GDP^{\tau})$ and $\beta^{\theta'}(GDP^{\tau})$, $\beta^{\theta}(AGR^{\tau})$ and $\beta^{\theta'}(AGR^{\tau})$, depend on two factors: θ and τ, where θ is a function of GDP and AGR, while τ is a function of CO_2 emissions. Therefore, equations (i, ii & iii) can be reformulated as $\beta_0(\theta, \tau)$ and $\beta_1(\theta, \tau)$. These equations can be rewritten as follows:

$$\beta^{\theta}(GDP_t) \approx \beta_0(\theta, \tau) + \beta_1(\theta, \tau)(GDP_t - GDP^{\tau}) \quad (iv)$$

$$\beta^{\theta}(AGR_t) \approx \beta_0(\theta, \tau) + \beta_1(\theta, \tau)(AGR_t - AGR^{\tau}) \quad (v)$$

3.4. Description of model variables

The purpose of this study is to examine the impact of GDP per capita and the production activities of the agriculture, forestry, and fishery sector on CO2 emissions. Data for the research were collected from the World Bank, covering the period from 2000-2022. The indicators studied include: GDP per capita (GDP – measuring average income per person, unit: USD), the production value of the agriculture, forestry, and fishery sector (AGR – measured by combining the values of the agriculture, forestry, and fishery indicators at current prices, unit: Million VND), and CO2 emissions (measuring the quantity of CO2 emissions, unit: metric tons).

Table 1. Data source description

Research Variable	Symbol	Measurement	Data Source
Economic Growth	GDP	Per Capita Income (USD)	WB
Agricultural activities	AGR	Total income from agricultural activities (million VND)	WB
CO_2 Emissions	CO_2	CO_2 Emissions (Metric Tons)	WB

CO_2 emissions are considered the dependent variable in the model, reflecting the impact of increasing per capita income and agricultural production activities on the environment. This clearly illustrates the relationship between variables in the transition to a green economy.

Independent Variables:

GDP: Per capita income, representing the level of economic development and the average living standard of the Vietnamese population.

AGR: The output value of the agriculture, forestry, and fishery sectors, reflecting the scale and contribution of the agricultural sector to Vietnam's economy.

Dependent Variables:

CO_2: Carbon dioxide emissions, used to assess the impact of economic activity and agricultural production on the environment.

Research hypothesis

Hypothesis H1: GDP impacts carbon dioxide emissions.

An increase in GDP per capita is often accompanied by an expansion of production and consumption, leading to higher CO_2 emissions. As GDP per capita rises, improved living standards often drive growth in industries and transportation, alongside increased demand for fossil fuels, consequently leading to higher CO_2 emissions. However, at a certain stage of development, the transition towards a green economy and the adoption of environmentally friendly technologies may help mitigate the negative environmental impacts of income growth.

Hypothesis H2: The agriculture, forestry, and fishery sector impacts carbon dioxide emissions.

Production activities in the agriculture, forestry, and fishery sector (AGR), particularly intensive farming, livestock raising, and the use of chemical fertilizers, are major contributors to increased CO_2 emissions. As the scale of agricultural production expands, the demand for land, water, and energy also increases, leading to higher CO_2 emissions. However, the extent of their impact on CO_2 emissions may vary across different stages of development.

(AGR) (unit: Million VND). Data was sourced from the World Bank. Upon completion of the data analysis, the research team will synthesize and will present the findings in research results.

4. Research results

4.1. The current situation of green economic growth in Vietnam

In Viet Nam, the "National Strategy for Green Growth 2011-2020 and Vision to 2050" has been implemented with specific objectives including: (a) Reducing the intensity of greenhouse gas emissions per GDP, whereby by 2030 the intensity of greenhouse gas emissions per GDP will be reduced by at least 15% compared to 2014. By 2050, the intensity of greenhouse gas emissions per GDP will decrease by at least 30% compared to 2014; (b) Greening economic sectors; (c) Greening lifestyles and promoting sustainable consumption; (d) Greening the transition process on the principle of equality, inclusiveness, and improving resilience *(see Appendix 3 online).*

From 2011 to 2021, Vietnam's average economic growth rate reached about 5.65%. In 2020 and 2021, Vietnam's economy was strongly affected by the COVID-19 pandemic. However, Vietnam's growth rate has remained positive in both years. According to the IMF's GDP data and economic growth data of statistical agencies of countries, Vietnam's GDP in 2021 is approximately 352 billion USD, ranking 5th.

Table 2. GDP ranking of major Southeast Asian economies in the period 2020-2021

Country	GDP 2020 (Billion USD)	Growth in 2021	GDP 2021 (Billion USD)	Ranking in 2020	Ranking in 2021
Indonesia	1060	3.69%	1099.11	1	1
Thailand	501.71	1.60%	509.74	2	2
Philippines	361.49	5.60%	381.73	3	3
Việt Nam	343.11	2.58%	351.96	4	5
Singapore	339.98	7.20%	364.46	5	4
Malaysia	337.01	3.10%	347.46	6	6

Source: AEC Portal of VCCI, 2022

One prominent sector is renewable energy, with significant growth in solar and wind energy. Solar installed capacity increased from 86 MW in 2018 to 4.5 GW in mid-2019 and reached 1.5 GW by the end of 2020, making Vietnam a leader in Southeast Asia in renewable energy. In addition, the potential for offshore wind power reaches more than 470 GW within 200 km of coastline, opening great opportunities for energy exports to countries such as Singapore.

Despite the impact of the COVID-19 pandemic, Vietnam maintained an average economic growth rate of 5.65% from 2011 to 2021, with a GDP of about 352 billion USD in 2021, ranking 5th among major Southeast Asian economies (VCCI, 2022).

The current green economy is not only a trend but has become an urgent issue in Vietnam's national economic development strategy. However, the process of promoting the green economy still faces many limitations.

The green economy is still a new problem in Vietnam. To operate a green economy in practice, it requires a change in mindset and a sense of responsibility for the environment, nature, and society. However, there are still many inadequacies in thinking about the green economy. According to the Ministry of Planning and Investment, by the end of 2018, only 7 ministries and 34/63 provinces and cities have plans to implement the green growth strategy.

Human resources play a key role in building and operating a green economy. Human resources in businesses in Vietnam are still limited in accessing modern knowledge and technology, making the green economy slow. High technology and innovation are essential for the development of a green economy. However, Vietnam still mainly uses outdated, energy-intensive technology.

Constraints on capital, technology, and policy mechanisms are major barriers. Developing a green economy requires large financial resources. According to calculations, Vietnam needs about 30 billion USD to implement the green growth strategy to 2030, of which the state budget only meets 30%, the rest must be mobilized from the private sector. Currently, although the Government has issued

many green growth strategies, the current legal system still lacks synchronization and there are no specific regulations on renewable energy and green industry.

Developing a green economy requires large resources, with an estimated need of $30 billion by 2030, of which the state budget only meets 30%, according to ADB. The World Bank estimates that $368 billion is needed by 2040 to transition to a low-carbon and sustainable economy.

The legal framework is not synchronized; there are no specific regulations on renewable energy, green industry, or environmental protection. The IMF report recommends that Vietnam needs to improve its policies, including priority packages such as the Mekong Delta program, strengthening coastal infrastructure, reducing air pollution in Hanoi, and promoting the clean energy transition.

4.2. Descriptive statistics

The paper uses descriptive statistical variables such as GDP, CO_2, and Agriculture to explore the role of green investment in improving the amount of CO_2 emitted into the environment. The team conducted research based on quantitative data analysis combined with modern quantile on quantile regression models to analyze and assess the impact of per capita income and agricultural production activities in Vietnam on CO_2 emissions causing pollution. Since then, the research team has not only clarified the correlated trends but also proposed practical green investment and green growth policies, contributing to promoting sustainable economic and environmental development in Vietnam *(see Appendix 4 online).*

The average and median values of Gross Domestic Product per Capita are not too different, so most of the values will be centered around the average value (1927.018). However, the high coefficient of variation (63.9%) shows a large dispersion of the data. In 2000, Vietnam's GDP per capita ranked 7th out of 11 in Southeast Asia and 173rd out of 200 in the world. By 2021, Vietnam's GDP per capita ranks 6th out of 11 in Southeast Asia and 124th in the world. Vietnam's GDP per capita has increased more than 7 times in the period 2000 - 2021. With this figure, Vietnam's GDP per capita in 2022 will jump 7 places compared to 2021 and 56 places compared to 2000 on a world scale. This shows the effectiveness of economic policies and the efforts of the whole society in promoting growth and development. The balance (>19%) on the right side sharply increases the average indicators. The value of GDP per capita from 2000 to 2022 increased sharply, reaching from 401,549 to 4110,219 (USD) with a sharp chart of 1.6 < 3, so the model has a thin "tail", the data is evenly distributed around the average, and the distribution peak is not too high. With a positive P-value, when the GDP per capita increases by 1 unit, carbon dioxide emissions will increase by 0.3864 metric tons *(see Appendix 5 online).*

The average value compared to the median is not too large, so most of the value is concentrated around the average value (535772724.3 million VND). The coefficient of variation (>64.5) indicates a large dispersion of the data. The production value of Agriculture, forestry, and fishing at current prices tends to increase continuously from 2000 to 2022, increasing from 108356000 million VND to 1129908120 million VND. The value reached its highest in 2022, playing a pivotal role in the economic sector, exceeding 2.5 - 2.8% of the Government's target. Accounting for 11.88% of the total added value of the whole economy. In addition, Agriculture, forestry, and fishing at current prices have a positive p-value (37%), so when Agriculture, forestry, and fishing at current prices increase by 1 unit, CO_2 emissions will increase by 0.37 metric tons *(see Appendix 6 online).*

Looking at the Carbon Dioxide Emissions data table and diagram, it can be seen that the average value of carbon differs slightly from its median value, indicating that the data is opposite to the mean value (173323981.2), which is a standard distributable data, with no obvious tail extending to one side. A fairly high coefficient of variation indicates a large dispersion of the data. The data from 2000 to 2022 has a large gap of 51207700 to 341588766.7 metric tons. It can be seen that in 2022, the amount of CO_2 emissions has decreased. At this time, Vietnam is in the top 5 countries to reach the CO_2 emissions reduction threshold in the Asia-Pacific region. *(see Appendix 76 online)*

4.3. Regession Quantile on Quantile

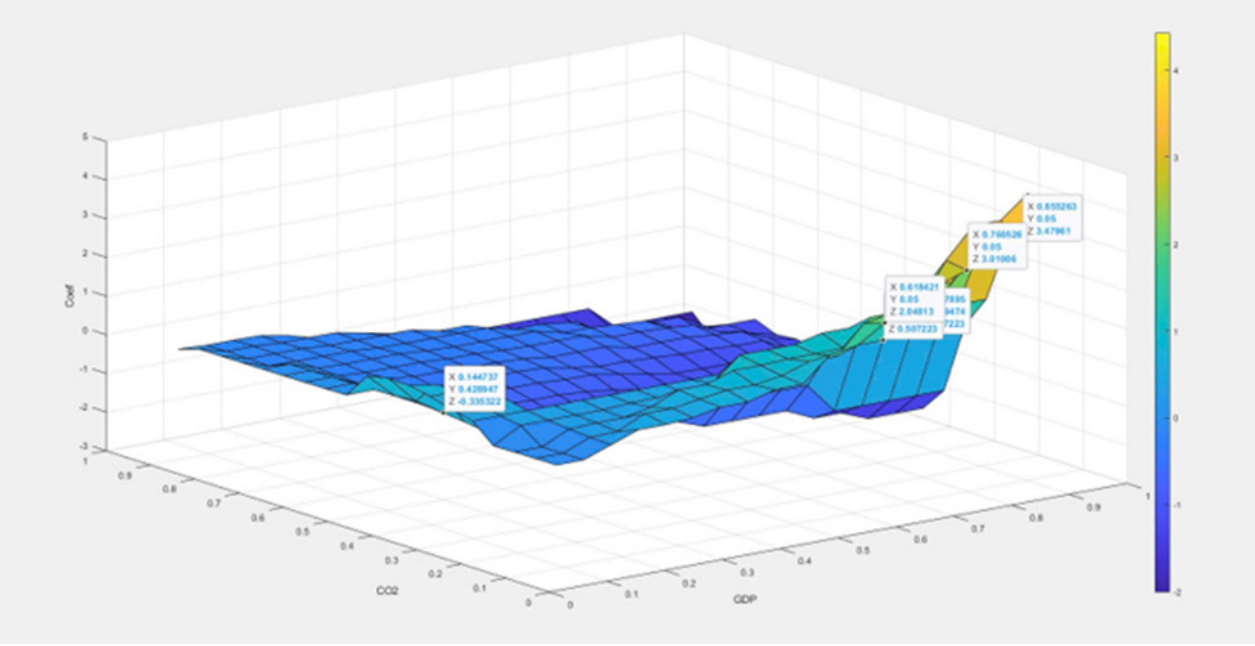

Figure 1. The impact of per capita income and CO_2 emissions

In this model, our team studied the mutual impact between gross domestic products and CO_2 emissions. From the results of the study, it can be seen that this is a two-way impact. Looking at the contrast of both of these factors, GDP has a low to high percentile (0.05 – 0.95) and a low percentile of CO_2 (0.1 – 0.5). We can see here that there is a strong fluctuation in the direction of positive impact. When GDP increases, the values in the table also tend to increase. In regions with a high GDP growth rate, there is a positive impact on the increase in CO_2, while in regions with a low GDP growth rate, the impact on the increase in CO_2 is negligible. In the long term, this pair of variables is correlated. When the GDP index increases, that is, human consumption and production activities will also increase. Many industrial parks (especially textile and garment industrial parks, heavy industries such as cement, iron and steel, chemicals) and export processing will be built. These factories use many machines in the production line mainly operated by fossil fuels, which increases the amount of CO_2 emitted into the environment. Moreover, Vietnam is an economically developing country. People's living standards are improving and the shift from rural to urban areas has increased the demand for housing, travel, and the consumption of goods and services of the people.

It is the production activities and changes in human lifestyles that have contributed to increasing the rate of CO_2 emissions into the environment. In the segment with a high GDP percentage (>0.7), the model surface can be found to be dark green and then gradually yellow. This shows that GDP growth tends to be positive, the higher the growth, the stronger the CO_2 emissions increase. When the Vietnamese economy reaches a high development threshold, each additional unit of GDP will lead to an increase in CO_2 emissions into the environment. For the segment group with low and medium percentages (GDP segment in blue), these are areas with low GDP growth rates, small economic scale and the impact coefficient of GDP on CO_2 will be insignificant. Looking at the results of the model, it can be seen that the green growth rate in Vietnam during this period is growing stronger and stronger. In particular, Vietnam is a developing country so the GDP ratio will change continuously, significantly affecting CO_2 emissions.

In previous studies, Hung's study in 2022, Tiwari's study in 2011 in India, World Bank and IMF reports also have similar conclusions. Developing countries, including Vietnam, in the development stage, GDP increases rapidly with the duration of CO_2 emissions.

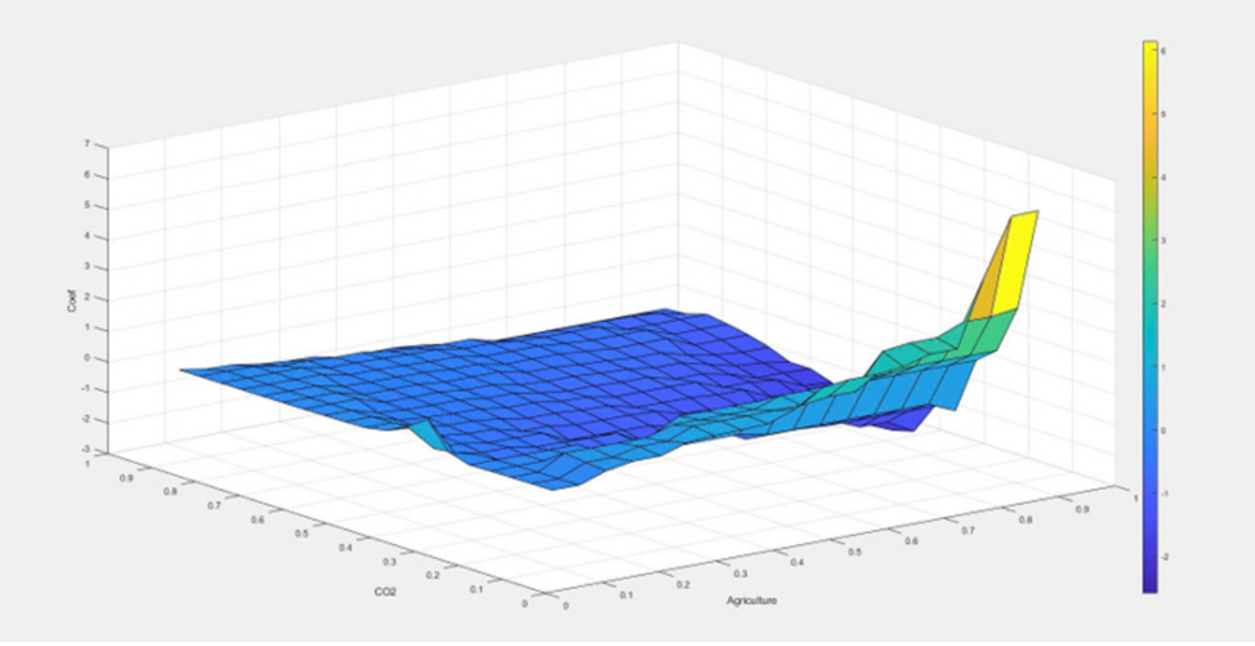

Figure 5. The interaction between agriculture variables and CO_2 emissions

Another factor that also has an impact on green investment is Agriculture. It can be seen that this model has similarities with the above model. The model describes the relationship between Vietnam's industrial development rate and CO_2 emissions. At low percentages of Agriculture (0.05 – 0.3), the graph is a lighter blue, indicating that Agriculture has a negligible impact on CO_2 emissions. During this period, agriculture in Vietnam was not developed strongly, the level of mechanization was not high, production activities were still on a small scale, low consumption of energy and chemical materials, so it did not have much impact on the environment. In the Agriculture area, the average is high (0.4 – 0.95), the surface of the model begins to rise quite high and turns green and then gradually yellow, reflecting the gradual

increase in CO_2 emissions. This change shows that the scale of agricultural development in Vietnam has developed significantly, especially in yellow areas. Farming activities to expand the cultivation area, the use of technological machinery, fertilizers and pesticides have increased the amount of CO_2 significantly. The growth rate of Agriculture has a positive impact on CO_2. This result is like the results of other studies (OECD 2011, Shahbaz 2013, Chen et al.2019) that the transition from small-scale agriculture to the scale of industrialization will increase rapidly.

The research team uses the Percentile-to-Percentile Regression Method to present the relationship between income variables, green economic development investment and CO_2 emissions. Thereby, the factors affecting green growth in Vietnam are identified. The results refer to the relationship between the variables in the research paper and the amount of CO_2 emitted into the environment. In terms of the relationship of GDP and CO_2 has a positive impact, most typically in most percentiles between 0.1 and 0.95, this is similar to the study by the Organization for Economic Co-operation and Development (OECD, 2015), which concluded that fiscal chiefs equate to a significant increase in CO_2 emissions.

For the impact of Agriculture on CO_2, although the statistical significance is not strong, it tends to have a positive impact, especially in moderate to high percentiles. Agriculture shifting from technological, large-scale, mechanized agriculture will increase CO_2 emissions. This, too, has been emphasized in the research of Tran et al. (2019).

In addition, the Quantile-on-Quantile model not only assesses the impact of GDP and Agriculture variables on CO_2 but also discovers nonlinear relationships at different percentiles of dependent variables on independent variables. The results of GDP and Agriculture are in a high percentile, showing that the model is maintaining stability, accurately and effectively reflecting the relationship between variables with each other. Therefore, the conclusions in this research paper can be judged to be reliable, valuable, and can make decisions and policies in accordance with this correlation.

5. Conclusion

The results from the research show that as GDP increases, CO_2 emissions also increase, especially during periods of strong development. Similarly, the agricultural sector when shifting from a small-scale model to large-scale production with a high degree of mechanization, also contributes to increasing this amount of emissions. Therefore, promoting a green economy and controlling environmental impacts has become an urgent requirement.

In terms of policies, the government has issued many regulations towards sustainable development, in which the Decree on the Management of industrial areas and economic zones plays an important role. With the National Green Growth Strategy (2021-2030), government aims to restructure the economy towards a green and low-carbon model and reduce at least 15% in GHG emissions per GDP by 2030. So as to achieve the goals, regulatory framework has been completed by established Law on Evironment Protection and a Circlar Economy Scheme, then extended Producer Responsible Ruglations for producers to be more responsible with their products and packaging. In addition, Vietnam can access advanced technology and improve the per capita income by attracting more FDI into the manufacturing ecosystem.

However, the implementation process still faces many challenges, requiring coordination between state agencies, businesses and the community to remove obstacles and strengthen cooperation in the production ecosystem.

Moreover, the model of this study does not account for other environmental, social, or technological indicators that could affect Vietnam's green growth dynamics and the use of secondary time-series data from 2000 to 2022 may involve measurement bias and restrict the precision of the findings.

Based on our study, future research can focus more on improving the quality of green ecosystem development and expanding data sources to have a broader view of the relationship between economic growth and CO_2 emissions. Thus, more accurate policy decisions will be made, and Vietnam's green economic growth will be sustained in the long run.

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