Will Delhi be Habitable in the Future ?

Shubhneet Sanjay Arora [1]
Swarthak Ranjan Swain [2]

Abstract

Most of the existing research in the theoretical and empirical understanding of environmental Kuznets curve (EKC) is based on data from countries rather than cities. In contrast to these papers, the purpose of this particular paper was to investigate the pertinence of EKC in developing cities. The sample city considered for this paper is Delhi, the capital of India. The paper aimed at predicting the year in which EKC will reach its eventual peak. We also investigated if the peak of Delhi will be before or after the severest magnitude of Air Quality Index as per national standards. We specifically selected Delhi for the study taking into consideration several factors. India is one of the fastest-growing countries, and it is also important to understand how well cities are performing. From the time of industrialization, it is a known fact that generation and consumption of electricity does have negative externalities on the whole ecosystem. This motivated us to merge the pollution and electricity consumption of Delhi with the hypothesis of EKC. Further, our test included the prediction of the year when the average AQI of Delhi will cross this level. The economy is on the upswing and so are the pollution levels, but eventually, this will show an inverse relationship. The anticipation of the turning point will let the policymakers formulate a better policy for the betterment of the city. Various pieces of evidence were collected from several sources such as published articles from journals, WHO, World Bank, etc.

Keywords : **environmental Kuznets curve (EKC), short run EKC, Delhi, pollution, air quality, GDP per capita**

JEL Classification : H790, O440, Q530, Q560

Paper Submission Date : April 25, 2020 ; Paper sent back for Revision : August 10, 2020 ; Paper Acceptance Date : October 15, 2020

Air pollution in India has taken a heavy toll on the environment and has evolved into a rather concerning and complex problem. The air quality is depleting at a staggering rate and requires immediate attention. Poor urban air quality is one of the world's worst toxic pollution concerns. Not only does air pollution causes health problems in adults, but also causes millions of premature deaths annually. The major pollutants that contribute to air pollution in Delhi are - particulate matter (PM), nitric oxide (NO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and ozone (O3), and on the other side, we have the greenhouse gases like carbon dioxide (CO_2) which also have an impact on health. The pollution in Delhi has become worse than ever. According to Ganesh, Singh, and Raj (2016), millions of lives have been lost and affected severely because of chronic respiratory diseases like asthma. The question in limelight is : Will the condition of Delhi become so vulnerable that it will render habitability in Delhi impossible ? The discussion of pollution is made specific to the city of Delhi and consequently, aims to obtain answers and highlight insights in relevance to the specific and exclusive problem of Delhi.

The theory of the environmental Kuznets curve (EKC) postulates an inverted-U-shaped relationship between

[1] *B.Sc. (Economics, Mathematics, Statistics) 2017 – 2020,* CHRIST (Deemed to be University), Bangalore - 560 029. (Email : shubhneetarora10@gmail.com) ; ORCID iD : https://orcid.org/0000-0001-7047-6117
[2] *B.Sc. (Economics, Mathematics, Statistics) 2017 – 2020,* CHRIST (Deemed to be University), Bangalore - 560 029. (Email : swarthak23799@gmail.com) ; ORCID iD : https://orcid.org/0000-0002-3048-0338

DOI : https://doi.org/10.17010/aijer/2020/v9i4/156809

different pollutants and per capita income, that is, ecological pressure rises to a certain extent as income increases; afterwards, it decreases. The EKC shows how the technically defined measure of environmental quality changes as the fortunes of a country change. The common point of all the studies is the assumption that the quality of the atmosphere deteriorates at the early stages of economic development and then improves at the later stages (Dinda, 2004). This hypothesis is valuable for forecasting values of the population.

In this paper, our first objective is to predict the year in which Delhi air pollution will cross the worst air quality mark. To obtain this year, we have created a regression model of second-order. GSDP per capita and per capita consumption of electricity of Delhi are the independent variables, and the Air Quality Index is the dependent variable. Our second objective is to predict when Delhi will touch the peak point of EKC. To achieve this objective, we have used an exemplary method. In this, analysis of time taken by various developed cities to attain the peak of EKC has been done.

Some explanation for the EKC downturn is the explanation that comes from literature emanating from the developed countries themselves. Stern (2004) explained that technology and capital, both of which developed countries have in abundance, are the main reasons for establishing the de-linking hypothesis. De-linking refers to decoupling of adverse environmental impacts from economic growth. The argument is that developed countries have the capital because they are capital intensive, and that capital can buy green technologies. This leads to de-linking when the developed countries go beyond a threshold, they can afford to harness such technologies, which are expensive but effective in reducing environmental degradation (Caleb, Gokarakonda, Jain, Niazi, Rathi, Shrestha, Thomas, & Topp, 2017). On the other hand, developing countries neither possess the technology nor do they have the necessary resources to implement these technologies. Further, developing overpopulated economies have two invariably negative features that are likely to aggravate the environmental problem, namely poverty and overpopulation. It is, therefore, argued that developed countries alone have the potential to delink pollution from growth. Even if the de-linking hypothesis holds, one could still doubt if the observed improvements in environmental quality would sustain in the long run. If such improvements could not be extrapolated into the future, delinking would only be a temporary phenomenon. This implies that there might come up an income level, where there would be technological and economic upper bounds to improvements in environmental efficiencies. At this stage, environmental degradation and economic growth would be relinked again. This is known as the re-linking hypothesis (De Bruyn & Opschoor, 1997).

Rizwan, Nongkynrih, and Gupta (2013) noted that air pollution accounted for many public health problems. The World Health Organization's urban air database published in September 2011 estimated that Delhi had surpassed the maximum PM10 mark at 198 $\mu g/m^3$ by nearly ten times. He noted that the emissions from vehicles and industrial activities in Delhi were consistent with air pollution both indoors and outdoors. Delhi air pollution and mortality studies found that mortality and morbidity due to all-natural causes increased with increased air pollution. Delhi has the largest cluster of small-scale industries in India, accounting for 12% of air pollutants along with other industrial units.

Carriazo (2016) explained the essence of the environmental Kuznets curve (EKC) and the possible explanations for the inverse U relationship between economic growth and pollution. The effect of regulation on emission mitigation is one of the most repeated reasons for the inverse U relationship. According to him, pollution, in general, is viewed as production and consumption-related economic problem. It is necessary, however, to recognize the public properties of the environment that may cause pollution. From an economic viewpoint, pollution was explained as a by-product of market failure.

Jain and Chaudhuri (2009) tried to investigate the environmental Kuznets curve hypothesis. By using time series data from 1990 – 2005 across countries, these researchers concluded that less developed countries such as India and China are on the rising part of the inverted U-curve, that is, having a highly polluted atmosphere ; whereas, developing to developed countries like the UK and Germany are on the falling part of the inverted U-curve, that is, decreasing the environmental pollution. On the other hand, developed countries like the USA and

Canada are on the rising part of the N-curve, that is, increasing environmental pollution. This indicated that both the inverted U-curve and N-curve are useful tools of analysis and can be used as indicators of economic development.

Meinshausen, Meinshausen, Hare, Raper, Frieler, Knutti, Frame, and Allen (2009) found that if we limit cumulative CO_2 emissions from 2000 – 2050 to 1,000 Gt (about 80% reduction in global emissions), there is a 25% likelihood of warming above the 2° C limit, and 1,440 Gt CO_2 over that duration (80% reduction in developed country emissions) provides a 50% likelihood of 2°C warming by the year 2100. Unless we maintain current emission levels, we're likely to exceed 2°C warming by 2100 by around 67%. In short, we need to reach significant reductions in global CO_2 emissions in the next 40 years to avoid the amount of global warming that is considered dangerous based on our knowledge of the environment and empirical evidence. It thus becomes quite clear that CO_2 is not only a pollutant, but also a danger to public health and welfare.

Kubatko (2008) made use of the environmental Kuznets curve (EKC) to model the impact of per capita income on pollution. His study's key finding was that Ukraine followed the EKC trend for some pollutants like SO_2, NO_2, and IZA, while there was a growing increase for other pollutants like dust, CO_2. His results based on the EKC predicted that pollution caused by SO_2 and NO_2 would begin to decline, while CO_2 and dust emissions would increase.

Stern and Common (2001) studied sulfur dioxide (SO_2) emission data and GDP series from 19 OECD countries during the 1870–2001 periods. Using the two-time series models, they conducted co-integration tests individually in each nation. From the Engle – Granger two-step method, they found that EKC regression was spurious for most of the countries. But when they integrated short-run dynamics and used unregulated ADL-transformed error correction model, they observed that most nations followed the EKC in the long-run and had a stable relationship between sulphur and income.

According to Suri and Chapman (1998), industrializing countries have a higher growth rate as opposed to industrialized countries. The study also showed that by importing manufactured goods, industrialized countries have been able to reduce their energy demands as opposed to industrializing countries. The study concluded that the main factor for the upward sloping portion was exports of manufactured goods by industrializing countries, and imports by industrialized nations have contributed to the downward slope of the Kuznets environmental curve.

Li, Chiu, and Lin (2019) analyzed the impact of economic growth and air pollution on public health in 31 Chinese cities. According to them, China's rapid economic growth in the last 20 years had brought about a commensurate increase in atmospheric pollution that has harmed both the environment and public health. Since 2013, the levels of SO_2, CO_2, and nitrogen oxide reached a level which can cause climate change and have adverse effects on residents, especially on their health. Their study results showed that in most cities, there is still a strong need for improvement. Therefore, investments in treatments need to be strengthened, and more specific measures are required to execute to increase efficiencies in urban pollution and health treatment. Carbon dioxide emissions and air pollutants have raised huge challenges before the environmental regulation of central and local governments. The impact of air pollutants on human health is extensive and long-lasting and should be prioritized in governance work.

According to Shah (2020), major metropolitan cities in India, including Bengaluru, Hyderabad, as well as Chennai are excellently and efficiently leading in the sphere of sustainable consumption of energy. These cities consume energy from renewable sources, which beneficially results in a safer and better environment. When this trend was brought under the light of comparison with Delhi, we noticed that even though usage of renewal sources is on the rise, Delhi lacks far behind in this trend and has a long way to go. Therefore, this is a matter of grave concern. The question of harnessing renewable resources to optimize sustainability still haunts the ever-growing city.

Research Gap

We observed numerous research gaps under the topic of environmental Kuznets curve. It is observed that all the research surrounding the verification of EKC was done for countries rather than cities. Our research paper's chief focus is on the prediction of the year when the average Air Quality Index in Delhi will cross the standard that has been set by WHO. Forecasting has never been done on EKC and Delhi pollution. Additionally, we aim to find the turning point of long-run EKC for Delhi.

Objectives

(i) To predict if the turning point of long-run EKC for Delhi will reach before the worst Air Quality Index or not.

(ii) Predict the year of the turning point.

Conceptualization

Economic Growth

Economic growth can be understood as development in the capacity of an economy to produce goods and services over a period. It is measured in nominal and real terms, the latter of which is adjusted for inflation. Economic growth is due to an increase in capital goods, labour force, and human capital. It is commonly measured in terms of the increase in the aggregate market value of final goods and services produced, using estimates such as the gross domestic product (GDP).

Air Quality

The condition of air within the surroundings is known as air quality. Air quality can be measured via various methods such as AQI, photochemical and optical sensor systems, and Air Pollution Index. Good air quality is required for maintaining the balance of life on earth for humans, plants, animals, and natural resources. Poor air quality can adversely affect the health of human beings and create an ecological imbalance.

Consumption of Electricity

Electricity consumption is the aggregate use of an electric source of energy for different purposes. Electricity generation and consumption play a vital role in the economic growth of a country. A substantial rise in energy use is found in developed countries.

Production of electricity, directly and indirectly, deteriorates air quality of its surrounding. Thind, Tessum, Azevedo, and Marshall (2019) concluded that air pollution doesn't just come from cars on the road, generating electricity from fossil fuels also releases fine particulate matter into the air. In the journal of International Atomic Energy Agency, Vienna (1999), it was explicitly mentioned that production and consumption of electricity hampers air quality and environment problems arise from emissions from the power plant or other parts of its fuel chain. It proves the fact that production causes significant negative externality on air quality. Including per capita consumption of electricity will increase the significance of the model and make it robust.

Operationalization

GSDP Per Capita

Gross state domestic product (GSDP) is a measure of the monetary value of all goods and services produced within the boundaries of a state during a given period. GSDP per capita is a measure of any state's economic output that accounts for its population. It is obtained by dividing the state's gross domestic product by its total population. GSDP per capita represents a state's standard of living. It describes how much citizens benefit from their state's economy. In this paper, we have considered Delhi's GSDP per capita as a measure of per capita income.

Air Quality Index (AQI)

Air quality index (AQI) is a scale used to report air quality. Higher the number on the scale implies greater is the risk for humans and inferior quality of air. According to Ott (1978), the objectives for developing air quality index are resource allocation, ranking of locations, enforcement of standards, trend analysis, public information, and scientific research. On the AQI scale, 0 – 50 is considered as good air quality. This air is healthy, free from all major pollutants such as dust, particulate matter, and other impurities. Air quality index is calculated by assessing a variety of pollution indicators.

Per Capita Consumption of Electricity

The per capita consumption is the amount of electricity consumed in kilo-watt-hour by a person in a year. It is calculated by dividing the total consumption of electricity per year by total population. Kilo-watt-hour is the unit used to measure the consumption of electricity. It shows capacity of production and its reach to the general public. In this paper, we have considered Delhi's per capita electricity consumption as a variable for predicting AQI.

Methodology

Data

The data of pollution parameters of Delhi were extracted and compiled from "State Domestic Product (State series)", Ministry of Statistics and Program Implementation, Government of India (n.d.). The database initially had sulphur dioxide (SO_2), nitrogen dioxide (NO_2), suspended particulate matter (SPM), and residual suspended particulate matter (RSPM) for all major cities of India noted daily from 01/01/1987 – 31/12/2015. The database also had a few missing values. We filled those values using the moving average and then converted the collected results to annual statistics.

To make our data more realistic and credible, we added fine particulate matter 2.5 (PM 2.5) and PM 10 into our selected data. This data were obtained from the archives of Central Pollution Control Board. A macros code from Central Control Room for Air Quality Management, New Delhi is used. The macros code was set to give the value of AQI when at least three values of AQI parameters were filled in as inputs. Thus, AQI was obtained by plugging the annual values of NO_2, SO_2, and PM2.5 in the macros formula. Here, annual values of $NO_2$and SO_2 are obtained by taking an average of all the daily values available in the dataset.

The next step was to get the values of gross domestic product per capita (GSDP PC) of Delhi. The GSDP PC data of Delhi were obtained from Ministry of Statistics and Program Implementation, Government of India (n.d.). The values obtained were in two different sets. From the year 1999 – 2010, the base year is 2004 – 05, while for values from 2011 – 2018, it is 2018 – 19. Further, we used the method of forward splicing to convert the base year to 2018 – 19 from 2004 – 05. The period of our study is 1999 – 2018. Since the data of consumption per capita of electricity of Delhi from 1999 – 2019 were not available on any credible website, we obtained the data from the Central Electricity Authority, New Delhi office.

We have eliminated the seasonal and cyclic factors that influence the air quality of the city. In this case for Delhi, we have removed the effect of stubble crop burning in the neighbouring states and pollution increase in the region during the celebration of Diwali. This was done because a spike in AQI is usually observed only in November and then it subsides to its annual trend. After normalizing the data, a clearer representation of EKC could be observed.

Econometric Tool (Forecasting – Econometric Model)

For our study, using the data of GSDP per capita, electricity consumption per capita, and AQI, we obtained the regression equation. The model includes AQI as the dependent variable and GSDP per capita and electricity consumption per capita as the independent variables.

The regression equation is given by :

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1^2 + \beta_4 x_2^2 + \beta_5 x_1 x_2 + \varepsilon \quad (1)$$

where,

y = AQI,

x_1 = GSDP per capita,

x_2 = Electricity consumption per capita,

$\beta_0 = 1844.324$,

$\beta_1 = -0.002445$,

$\beta_2 = -2.045593$,

$\beta_3 = 4.11 * 10^{-10}$ or 0.000000000411,

$\beta_4 = 0.000597$,

$\beta_5 = 1.76 * 10^{-6}$ or 0.00000176.

Further, the future values of AQI are obtained using this equation.

Tests for Model Adequacy

To ensure that the econometric model taken for analysis in our study is adequate, we conducted the tests for model adequacy. We have the sample size of 20, which is a short-term time series. The model is highly unlikely to attain a cyclic trend due to small sample size. Therefore, the series is stationary as the variables are relatively stationary in the short-run. The tests for model adequacy include a test for heteroscedasticity, test for autocorrelation, and regression statistics.

Regression Statistics

We observe that the R - square value is 0.8380. The dependent variable Air Quality Index is 83.80% dependent on the independent variables - GSDP PC and electricity consumption per capita. The adjusted R - square value for the model is 0.780224. It states that the independent variables are significant in explaining the Air Quality Index (Table 1).

Table 1. ***Test for Model Adequacy***

R-Squared	0.83860
Adjusted *R*-Squared	0.780224
LM Test (*F*-Statistic Value)	0.418460
Breuch – Pagan – Godfrey Test (*F*-Statistic Value)	0.9562

Test for Autocorrelation (LM Test)

Using the LM test, we check for autocorrelation. We observe that the *p*-value is more than 0.05 ; therefore, we accept the null hypothesis (Table 1). The null hypothesis is that there is no autocorrelation. So, from the LM test, we say that there is no autocorrelation.

Test for Heteroskedasticity (Breusch – Pagan – Godfrey Test)

Using the Breusch – Pagan – Godfrey test, we check for heteroskedasticity. We observe that the *p* - value is more than 0.05. Therefore, we accept the null hypothesis (Table 1). The null hypothesis is that there is no heteroskedasticity. From the Breusch – Pagan – Godfrey test, we say that there is no heteroskedasticity.

Historical Evidence from Available Sources

We have also considered 'Exemplary Method' to predict the peak point on long run EKC. EKC of Delhi follows an identical trend to what lots of developed cities have gone through in their past. To analyze long run EKC further, we tried to find GSDP PC values of various cities of the nineteenth century.

Two main factors were considered to select the city to perform a comparative analysis with Delhi. The first criterion was cities with huge commercial markets or factories in the past, large stock of raw materials, cities with hazardous habitable conditions majorly due to heavy air pollution, unplanned industrialization, rampant deforestation, and poor sanitation. The second criterion was to select a city which had a stable and nature-friendly step while developing the city.

It was done by studying various research papers, articles, and diaries of people of that period. The data about the cities were extracted from various credible sources such as research papers, World Bank and the WHO databases. We further used the data to calculate the time taken in years to cross the turning point in the EKC. The period calculated from these cities is later used to predict the year when Delhi will surpass its turning point on EKC.

This paper has successfully achieved its key objective to predict when the severest AQI mark will be crossed and later in which year the turning point will be achieved. It is also essential to understand why AQI 500 is taken into consideration.

For finding the turning point of Delhi in the long run EKC, we have used the exemplary method. We observed the time taken by cities similar to Delhi on achieving their turning points on long-run EKC.

The findings obtained from the cities are :

(i) London : London was known as the big smoke. The process of industrialization started far back in 852 AD. As the growth rate increased, pollution grew to new levels. Edinburgh was nicknamed as 'Auld Reekie' in tribute to its smoking chimney pots. In 1273AD, The First Smoke Abatement Law was enacted in London, prohibiting the use of coal as 'prejudicial to health.' By the 1750s AD, under stable conditions, London's urban plume was observable at distances of 100 km (Heidorn, 1978). This behaviour of depletion of air quality continued till 1850. This was the year where EKC attained its turning point. Though there were sudden episodes of noxious air quality, in general, the air quality improved.

(ii) Tokyo : It is observed that Tokyo had a rapid growth and expansion. It came across similar problems that other developed countries faced. Though its development was more stable and culturally environment friendly, yet there were lots of hurdles when it came to preserving nature while developing the city (Wakamatsu, Morikawa, & Ito, 2013). The development of the city started in the year 1603 AD and the peak was attained in the year 1950. The city took nearly three and a half centuries to reach the turning point (Heidorn, 1978).

(iii) Pittsburgh : Pittsburgh is a city in Pennsylvania, also known as the steel city. Through the rise of the industrial revolution in 1758 AD, easy navigation through inland waterways and abundance of natural resources made Pittsburgh a center for the industrial revolution. This city attained the turning point in 1950 AD (Davidson, 1979).

(iv) Los Angeles : The city got its name because of its abundant gold mines. During the period of growth and development of the city, tons of gold were extracted from the mines. In the year 1542 AD, Juan Rodriquez Cabrillo sailed into the Los Angeles Bay. Upon observing the smoke from Indian fires onshore rise and spread after hitting an elevated inversion, he named it 'The Bay of Smokes' (Heidorn, 1978). All the smoke filling up the city was from the furnace and the ships. The level of pollution was on the rise from 1781 and finally reached its height in 1968 (Madronich, Shao, Wilson, Solomon, Longstreth, & Tang, 2015). The city attained its turning point in nearly 190 years.

Analysis and Results

1st Stage (Developing Stage)

There are three stages of the environmental Kuznets curve : pre-industrial economy, industrial economy (turning point), and post-industrial economy. In the first stage, AQI increases at a diminishing rate for GSDP per capita. Presently, Delhi is in the middle of the pre-industrial economy stage. London and Glasgow were at the same point in the 1880s and 1910s, respectively.

Short Run

Air Quality Index (AQI) has several slabs. According to AirNow.gov, the severest and hazardous air quality considered is 500. It means the air quality is considered to be hazardous for the ecosystem if the AQI value is 500 or above. The severest AQI point is expected to be crossed by 2032 – 2033 (95% CI) in Delhi if there is no notable change in the environmental protection policy. This result was achieved by the equation of the econometric model containing GSDP per capita and electricity consumption per capita as independent variables and AQI as the dependent variable.

Through the graphical representation from Figure 1, it can be established that EKC exists on short period as well. Further, long run EKC is a cumulative result of short run EKC.

Long Run - Forecasting

From all examples mentioned in the discussion and through news articles and official reports in the mentioned cities in various periods, the following facts can be established :

Figure 1. *Environment Kuznets Curve*

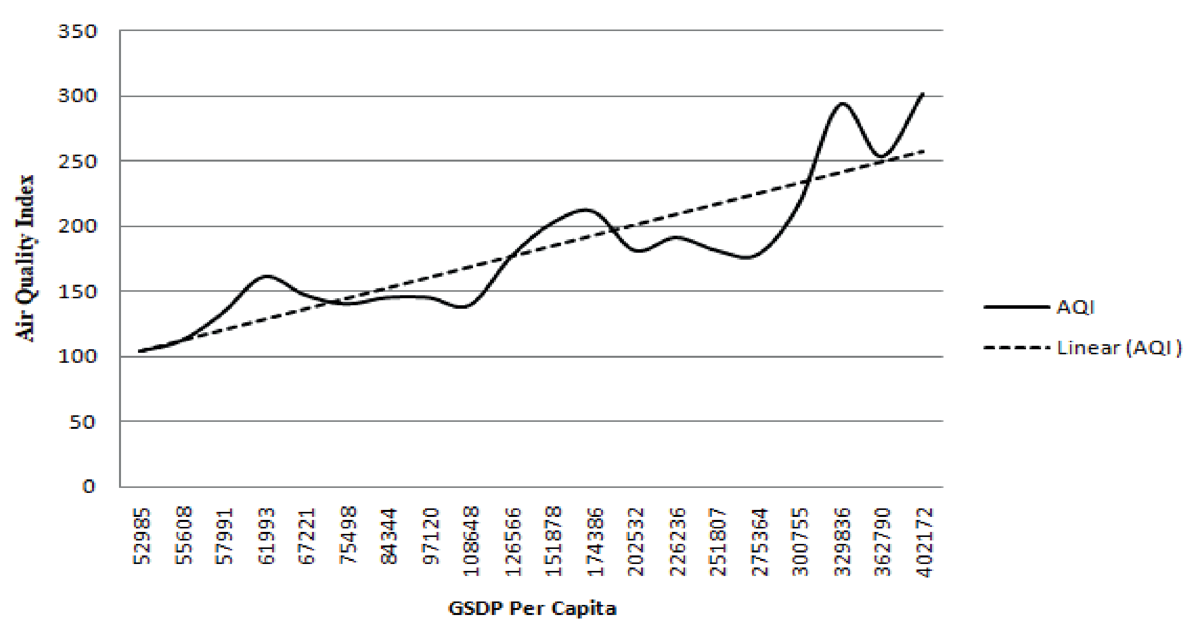
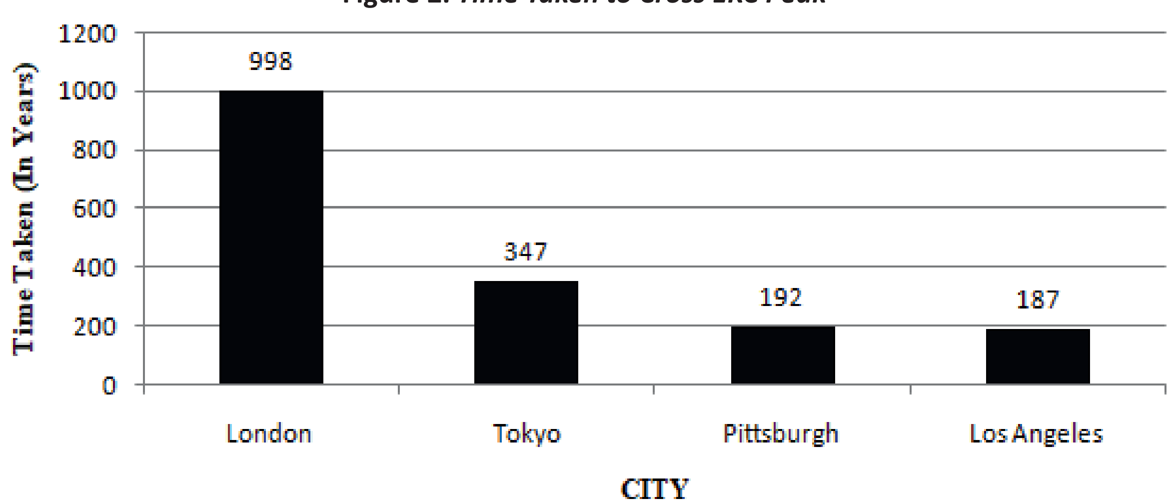


Figure 2. *Time Taken to Cross EKC Peak*



➷ Delhi is following the same trend that all these cities have displayed in the past. All the cities have faced similar conditions of pollution, though on different scales of intensity and duration.

➷ As technology improves by time, it takes less time for cities to cross the peak point of EKC.

➷ Year in which industrialization starts plays a vital role.

➷ The entire world, in general, has become aware and has a clearer plan for sustainable growth. It helped the expansion to be systematic and in line with the idea of sustainable development.

Pittsburgh and Los Angeles have taken almost equal time to reach the peak as they started nearly and at the same time. The difference in year of the beginning of industrialization between London and Tokyo or the difference between Tokyo and Pittsburgh shows that by starting the industrialization a few years later could result in a huge reduction of time taken to reach the peak.

Using the limited data we have, the latest city to cross the peak is Los Angeles ; the city attained its peak before Delhi started its industrialization process. It confirms that Delhi will take less than 187 years to cross the peak, given that Delhi follows the same trend and frames similar policies. Figure 2 depicts the reduction in time required by the four cities to cross the peak.

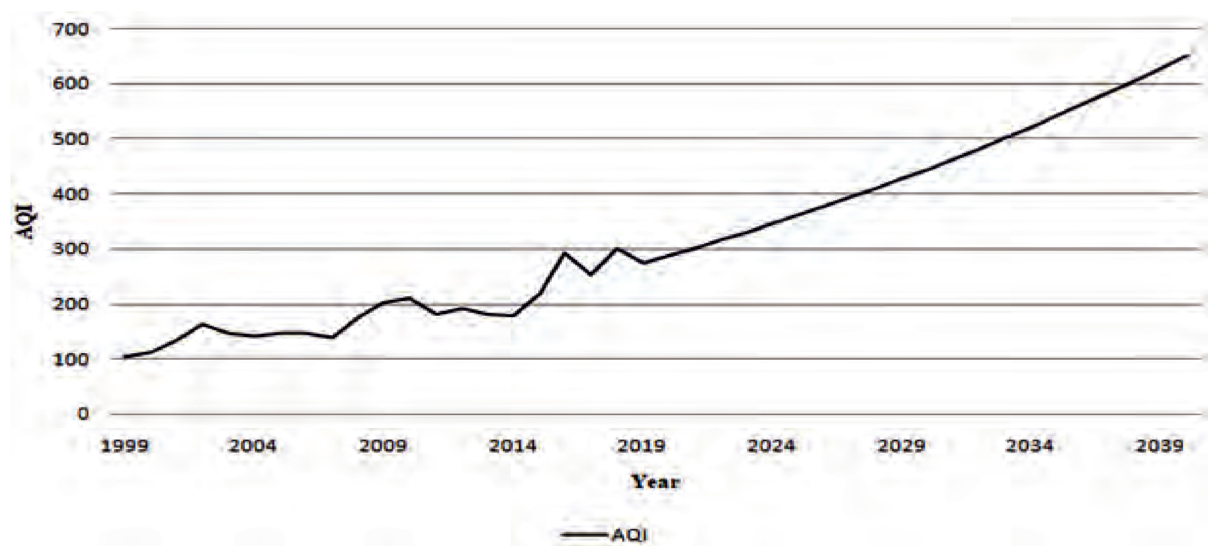
The next factors which further reduce the time duration to cross the peak are technological advancements and a better understanding of sustainable growth. Through these factors, we can safely establish that Delhi will take a maximum of 150 years to cross the peak from the initialization of its industrial process. *This indicates that Delhi will cross the peak at maximum by the year '2121'.*

Findings

It is wrong to assume that today's major developing cities – such as Delhi, Beijing, Jakarta, Karachi – are experiencing unprecedented levels of air pollution. Many of today's high-income cities have likely gone through similar periods of high (or higher) pollution levels (Ritchie, 2017).

We can say that Delhi is in its first stage of EKC, that is, the pre-industrial economy. The AQI will, therefore, increase at a diminishing rate and will reach the turning point in approximately around 150 years. As observed from Figure 3, the average AQI of Delhi will cross the 500 mark by 2032 – 2033. AQI exceeding 500 level is considered as the severest level which is claimed by WHO.

Figure 3. ***Forecasted AQI Values***



Policy Suggestions

The main focus of formulating policies must revolve around preventing and curbing pollution rather than covering up the tragedy. Policies for preventing pollution are the foremost step that must be taken into consideration to mitigate the eruption of mushroom colonies. The reason for this is migrants do all types of jobs which are generally rejected by locals (Malhotra & Devi, 2018). These colonies are severely unregulated and dominantly unsupervised. It results in an uncontrolled and unaccountable increase in air pollution (Egondi, Kyobutungi, Ng, Muindi, Oti, Vijver, Ettarh, & Rocklöv, 2013 ; Shrivastava, Ghosh, Bhattacharyya, & Singh, 2018). As mentioned by Jindal (2020), there must be a policy of the differential lens for planned immigration of migrants from other states. The key is to inculcate and imbibe the political will to restructure Delhi's mushroom colonies and transform or relocate them to planned and structured colonies.

Secondly, warehouses should shift outside the city. Only small vehicles should deliver goods to consumers in the city. This step will reduce the pollution level caused by heavy vehicles in the city and traffic jams due to the breakdown of heavy vehicles can be reduced.

Further, the headquarters of project-based companies must relocate smaller offices for liaising with government authorities in Delhi. The positioning of these headquarters to their project sites or any other feasible location other than Delhi will enable reallocation of immense development pressure from Delhi to other cities. Another advantage of relocation is the reduction in the number of migrants in the city as the new locations possess enough workforce to produce quality input.

From the example of Delhi, it is understood that the intensity of the effect of environmental degradation can be reduced if sustainable economic growth & development are considered. Steps taken to reduce the effect of pollution are installation of large-scale air purifiers in all developing cities. It will prepare the cities to bear the environmental degradation that will take place during the course of their growth as a developed city. This step will indirectly improve the HDI of the city as well. Environmental emergency funds for each state must be created to revive the economy in the situation of environmental emergency. These funds will act as a cushion at the time of severe environmental crisis. These small steps taken before the advent of the deterioration of the environment will reduce the effect of environmental degradation and smooth out the journey of economic development.

Conclusion

From the findings and results obtained, we find that Delhi is currently in the rising part of the environmental Kuznets curve (EKC), that is, as GSDP per capita is increasing and environmental degradation is also increasing.

If the current situation in Delhi continues, the average Air Quality Index (AQI) of Delhi will cross the 500 mark by 2032 – 2033 (at 95% CI). AQI exceeding 500 level is the severest level which is claimed by WHO.

The environmental Kuznets curve (EKC) will reach its peak by 2121. Reaching the turning point of the long run EKC is a gradual process. It keeps on a check and questions whether the society is ready to trade off its present environmental conditions for a better future or not. Hence, we conclude that the peak of long-run EKC for Delhi will cross the worst AQI mark to achieve it.

According to Balakrishnan et al. (2019), 1.24 million deaths in India in 2017 were due to air pollution. Of these air pollution-related deaths, 51.4% were people under 70 years of age. India's air pollution causes disproportionately high mortality and disease burden. In the low socio-demographic index (SDI) states of North India, this burden is usually the largest. A significant feature of India's air pollution is its relation to ischemic heart disease, stroke, chronic obstructive pulmonary disease, and lung cancer. These are commonly associated with smoking, but in the case of Delhi, these diseases are associated with heavy pollution in the air. It is the need of the hour to take paramount actions to control the devastating state of Delhi and implement measures to make other developing cities prepare for the upcoming shock.

Limitations of the Study and Scope for Further Research

Data of NO_2 and SO_2 from 1987 – 2019 were accessible, but the major component of AQI PM 2.5 was only present from 1999. Hence AQI could only be calculated from 1999 with the assistance of the AQI calculator provided by the Central Pollution Control Board. Due to the lack of availability of data, we used the regression equation model to achieve predicted figures of AQI. Major econometric forecasting methods require a minimum of 50 observations for a precise prediction. It is the best forecasting technique adopted for the available data. Another challenge we faced was to collect information about various cities for forecasting the turning point of EKC. There are limited papers throwing light on the environmental conditions of the cities. Majorly, these papers focus on the countries rather than cities. Out of the few papers, situations in a small-time frame were analyzed. Only a handful of them have covered the environmental conditions from the start of the industrialization period until now.

The theory of EKC takes GDP per capita and air pollution into account for establishing the inverted U-shape pattern. It does not specify the nature of the relationship between GDP per capita and sound pollution or water contamination. Hence, to analyze the nature of the curve for Delhi, we had to restrict ourselves to only two variables.

A substantial number of factories and industries that generate economic activities are in and around the North Central region (NCR). NCR consists of Delhi and a few districts of Haryana, Rajasthan, and Uttar Pradesh. These factories generate massive pollution, which can be witnessed in Delhi air space, consequently leading to a gigantic increment in the pollution levels in the capital city. It proves to be rather unfavourable for Delhi's air quality. Negative externality adds into Delhi's air pollution and value-added by the human resource of Delhi is computed in GSDP of states where the respective factories and industries are situated. It results in synthetic inflation in AQI figures and a reduction in GSDP of Delhi.

There is a vast scope for further research as better observations for Delhi can be found with higher precisions if more data can be made available in due course of time. Since a majority of pollution in Delhi comes from the NCR region, an exhaustive model for the whole area can be developed using the same explanatory variables of the entire region. Also, similar results can be found for other cities as well.

Authors' Contribution

Shubhneet Sanjay Arora worked on the conceptualization of the idea and came up with research methodology for the research paper. Swarthak Ranjan Swain pulled out fine quality research papers related to our concept. Shubhneet and Swarthak extracted data from various sources and reframed it into the required format. Formal analysis of data using different software, comparative analysis, and policy suggestions were covered by Shubhneet. Tabulation and pictorial depiction of data were done by Swarthak. The manuscript was written by Shubhneet Sanjay Arora.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter, or materials discussed in this manuscript.

Funding Acknowledgment

The authors received no financial support for the research, authorship, and/or for the publication of this article.

Acknowledgment

Drafting a research paper remains one of the most significant challenges we have faced so far. We would like to express our sincere gratitude to our Professor, Dr. Rajeshwari U. R. for her continuous support of our study and research, for her patience, motivation, enthusiasm, and immense knowledge. Her guidance helped us in all the time of research and writing of this paper.

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About the Authors

Shubhneet Sanjay Arora hails from Mumbai and graduated from Christ (Deemed to be University) with majors in economics, mathematics, and statistics. He has a keen interest to frame policies to restructure the way of developing India. He plans to pursue masters in applied economics and public policy.

Swarthak Ranjan Swain earned his undergraduate degree from Christ (Deemed to be University) and has majored in economics, mathematics, and statistics. He has interned at leading companies as well as emerging startups. He has experience in operations, marketing, and management. An avid lover of reading books, Swarthak is deeply passionate about researching and aims to pursue a secure career in applied economics.