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Economic Growth-Environment Relationships in Developing Countries: Panel Evidence on EKC Dynamics, Energy Use, and Population

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Abstract

The impact of economic growth on environmental quality remains uncertain, with inconsistent results across various indicators. This study aims to address this gap by examining the effects of economic growth, gasoline consumption, and population on air quality in developing countries. The Environmental Kuznets Curve (EKC) theory suggests an inverted U-shaped relationship between economic growth and environmental degradation, but empirical evidence, especially in developing countries, remains mixed. Using panel data analysis, this study combines these three variables to provide a more comprehensive understanding of their collective impact on air quality. Data from 24 developing countries from 2014 to 2023 are analyzed, with findings revealing significant influences of economic growth, gasoline consumption, and population dynamics on air quality. Based on these findings, a key policy implication is enhancing public awareness of ecological issues to encourage environmental responsibility. Educating the public on the impact of their actions can promote sustainable practices, such as reducing energy use and waste. Additionally, promoting sustainable economic development models is essential. Developing countries should focus on balancing growth with environmental protection by adopting green technologies, renewable energy, and environmentally conscious industrial practices. This research contributes to the understanding of how economic and demographic factors interact to affect air quality in developing nations.

Keywords: *Environment, Economy, Gasoline, Population, Developing Countries, Air Quality, Degradation, EKC.*

JEL Classifications: Q53, Q56, Q58, O44, C33.

Introduction

Human activities have significantly altered the Earth's natural systems, often exceeding the planet's ecological carrying capacity and threatening long-term environmental stability. The increasing reliance on fossil fuels, rapid industrialization, and expanding urbanization have intensified environmental pressures, leading to deteriorating air quality and rising greenhouse gas emissions. These challenges pose serious risks not only to ecosystems but also to human health and economic sustainability (Pujiati & Imron, 2020; Sachs, 2015).

One of the most debated scientific problems in environmental economics is the complex relationship between economic growth and environmental quality. While industrial expansion and energy consumption have historically contributed to pollution, some theories, such as the Environmental Kuznets Curve (EKC), suggest that economic progress may eventually lead to improved environmental outcomes through technological advancements and regulatory policies (Yang et al., 2023; Sutikno et

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al., 2024). However, empirical findings on this relationship remain inconsistent, with some studies indicating that economic growth exacerbates environmental degradation (Widyawati et al., 2021; Malik et al., 2021), while others highlight potential benefits through cleaner production methods and policy interventions (Candra, 2018; Fauzi, 2017; Kurniarahma et al., 2020).

In addition to economic expansion, population growth plays a crucial role in environmental sustainability. Increased demand for energy, transportation, and industrial production leads to higher emissions of CO_2, NO_x, and particulate matter, worsening air pollution (Chaurasia, 2020; Todaro & Smith, 2003). Developing nations, in particular, face the dual challenge of fostering economic development while mitigating environmental harm, often lacking the infrastructure and policies needed to balance these priorities (Todaro & Smith, 2003). Research also shows that as countries advance economically, their awareness of environmental quality increases, prompting efforts to transition toward cleaner energy sources and stricter environmental regulations (Oktavilia et al., 2019).

Empirical studies suggest a close relationship between carbon dioxide emissions and energy consumption, as countries continue to follow carbon-intensive growth models (Álvarez & Montañés, 2023). The transportation sector remains a significant contributor to air pollution, accounting for a large share of CO, CO_2, NO_x, and unburned hydrocarbons (UHCs) due to fossil fuel combustion (IEA, 2021; Upadhyay et al., 2023; Kuang & Lin, 2023). Without effective energy management and policy intervention, the ongoing reliance on oil and gas consumption may further degrade air quality and accelerate climate change.

Understanding the interplay between economic growth, population expansion, and environmental degradation is essential for addressing air quality challenges in a rapidly developing world. The scientific challenge lies in determining the extent to which economic progress and demographic shifts influence environmental sustainability and identifying the most effective strategies to balance economic and environmental objectives.

Human behavior in satisfying its needs and desires often exceeds the carrying capacity or endurance of the Earth, which will eventually threaten the future survival of nature and even humans and other organisms. Human ad behavior like using dirty energy and industrial will impact to the quality of the environment specially the pollutant effect (Pujiati & Imron, 2020; Pujiati et al., 2023) When humans exceed the carrying capacity of the Earth, it means that the pressure on the environment becomes greater than the ability of the Earth's natural system to accommodate human pressure. The result is that the functioning of the Earth's ecosystem has undergone major changes. These changes in turn will also threaten human well-being and even human survival (Sachs, 2015).

Previous studies have shown that economic growth through energy consumption increases carbon dioxide (CO2) emissions (Arista & Amar, 2019; Boontome et al., 2017; Namahoro et al., 2021). In contrast, other studies have shown that emissions are not an engine of economic growth, and the CO2 emissions can hinder economic growth at very high costs by causing health burdens and reducing human productivity (Dong et al., 2018; Todaro & Smith, 2003). Studies in multiple countries have found that environmental quality was affected by economic growth, that was economic growth has a positive impact on environmental quality (Candra, 2018; Fauzi, 2017; Kurniarahma et al., 2020), in the other studies of economic growth can harm environmental quality (Widyawati et al., 2021; Malik et al., 2021). Furthermore, studies about the impact of economic growth on environmental quality show that the higher the economic growth has a better impact for CO2 emissions on environmental, that was the process of a country developing its economy and improving the well-being of its people requires the management of natural resources. Although the other studies have shown different situations, short-term increases or decreases in CO2 emissions take a long time. This was because the change of economic structure taking a long time (Kurniarahma et al., 2020). Although many researchers have used various environmental indicators, the positive or negative relationship between economic growth and environmental quality remains unclear based on the results of empirical studies.

With the increase in the number of vehicles was increased the fuel consumption and more fuel was burned, generating pollutants that are very life-threatening. These pollutants are CO, CO2 and HC emissions. The main source of pollution was at the transportation sector, which produces nearly 60% of the pollutants in the form of carbon monoxide (CO) and about 15% hydrocarbons (HC). In addition to the production aspect, the recent excessive consumption of oil has also had a profound impact on all areas of life, especially air quality and air pollution. In addition, the continued burning of fossil fuels also has a negative impact on the environment due to oil consumption. The smoke produced by the combustion of petroleum fuels leads to a deterioration of air quality, which contains harmful gases such as CO, NOx and UHC (unburned hydrocarbons) as well as metal elements such as lead (Pb). Then greenhouse gas emissions caused by carbon dioxide gas produced by burning oil will cause global warming. Therefore, the use or consumption of transportation and industrial fuels has negative externalities in three aspects: oil consumption, oil production, and the impact of greenhouse gas emissions caused by the combustion of fuel oil. Empirical studies have found that the relationship between carbon dioxide emissions and energy consumption is very close, which means that countries have maintained a fixed carbon-intensive fuel consumption pattern. It also shows that more efforts are needed to find cleaner energy production methods and achieve a more sustainable economy(Álvarez, & Montañés, 2023). A country's awareness of the significance of improved environmental quality increases with its level of development and progress (Oktavilia et al., 2019).

Due to the continuous growth of the world population, the demands of humanity are increasing, which may lead to the earth being unable to meet the needs of humanity. One form of earth incapacity, namely pollution, has become a major problem and has attracted worldwide attention so far. The impact of population growth leads to an increase in energy demand on the one hand and an increase in carbon dioxide emissions on the other hand (Chaurasia, 2020). The link between population and environmental degradation has received increasing attention. Population growth leads to great pressure on environmental carrying capacity (Todaro & Smith, 2003) which theoretically explains the relationship between population density and environmental degradation. As the world's population density and income levels increase, environmental conditions will continue to deteriorate due to degradation. Based on the research based on Todaro and Smith (2003) believe that rapid population growth and expansion of economic activities in developing countries may lead to serious environmental damage unless measures are taken to mitigate the negative impacts. This study also analyzes the relationship between population density and environmental quality. High population density may affect the high demand for natural resources such as water and fossil fuels, thereby increasing the pressure on environmental capacity (Todaro & Smith, 2003).

The relationship between economic growth and air quality is complex. In the early stages of development, increased industrial activity and energy consumption typically lead to higher pollution emissions. However, the Environmental Kuznets Curve (EKC) suggests that after reaching a certain level of affluence, countries can reduce pollution through environmental awareness, stricter regulations, and clean technologies (Yang et al., 2023; Sutikno et al., 2024). Similarly, while natural gas is considered a cleaner alternative to coal and oil, it still emits CO_2 and NO_x, and methane leaks during production and distribution can worsen pollution. Despite its lower emissions, effective management is essential to minimize greenhouse gases (IEA, 2021; Upadhyay et al., 2023; Kuang & Lin, 2023). Additionally, population growth exacerbates environmental harm by increasing energy consumption, transportation demand, waste generation, and urbanization, leading to higher emissions of CO_2, NO_x, and particulate matter. Research suggests that rapid urban expansion, particularly in developing nations with weak environmental policies, worsens air quality (Sarkodie et al., 2020).

Based on the empirical studies, the impact of economic growth on environmental quality still shows uncertain results in several indicators, so there was has a large research gap to answer these questions. In theory, the relationship between economic growth and environment can be explained by the Environmental Kuznets Curve (EKC). This study aims to analyze the impact of economic and non-economic growth on the air quality in developing countries. Therefore, this study adopts a comprehensive approach, considering both of economic and population aspects. By combining these variables, this study can make a significant new contribution to the literature and policy practice on the relationship between economic growth and the environment, especially in the study of air quality in developing countries. This study will provide answers to the question of which variables have the greatest impact on environmental problems. The answers will provide solutions in the form of policies to overcome current environmental problems.

Literature Review

Nowadays, the connection between environmental degradation and economic growth has garnered significant attention in economic literature. These issues can be categorized into three main areas: (a) behavior related to production and consumption, (b) deteriorating reserves of natural resources, and (c) deteriorating the quality of environmental resulting from heightened pollution. When examining the production and consumption patterns of energy and natural resources, it was crucial to consider various factors that can harm the environment, with plastic pollution being a prominent threat to both our planet and its oceans (Almiya et al., 2020). As our understanding expands, an increasing number of individuals recognize the significance of environmental sustainability. They begin taking steps to protect the environment, as human behavior is crucial to achieving sustainability (Suliswanto, 2024). This awareness has led to a shift in their lifestyle, with many opting to consume organic food (Endyanti et al., 2021)

Research trends on the connection between environmental deterioration and economic growth were analyzed in a study. Research employed a quantitative exploratory approach and performed a bibliometric analysis on articles that were registered between 1972 and 2022 in the Scopus and Web of Science databases. The data indicates that the number of publications and authors investigating the application of the Kuznets curve to ecological footprint indicators and carbon emissions, the two aspects deemed the most significant has significantly increased. Indicates that the relationship between environmental deterioration and economic growth is inverted U-shaped. Insufficient use of natural resources, particularly non-renewable energy contributes negatively to environmental deterioration. Consequences highlight how urgent it is to make coordinated efforts to address this pressing matter (Coronado et al., 2024).

An analysis of 15 wealthy countries was conducted to look at the relationship between economic development and energy use between 1986 and 2015. The findings of the cointegration test indicate that there is a sustained correlation between energy use and economic growth. There is a bidirectional causal relationship, according to the findings of the Dumitrescu-Hurlin causality test study. The analysis's conclusion is that, for the 15 industrialized countries that were chosen, economic development and energy use are causally related to one another between 1986 and 2015 (Uçan et al., 2022).

The literature study explained that economic factors was not most responsible for global environment deterioration, contrary to popular belief. Environmental degradation also influenced by a number of other factors, including population growth, lifestyle choices, and carbon emissions. These non-economic elements are, nevertheless, also influenced by economic variables. Consequently, utilizing a number of hypotheses that will be covered in the section that follows, this study will examine the relative weights that economic and non-economic factors have on the environmental quality index in emerging nations.

Hypothesis and Research Model Construction

The comprehensive understanding of the relationship between economic growth and the environment after going over some of the empirical studies mentioned above. This comprehension serves as a foundation for formulating theories and building the mathematical models that this investigation will use.

Effect of Economic Index Growth on Air Quality

The air quality and economic growth have a complicated relationship; in the early phases of economic development, higher levels of industrial activity and energy consumption typically result in higher levels of pollution emissions. However, the idea of the Environmental Kuznets Curve (EKC) demonstrates that, via improved environmental consciousness, stronger application of legislation, and the adoption of clean technology, countries are frequently able to reduce pollution levels after reaching a certain level of affluence. Additional study emphasizes the significance of green technologies and efficient environmental regulations in lowering pollution in conjunction with economic expansion (Yang et al., 2023; Sutikno et al., 2024).

H1: Economic growth has a positive (unidirectional) influence on the air quality.

The Effect of Natural Gas Consumption on the Air Quality

Despite being seen as a less polluting energy source than coal and oil, natural gas nevertheless emits CO2 and NOx, which can raise the air quality. Since natural gas produces fewer emissions than other conventional energy sources, it is sometimes seen as a step toward cleaner energy. However, methane leaks that occur during the distribution and production of natural gas have the potential to worsen air pollution issues and the greenhouse effect. Thus, while using natural gas can lower certain pollution, effective management is required to reduce all emissions, including greenhouse gases (IEA, 2021; Upadhyay et al., 2023; Kuang & Lin, 2023).

H2: Natural gas consumption has a positive (unidirectional) influence on the air quality.

Effect of Population on Air Quality

Population growth and the air quality are strongly correlated because population growth typically results in an increase in environmentally harmful human activity. Increased energy use, transportation, waste generation, and urbanization are all brought on by population growth and result in higher emissions of pollutants like carbon dioxide (CO2), nitrogen oxides (NOx), and fine particles. Research indicates that locations experiencing rapid population development typically have worse air quality, particularly in metropolitan areas where there is a high concentration of people and inadequate infrastructure to handle the rising levels of pollution. Furthermore, poorer nations see a greater negative impact due to laxer environmental rules, subpar waste management, and outdated emission technology (Sarkodie et al., 2020).

H3: The number of people has a positive (unidirectional) influence on the air quality.

Method, Data, and Analysis

In order to determine which of the three variables has the biggest impact on the air quality, this study aims to look into how economic and demographic factors affect the air quality in emerging nations. As seen by the framework of the pincer thinking notion in Figure 1, these two components are connected and intimately related to the environmental aspect.

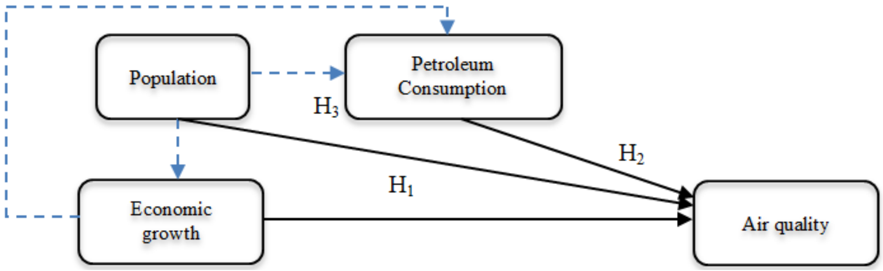

Figure 1. Conceptual Framework of Research and Hypothesis Mapping of the Relationship between Independent and Dependent Variables.

Source: Researcher

The visual conceptual framework of independent interactions between the population and the dependent variable the air quality explained in Figure 1. The economic aspects are represented by economic growth and gasoline fuel consumption, while the demographic elements are represented by the population. Whereas dotted lines depict the relationships between independent variables, straight lines depict the relationships between independent variables and dependents. The aforementioned figure illustrates the relationship between population and demographic factors, including economic growth and gasoline consumption, and environmental quality, specifically the air quality. According to the hypothesis, there is a positive or unidirectional link between independent factors and dependents, which means that when independent variables increase, the air quality will rise or the quality of the environment would decline. Apart from elucidating the connection between.

Research Approach

To use quantitative data to examine the relationship between the variables in the study model. Regarding the meaning of quantitative research, there are two schools of thought in academia: the one stresses the mathematical techniques employed in the field, while the second emphasizes the importance of numbers or quantities. The first opinion defines quantitative research as an umbrella word for a collection of mathematical and statistical techniques used in verifying theoretical ideas. It also refers to the statistical analysis of observational data, experimental data, and other data (Slevitch, 2011), which focuses on quantifying, computing, and examining connections between things in order to discover the fundamentals of those connections (Xiong, 2022). The second opinion is that any research that presents, explains, and analyzes a problem or object of research in terms of its magnitude or magnitude is quantitative research, and the essence of quantitative research is to use mathematical language, mathematical symbols, and others, to elaborate and explain the problem (Mohajan, 2020).

Objects and Sources of Research Data

Using panel data and serial data for the years 2014 to 2023. These countries are Nigeria, Turkey, Indonesia, Malaysia, Thailand, Philippines, Ukraine, Pakistan, South Africa, Brazil, Russia, Colombia, Mexico, Chile, Peru, Hungary, Czech, China, Romania, Bulgaria, Poland, South Korea, Croatia, and

India. This study's data came from a number of trustworthy sources, including the World Bank, Numbeo, The Global Economy, and World Population. Static panel data regression was utilized in this study to examine the relationship between independent and dependent variables. The operational definitions and data sources for each variable in the regression model are shown below in Table 1.

Table 1. Variable Operational Definition

Variable	Information	Unit	Source
Economic growth	Total GDP of Emarging Market country.	Billion ($)	https://data.worldbank.org/
Gasoline fuel consumption	Consumption of fossil fuels (petroleum)	Thousand/Barrel	www.theglobaleconomy.com
Population	The total number of people or residents in an area	Millions of people	www.worldpopulationreview.com
Air quality	A measure used to assess air pollution.	Index	www.numbeo.com

Source: Researcher

Natural logarithms (Ln) were used in this work to translate data on population increase, gasoline fuel use, carbon emissions, and greenhouse gas emissions. In order for the parameters to be understood as elasticity, the study data is transformed into a natural logarithmic form. The natal logarithm (Ln) is the form of logarithm employed in this study model.

Objects and Sources of Research Data

This study uses three estimation models, namely the Common Effect Model (CEM), Fixed Effect Model (FEM) and Random Effect Model (REM). The regression equation in estimating the research model is as follows.

$$LnY_{it} = \alpha + \beta_1 lnX_{1it} + \beta_2 lnX_{2it} + \beta_3 lnX_{3it} + e_{it} \dots (1)$$

That was:

Yit = Air quality (Bound Variable)

lnX1it = log Economic growth

lnX2it = log Gasoline fuel consumption

lnX3it = log Population

t = Period t

i = Entity i

α = Constant

e = Variables outside the model

A panel data regression analysis model was used to assess the impact of population, gasoline consumption, and economic growth on the Air quality from 2014 to 2023. Three different model types can be used to understand the panel data regression model: the Common Effect Model (CEM), the Fixed Effect Model (FEM), and the Random Effect Model (REM). One of the Housman test and Chow test model estimating approaches is applied to identify the optimal model (Hasanah & Ahmadi, 2017).

The researcher used the log approach in order to acquire significant and reliable estimation results prior to doing data management. The log technique is employed by researchers for two primary reasons: Since one of the core tenets of traditional regression models is that variables are not freely distributed normally, you need first normalize the data distribution. Data isn't always normal in practice. In nature, a lot of economic facts are not regularly distributed. Second, the rationale for interpretation, mathematically the change in the recorded data is an approximation of the relative change (in percent) of the starting data (before the transformation). As a result, there is greater meaning in the interpretation of the marginal effect of changing the free variable on the non-free variable.

A follow-up test for choosing panel data regression models is the Hausman test. The Hausman test compares the effectiveness of FEM and REM to determine which model is better. If the Chi-square Probability value is less than alpha (α) (0,0000 < 0,05), FEM is preferable to REM, and vice versa, if the Chi-square Probability value is greater than alpha (α) (0,0000 > 0,05), REM is preferred to FEM. The Statistical Significance Test comes next after the optimal model has been identified. The F test (Concurrent Significance Test) is used in statistics.

Result and Discussion

Model Estimation Results

The two questions this study seeks to address are: what factors have a greater impact on environmental quality than the other three? And how do economic, ecological, and demographic variables affect environmental quality? Three estimation models was the Common Effect Model (CEM), the Fixed Effect Model (FEM), and the Random Effect Model (REM), were utilized to analyze the effects of the following variables on the Air quality: population, petroleum consumption, carbon emissions, greenhouse gas emissions, and economic growth (REM). However, it is necessary to confirm that the model has passed the classical assumption test before estimating it. The results of the statistical tests achieved on the estimations of the CEM, FEM, and REM models.

Table 2. Model Estimation Results

Variable	*CEM*		*FEM*		*REM*	
	t-Statistics	P>| t |	t-Statistics	P>| t |	t-Statistics	P>| t |
LnEconomic Growth X1	-6.40	0.000	-3.76	0.000	-3.91	0.000
LnGasoline Fuel Consumption X2	3.92	0.000	0.43	0.000	1.01	0.312
LnPopulation X3	12.14	0.000	0.48	0.000	5.59	0.000

Source: Stata 17, processed

This study used the Natural Logarithm (Ln) method, which attempts to eliminate excessive data fluctuations, based on the previous estimating methodologies, notably by modeling the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) in data processing. There are a few stipulations in the (Ln) model that need to be taken into account, including the fact that the Ln model's coefficient has a straightforward interpretation and that the Ln model frequently lessens the general statistical issue known as heterogeneity. Tests are then conducted to determine which estimating model is optimal. The best model between the CEM and REM models is determined using the LaGrange more multiple (LM) tests in the first phase, and the FEM or REM model is determined using the Hausman test in the second. The results of the LaGrange multiplier test and the Hausman test on the three models can be seen in Table 3. The results of the calculations in the table below explain that each model has different significance values.

Table 3. Chow Test

Model Comparison	Prob > F	Decision
CEM vs. FEM	0.000	Reject CEM, Use FEM

Source: Stata 17, processed

The limited F-test findings from the FEM output data, as displayed in Table 3, indicate that the Fixe Effects Model (FEM) is the most appropriate preliminary model since the probability value of F = 0.0000 is below the 0.05 significance threshold, leading to the rejection of H0 (CEM). Given this outcome, a Hausman test is necessary to determine whether the Random Effects Model (REM) or FEM is more suitable. The Hausman test operates under the assumptions that H0 = REM and H1 = FEM. The test findings, displayed in Table 4, show a chi-square probability of 0.0134, which is less than 0.05. As a result, H0 (REM) is rejected, confirming that the H1 (FEM) is the most suitable model for adoption.

Table 4. Hausman Test

Model Comparison	Prob > chi²	Decision
FEM vs. REM	0.0134	Reject REM, Use FEM

Source: Stata 17, processed

Multicollinearity, heteroskedasticity, and autocorrelation are demonstrated by the traditional assumption test; therefore, the model must be cured by employing the seemingly unrelated regression (SUR) approach in order to pass the test. The healing outcomes in the FEM model are listed in Table 5. below.

Table 5. FEM-SUR Results

Variable	Coefficient	Std. Err.	T-Value	P-Value
LnEconomic Growth (X1)	-5.83494	0.90380	-6.46	0.000
LnGasoline Fuel Consumption (X2)	3.70525	0.93630	3.96	0.000
LnPopulation (X3)	9.06181	0.77505	12.24	0.000
Intercept (_cons)	22.06181	14.03712	1.57	0.116

Source: Stata 17, processed

From the results of the regression of the Fixed Effect Method (FEM) model through improvement with the seemingly unrelated regression (SUR) method, by determining independent variables that do not have a significant influence on the model, the following equation was produced.

$$Y = 22.06181 + -5.83494 * \ln X1 + 3.70525 * \ln X2 + 9.06181 \ln X3 \ldots\ldots\ldots \quad (2)$$

From the results of the regression equation of the above panel data, it can be interpreted: that first, the constant value of 20.35941 shows the value of the air quality constant (Y). The air quality will have a constant or stable value of 22.06181 if the variables of economic growth, carbon emissions, greenhouse gas emissions, gasoline fuel consumption, and population numbers are all equal to zero or constant.

Additionally, a significant effect was found for the economic growth variable (X1), as evidenced by the negative coefficient value of -5.83494 that was obtained and the t-table value of 0.000. This suggests that an increase in economic growth will likely result in a decrease in the air quality in developing nations. In the meantime, gasoline fuel usage (X2) had a considerable impact as indicated by its positive coefficient value of 3.70525 and t-table value of 0.000. This means that every increase in gasoline usage will increase the air quality. Additionally, the population variable (X3) showed a significant effect with a positive coefficient value of 9.486292 and a t-table value of 0.000 in the results. This implies that in emerging nations, the air quality will rise with every increase in population.

The results of this study indicate that economic growth has a significant negative impact on air quality in developing nations. The regression analysis shows that the coefficient for LnEconomic Growth (X1) is -5.83494, with a p-value of 0.000, indicating a strong and statistically significant relationship. This suggests that as economic growth increases, air quality tends to deteriorate. The negative relationship may be attributed to the expansion of industries, increased energy consumption, and higher emissions associated with economic development. Without adequate environmental regulations, economic growth can contribute to rising pollution levels, leading to adverse health and ecological consequences.

Similarly, gasoline fuel consumption (X2) is found to have a significant impact on air quality, with a positive coefficient of 3.70525 and a p-value of 0.000. This result implies that increased gasoline usage is associated with worse air quality, likely due to the release of harmful pollutants such as carbon monoxide and nitrogen oxides from vehicle emissions. The growing demand for transportation in developing countries, driven by urbanization and population growth, exacerbates this issue. Without cleaner fuel alternatives or stricter emission controls, gasoline consumption will continue to be a major contributor to air pollution.

Furthermore, the population variable (X3) also shows a significant positive effect on air quality, with a coefficient of 9.06181 and a p-value of 0.000. This indicates that a larger population correlates with increased pollution levels, likely due to greater energy consumption, industrial expansion, and increased waste generation. Rapid population growth in developing nations places additional strain on infrastructure and natural resources, leading to a decline in air quality if sustainable policies are not implemented.

The intercept (constant) in the regression model is 22.06181 but is not statistically significant (p-value = 0.116). This suggests that the baseline level of air quality when all independent variables are at their reference levels is not a reliable predictor. Therefore, the focus should be on the explanatory variableswhich have been found to significantly impact air quality.

Findings and Discussion

The findings of this study show that economic growth has a negative effect on the increase in the air quality (H1). The results of the analysis are in line with the results of other studies that state that along with the increase in economic growth, the quality of the environment will also improve (Widyawati et al., 2021) These findings are in line with the concept of the Environmental Kuznets Curve (EKC) showing that after reaching a certain income level, countries are often able to reduce pollution levels through increased environmental awareness, stricter implementation of regulations, and the adoption of clean technologies (Yang et al., 2023)

This study's premise was supported by the fact that increasing gasoline use has a beneficial impact on raising the air quality (H2). Consistent with the study's findings (González-Álvarez & Montañés., 2023) discovered that there is a strong correlation between energy consumption and CO2 emissions; this suggests that these nations have stuck to a consistent consumption pattern of fuels that contribute to carbon intensification. It also demonstrates the need for more work to develop more sustainable economic practices and discover cleaner ways to produce energy such as using of biodiesel from natural local plant (Sholiha & Yuniastuti, 2024). Therefore, there are three negative externalities associated with the use or consumption of fuel for industry and transportation: oil production, oil consumption, and the impact of greenhouse gas emissions from the burning of fuel oil (Sholiha et al., 2024).

This finding is consistent with the study's premise, which states that a rise in population has a positive impact on an increase in the air quality (H3). The present study's findings are consistent with the research conducted by Sasana & Aminata, 2019 which found that a country's population growth is positively correlated with CO2 emissions. Specifically, higher population levels are associated with higher per capita energy consumption, which exacerbates air pollution and poses a threat to the environment and health of living organisms, provided that the pollution is not absorbed by the soil. These findings support the idea positing a connection between environmental degradation and population growth (York et al., 2003) Land cannot produce enough agricultural goods to meet the population's growing food needs due to population growth. The carrying capacity of soil as one of the components of the ecosystem would decline and subsequently result in a high degree of pollution owing to the usage of fuel, especially those that cause greenhouse gas emissions.

The population variable was also shown to be the most important factor influencing changes in the Air quality in emerging market nations. According to this study, changes in the air quality were more heavily influenced by demographic factors than by economic ones, such as economic growth and gasoline fuel usage. Therefore, regulations pertaining to environmental issues should place greater emphasis on the relationship between environmental issues and public awareness. Campaigns to raise public awareness of the risks posed by pollution are now being conducted in relation to the threat posed by air pollution. In addition to stimulating innovation in renewable energy sources and lifestyle modifications, this will raise human quality as shown by the Human Development Index. Even though population growth is ongoing in many nations, if this growth is accompanied by a rise in the good human quality index, it will spur innovation and raise public awareness of environmental degradation (Esquivasi et al., 2022; Suliswanto, 2022).

Research Limitations and Future Research Recommendations

This study still has several limitations that point the way for more research even though it generates new discoveries and facts that help clarify the idea of the Environmental Kuznets Curve (EKC) and direct policy on environmental issues in emerging nations. Firstly, the population data used in this study is not sorted by age group; rather, all residents are counted starting at age 0, which has no bearing on environmental impact. To further represent the population that interacts with the environment, the number of persons aged 7 and older should be included in future study. Second, although a non-linear model will be preferable for future research, the current model is still linear and does not adequately support the Environmental Kuznets Curve (EKC) theory.

Conclusion and Suggestion

The following conclusions can be drawn from the data analysis conducted in the results subchapter and discussion: (a) economic growth, population, and gasoline consumption all have an impact on air quality in developing countries; (b) demographics, as opposed to economic variables, have the greatest impact on air quality in developing countries. Based on the findings mentioned above, the policy implications that can be implemented are that population growth must be balanced with greater community education to provide knowledge about environmental quality conservation.

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