GREEN GROWTH: THE COST OF URBANIZATION IN AIR QUALITY TERMS

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ABSTRACT

The objective of this paper is to analyze the relationship between urbanization and air pollution using cross-section data to better understand the relationship and recommend policies toward the "Green Future". The data for OLS regression analysis was taken from the official database of the World Bank. Claiming the hypothesis of the positive relationship between air pollution and urbanization, the results of this analysis comply with the findings of the previous literature. Sample size consists of 45 countries randomly chosen from the IQAir website. The limitations of this analysis are acknowledged at the end with further recommendations for future research

Introduction

Air quality has become a common topic of discussion over the past few years. According to Goossens et. al. (2021), urbanization is one of the major contributors of air pollution. The idea of "green growth" has become prevalent in discussions of sustainable development, especially in rising nations that try to find a balance between environmental sustainability and economic growth. Over the past 20 years, the economy has been expanding rapidly in most countries, has seen a noticeable increase in its urban population, indicating the need for suggestions towards green development. Urbanization presents significant environmental concerns, especially in the form of worsening air quality, even as it frequently raises living standards, diversifies the economy, and improves infrastructure. The environmental consequences of expanded industry sector and population density are reflected in the significant rise in fine particulate matter (PM2.5) levels in large cities, including Lahore, Tashkent, New Delhi and others.

This paper aims to empirically assess the impact of urbanization on air quality, combining available data and regression analysis from the settings of different countries. It also focuses on the more general relationship between environmental outcomes, sectoral contributions (industry vs. services), and economic development. The results are meant to guide policy suggestions that match long-term sustainability and green growth goals with urban development.

Literature Review

In the context of empirical research, a critical analysis of existing findings, methodological strategies, and patterns across various settings is necessary to comprehend the relationship between urbanization and air quality. The major studies that examined the environmental effects of urbanization are reviewed in this section, with an emphasis on air pollution, notably PM2.5 levels, as a quantifiable measure of air quality.

Urbanization is one factor that can contribute to air pollution. The main reason for this assumption is linked to the density of population in urban areas, meaning that there will be an increase of needs in infrastructure, transportation, energy and other utilities. In the article written in the Sustainability journal by Fang, Ch., et. al. (2015), it is claimed that there is a strong positive correlation between urbanization and the level of PM2.5 particles in air. In other words, the regression analysis they run revealed that urbanization increases pollution on air in China. Furthermore, Guangdong Li and his colleagues in 2016 also remarked that as the density of population increases, the air pollution rate also goes up.

Economic development has an indirect effect on air quality. The assumption proposed by most literature highlights that governments start prioritizing sustainability as the income level increases and the economy matures. In other words, air quality worsens at the beginning of development phase and gets better after a certain level since the country has sufficient funds to adopt policies to prevent environmental issues. More precisely, countries with high GDP per capita tend to have less air pollution levels. In their paper written in collaboration by Liang, Wang and Li, researchers from different universities of China stated the adverse behavior of correlation of Air Quality Index and economic growth. In other words, they stated that countries with strong economies tend to have less air pollution than low GDP countries (2019). In addition, Qi, Che and Wang, maintained the same view in their paper published in Ecological Indicators journal in 2023. Moreover, air pollution depends not only on the level of GDP but also on the sector of composition. According to Dinda, et. al. (2021), the sectors which involve manufacturing contribute more air pollution than the service sector. Naturally, production and industrialization require more resources than the services sector, causing air pollution apart from other negative environmental externalities.

In conclusion, air quality is affected by many factors, including urbanization, economic growth and the primary economic sector of the country. The common finding was that as more and more people live in cities, the quality of air worsens. However, to strengthen the empirical understanding of these relationships, particularly in under-researched regions, a rigorous regression analysis will be conducted. The findings will be presented and discussed in the results section to address existing gaps in the literature.

Methodology

In this study, cross-sectional data is used while statistics are retrieved from World Bank Development Indicators and IQAir databases for the year 2023, focusing on randomly chosen 45 countries. The brief definition of each variable is explained in Table 1 below.

Variable	Definition
AQI	Air Quality Index is dependent variable
Urbanization	Percentage of urban population is the independent variable of interest
GDP_pc	GDP per capita is the independent control variable
Prim_Ecs	Primary economic sector is dummy variable (Service-dominated and Industry-dominated)

Table 1: Definition of variables

Air pollution levels are defined by the dependent variable, AQI. While GDP per capita serves as an indicator for economic development, which is an independent variable, the percentage of the population living in urban areas represents the level of urbanization. The second control variable is the primary economic sector in that country with assigned values of 0 and 1 for Agriculture/Services and Industry/Manufacturing respectively by their nature. This classification is based on the percentage contribution of each sector to GDP of the same country. Evident from the literature that as the agriculture and service sector causes less air pollution compared to manufacturing and industry sectors, I decided to merge and set them together to define them as dummy variables. Finally, each observation is independent from one another.

Summary of the dataset is as follows:

Variable	Observation	Mean	St Dev	Min	Max
AQI	45	19,491	14,39	4	79,9
Urbanization	45	65,111	22,42	19	100
GDP_pc	45	23115,624	28239,13	1013	128259,4
Prim_Ecs	45	0.2	0.405	0	1

Table 2: Summary statistics

There are expected and unexpected figures on the dataset provided. One of them is that most countries which have high GDP per capita have lower PM2.5 particles per m^3. In addition, although qualitative data is not expressed in numbers, it is clear from the dataset table that the primary economic sector in many countries is services, not industry or manufacturing. Finally, and perhaps most importantly, as seen from the summary statistics table, the standard deviation of GDP per capita is relatively high, meaning that there are outliers on the dataset on both tails.

The following econometric model is used to estimate the relationship among variables:

$AQI_i = \alpha + \beta_1 * Urbanization + \beta_2 * GDP\_pc + \beta_3 * Prim\_Ecs + u$

Where:

α is intercept,

β, β_2 and β_3 are the parameters of each variable respectively

u is the error term (unobservables).

When it comes to regression analysis, the Ordinary Least Squares (OLS) method is used in this analysis since it minimizes the difference between sum of squared residuals of real and predicted results. This method can be the best linear unbiased estimator when it satisfies all its assumptions. Therefore, this model is applied under the assumption of homoscedasticity, normality and no multicollinearity after testing in Stata. Additional tests performed in Stata software:

(i) F test (for the overall model significance with fixed effects)
(ii) Jarque-Berra (for normal distribution of the residuals)
(iii) Breusch–Pagan (to check for the signs of heteroscedasticity)
(iv) Variance Inflation Factor (for multicollinearity check)
(v) Ramsey RESET test (for omitted variables)

The sign of heteroscedasticity is corrected by using robust standard errors adjustments while the result of Ramsey RESET test indicates the possibility of omission of certain other variables, indicating one of the limitations of this paper. Other assumptions are not violated in the dataset.

Results and Interpretations

In this section, key regression outputs, including coefficient estimates, significance levels, and goodness-of-fit measures, are reported and interpreted to assess the validity of the proposed hypotheses. Two models are tested in this analysis. The first model determines the relationship between the main dependent and independent variables while the second one comprises control variables to reduce the omitted variable bias. The regression results for both models are presented in the table below:

Variables	Model 1	Model 2
AQI		
Urbanization	0.2325	0.2364
	(0.0912)	(0.1169)
GDP_pc	-	-0.00000613
	-	(0.0000929)
Prim_Ecs	-	12.5795
	-	(4.8022)
Constant	34.6287	32.5088
	(6.2734)	(6.7106)
R squared	0.1313	0.2559
F statistics	6.50	4.70
N	45	45

Table 3: The estimated models

Model 1: The coefficient of independent variable *Urbanization* in both models is positive. More precisely, for the first model, 1 unit (percent) increase in urbanization leads to 0.2325 unit increase in PM2.5 legend per m^3 on average (ceteris paribus). The standard error for the variable of urban population is 0.0912 which is less than the coefficient of it. Therefore, it can be claimed that the estimate is relatively precise, and the *Urbanization* variable is statistically significant in this model.

Further to explain, when urbanization level equals 0, the AQI is expected to be 34.6287 that is regarded as the intercept or, in other words, constant value. The figure for R-squared equals 0.1313 in the first model, which represents that 13.13% of the variations in AQI can be explained by the independent variable, urbanization level. As for looking at the value for F-statistic, 6.50, we can claim that urbanization has a significant impact on air quality by comparing values of F-critic at 5% and F-stat which lies in the rejection area. The positive relationship can also be determined in the graph with logarithmic trendline:

Model 2: In the second model, the coefficient for *Urbanization* variable did not significantly change compared to the first model, with a value of 0.2364. This finding complies with the finding of Fang, Ch., et. al who claimed that as urbanization increases air quality worsens. Furthermore, GDP per capita has very little negative impact on air quality. In other words, holding all other variables constant (ceteris paribus), if GDP per capita increases by $10000, AQI is about to decrease by 0.0613 units, which is similar to the findings of Liang, Wang and Li, written in the literature review section.

The relative coefficient for *Prim_Ecs* equals to 12.5795, meaning that countries in which industry/manufacturing sector is dominant, are expected to have this figure much higher AQI compared to service/agriculture dominated countries as indeed remarked in literature review. Finally, the value of the R-squared increased by almost two times as much as the addition of two control variables. In other terms, approximately 26% of the model can be explained by using the independent and control variables included. However, as this percentage value is relatively small, we can say that there are other important variables which affect AQI but not included in this model estimates. The F statistic value is 4.70 in the second model. When compared to F critic, it still lies in the rejection region. Thus, we can say that urbanization has a significant effect on air quality at 95% confidence threshold.

Conclusions and Policy Recommendations

As more and more people start to live in cities, the amount of PM2.5 particles in air increases, indicating possible threat of urbanization to air quality. However, when countries grow economically, they usually start to prioritize sustainability and reduce air pollution as was supported by the regression results. Moreover, claiming the hypothesis, manufacturing and industry contributes to air pollution more than services and agriculture sectors of the economy. Based on the determined relationship between urbanization and air quality, the following policies are suggested to be implemented/improved to achieve sustainable development in the long run:

- Strengthening urban air quality monitoring and emissions reporting: to facilitate data-driven decision-making and raise public awareness of pollution levels, the governments should boost real-time monitoring of PM2.5 and other hazardous pollutants, especially in large urban and industrial zones.
- Promoting a "Green Urban Transport System": traffic-related air pollution may be greatly reduced by implementing low-emission zones, subsidizing electric vehicles, and increasing the usage of electric public transportation in cities. This would improve the environment and public health.
- Relocating or upgrading high-polluting industries away from cities: implementing infrastructural improvements and relocation incentives, moving high-emission sectors to specifically designated regions outside of crowded city centers will help minimize localized pollution and urban residents' health concerns.
- Air Quality Taxation: long-term sustainability would be encouraged, and excessive pollution would be financially deterred by introducing an air pollution tax that targets businesses and transportation systems that emit more pollutants than are allowed and reroutes the money to clean energy and public transportation development.

The government of not only Uzbekistan but also other countries can provide equitable economic opportunities for future generations by raising investment in sustainable urbanization policies by implementing the proposed recommendations.

Although the findings of this study comply with the previous literature, there were many challenges and limitations regarding selecting appropriate variables and data. One limitation was omitted variable bias. Other variables, apart from urbanization and economic status of the country, such as traffic density, adopted policies and renewable energy usage could have affected AQI. Furthermore, it must be stated that the data collected was cross-sectional rather than panel data. This prevents analyzing trends over the years and making inference about one country. Nevertheless, these limitations are not very critical to affect significantly the results of the regression analysis. It is recommended to consider these limitations in the future analysis.

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