



# Policy Briefs

## ECONOMIC COST OF AIR POLLUTION



The Economics  
Society, SRCC



# CONTENTS

|  |              |
|--|--------------|
| <b>Introduction</b>                            | <b>01</b>    |
| <b>Capital and Stock Markets</b>               | <b>02-08</b> |
| • Capital Markets                              | 03           |
| • Risk Appetite                                | 04           |
| • Stock Markets                                | 05           |
| • S&P Sensex And Air Pollution:<br>Methodology | 06           |
| • S&P Sensex And Air Pollution                 | 07-08        |
| <b>Real Estate</b>                             | <b>09-12</b> |
| • Real Estate                                  | 10           |
| • Indian Real Estate Market                    | 11           |
| • The Supply Side                              | 12           |
| <b>Aviation</b>                                | <b>13-16</b> |
| • Aviation                                     | 14           |
| • India's Busiest Airport                      | 15-16        |
| <b>Conclusion</b>                              | <b>17</b>    |

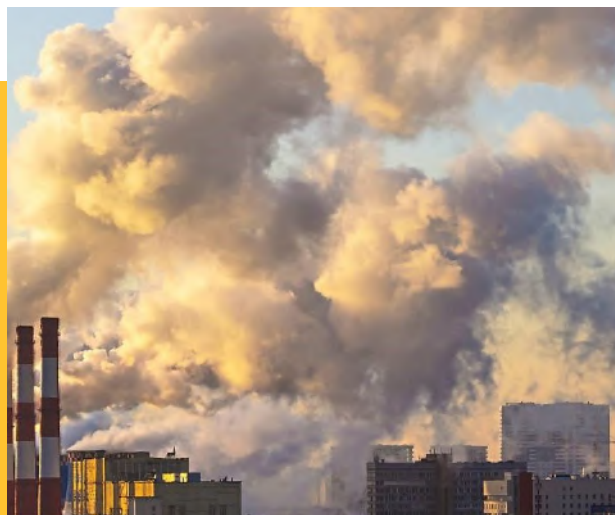
## INTRODUCTION

Pollution, for long, has been a problem which has found itself brushed aside to make way for development through industrialization and other practices which harm the environment. The threat had moved beyond the latency period a long time back but only recently have people started taking notice of the now tangible impact of pollution on both, human health and the economy, the impacts on the latter being both, standalone and as a corollary of the first.

With the development and the advent of technology, more and more pathways have been created for pollution to manifest itself. Add to that an ever-growing population which burdens the scarce natural resources which are available. What this leads to is a snowball which seems to be turning into an avalanche unless something is done soon.

Addressing what one may call the most potent and widespread of all types of pollution, air pollution takes up major column inches throughout papers worldwide. Air pollution is a major cause of concern for many countries, especially the developing nations like China and India, and rightly so with huge public outcry and the Air Quality Index levels post festivals becoming a moot point. As the world gears up to face this head on, an analysis of how and who air pollution affects the most would be crucial.

With the intent of providing an overview as to how India is already facing the brunt of a high level of air pollution in major cities and how it impacts our everyday lives, and our economy, focus has been given to the impact of air pollution in three fields namely, Aviation, Capital Markets and Real Estate.



# CAPITAL AND STOCK MARKETS



## Air Pollution and Capital Markets

Air Pollution has a major negative impact on the capital markets as well. It has been explored from the side of the capital markets in general with a special emphasis on the stock markets.

From the capital market point of view, the rise of air pollution levels seems to be spelling doom. It has a negative impact which increases over time. When air pollution levels rise, the marginal productivity of labour falls. Hence, the labourers look to shift to industries which are capital intensive in order to cover up for the loss of efficiency caused due to health hazards from the bad quality of air. The economy is in a turbulent period when there is a large scale labour migration, even if it's intra-economy - from one sector to the other. This productivity shock leads to a huge adjustment of demand for labour as well as other goods in the economy and pushes the economy towards a slowdown. Moreover, at the current increase in air pollution levels, the overall Gross Domestic Product for the world would be lower in the future than if forecasted without the losses due to air pollution.

### Labour to Capital Market Spillover

The negative impact on the capital markets can take place in two ways. Here, it is assumed that the investment in the capital markets are done from the savings from income of the people. Firstly, when due to a labour shift and a slowdown in the economy, the wage income falls, the investment in the capital markets fall. This happens because at a given autonomous consumption expenditure, a fall in income would lead to lower savings and hence a lower amount of money invested in the capital markets. Secondly, at a given level of income, due to the health hazards posed by air pollution, the expenditure of healthcare rises which pushes down the savings, as a corollary of which the investment in the capital markets also falls. If the two reasons are combined, there will be a fall in income coupled with an increase in expenditure which would be doubly bad for the level of saving in the economy and doubly bad for the capital markets.

The countries which will be majorly hit by this will be the countries which rely heavily on labour as the productivity shock will be greatest for them, for example China. It's interesting to note, however, that India, although a majorly labour dependent country, will not have its capital markets hurt much. This is because the average Marginal Propensity to Save and the investment from these savings in India is so low, that lower savings will not lead to a significant impact on the capital markets. This is opposed to a country like China which has a high Marginal Propensity to Save and Invest and whose capital markets will be one of the most severely affected ones in the world. [1]

## Air Pollution and Risk Appetite – A detailed study

The first impact that we seek to analyze is based on “Mental Wellbeing”. Being exposed to bad quality of air for prolonged periods, if not even for a day, affects a person’s emotional wellness. It puts a person in a more depressed mood and thereby reduces cognitive abilities. This reduces the thinking capacity of a person. It might also reduce the risk appetite of a person. Low risk tolerance is in turn associated with lower returns.

Air pollution, mood and stock returns are related to each other in a way such that; as air pollution increases, it deteriorates the mood of a person and thereby leads to a reduction in the stock market indices. Studies show that mood influences decision making. It can be seen that people are more pessimistic if their mood is deteriorated. This is due to the mood congruence effect. Due to pessimism people would be inclined towards selling stocks. As can be seen in the subsequent analysis, air pollution is usually negatively correlated with stock returns. Thus we can see that air pollution leads to increase in risk aversion.

Air pollution also leads to lower investor Elasticity of Inter-temporal substitution (EIS). Low EIS means low willingness substitute. Today’s consumption with future consumption so investors prefer to consume more in present thereby lowering the demand for investment today and ultimately leading towards falling stock prices. [2]



## Air Pollution and Stock Markets

Air Pollution majorly, but subtly impacts the stock markets. It already does so and will continue to as the air worsens. It has an impact by influencing investor behaviour. Bad air quality, very literally depresses a person, lowers their risk appetite and harms their cognitive capabilities. For a variety of stock indices across various countries, bad air quality has shown a decreased return. According to a study, for every one reduction in standard deviation in the ambient air quality, which is a 1 unit increase in the PM2.5 concentration, there is a 12% dip in the U.S. stock index, S&P 500. One should keep in mind, however, that good air quality doesn't warrant a bullish stock market. It just would mean that the calculations are done correctly and the stocks are not undervalued because of irrational investor decisions due to externalities and that the market is closer to efficient working than with air pollution involved. [3] The chart below also shows the effect of various pollutants on the stock market index of Helsinki and Hong Kong, OMX Helsinki 25 and Hang Seng respectively, on a one-day lagged effect and on the same day. The results show a mostly negative effect of the increase in pollution to the returns across various market indices.

| Helsinki and Hong Kong  |                          |           |           |         |                    |           |        |         |
|-------------------------|--------------------------|-----------|-----------|---------|--------------------|-----------|--------|---------|
| Stock index             | One day lagged pollution |           |           |         | Same day pollution |           |        |         |
|                         | Mean daily return (%)    |           |           |         |                    |           |        |         |
|                         | Good                     | Unhealthy | UMG       | p-value | Good               | Unhealthy | UMG    | p-value |
| <i>Kallio</i>           |                          |           |           |         |                    |           |        |         |
| OMX Helsinki            | 0.030                    | -0.661    | -0.691*** | 0.002   | 0.008              | -0.004    | -0.012 | 0.940   |
| OMXH25                  | 0.033                    | -0.499    | -0.532*** | 0.003   | 0.013              | 0.052     | 0.040  | 0.767   |
| Basic Materials         | 0.020                    | -0.308    | -0.328*   | 0.086   | 0.005              | 0.042     | 0.037  | 0.845   |
| Financial               | 0.043                    | -0.293    | -0.337*   | 0.095   | 0.027              | 0.018     | -0.009 | 0.958   |
| Industrials             | 0.044                    | -0.153    | -0.197    | 0.148   | 0.029              | 0.203     | 0.174  | 0.111   |
| Consumer Goods          | 0.043                    | 0.022     | -0.021    | 0.865   | 0.039              | 0.066     | 0.027  | 0.796   |
| Oil & Gas               | 0.053                    | -0.750    | -0.803*** | 0.009   | 0.028              | 0.130     | 0.103  | 0.760   |
| <i>Mannerheimintie</i>  |                          |           |           |         |                    |           |        |         |
| OMX Helsinki            | 0.027                    | -0.037    | -0.064    | 0.568   | 0.117              | -0.010    | -0.128 | 0.690   |
| OMXH25                  | 0.042                    | -0.051    | -0.093    | 0.405   | 0.116              | 0.032     | -0.084 | 0.945   |
| Basic Materials         | 0.033                    | -0.101    | -0.134    | 0.357   | 0.092              | -0.104    | -0.196 | 0.250   |
| Financial               | 0.038                    | 0.107     | 0.069     | 0.639   | 0.137              | 0.130     | -0.007 | 0.496   |
| Industrials             | 0.057                    | 0.033     | -0.024    | 0.832   | 0.171              | 0.089     | -0.083 | 0.704   |
| Consumer Goods          | 0.047                    | -0.055    | -0.102    | 0.343   | 0.082              | -0.017    | -0.099 | 0.523   |
| Oil & Gas               | 0.057                    | -0.133    | -0.190    | 0.287   | 0.615              | 0.119     | -0.496 | 0.613   |
| <i>Hong Kong</i>        |                          |           |           |         |                    |           |        |         |
| Hang Seng               | 0.023                    | -0.100    | -0.123    | 0.301   | -0.031             | -0.111    | -0.142 | 0.307   |
| Utilities               | 0.035                    | -0.052    | -0.087    | 0.235   | 0.021              | -0.054    | -0.033 | 0.205   |
| Financial               | 0.026                    | -0.107    | -0.134    | 0.266   | 0.021              | -0.145    | -0.124 | 0.197   |
| Commercial & Industrial | 0.022                    | -0.060    | -0.082    | 0.548   | -0.044             | -0.089    | -0.133 | 0.460   |
| Consumer goods          | 0.029                    | -0.057    | -0.085    | 0.464   | -0.277             | 0.118     | -0.158 | 0.383   |
| Oil & Gas (CALC)        | 0.216                    | 0.337     | 0.121     | 0.482   | 0.211              | 0.366     | 0.577  | 0.406   |
| Oil & Gas (HS)          | -0.024                   | 0.084     | 0.061     | 0.555   | -0.016             | -0.190    | -0.206 | 0.345   |

*Notes:* The time period covered is 2000-2016. However, due to data availability Mannerheimintie sample begins from 2005. Similarly, the index start dates vary slightly. Refer to Table 2 for specific periods. UMG denotes the Unhealthy minus Good return difference. Kallio and Hong Kong (Central) are background stations, whereas Mannerheimintie is a traffic station. P-value for Model 4 is reported and \* denotes statistical significance of 10%, \*\*denotes statistical significance of 5% and \*\*\*denotes statistical significance of 1%.

<sup>6</sup> The Helsinki *Basic Materials* and Hong Kong *Utilities* as well as *Industrials* and *Commercial & Industrials* indices are comprised with similar companies. For further detail of the indices used refer to websites in

[Forsti, A. (2017) *The Stock Market Effect of Air Pollution: Evidence from Finland and Hong Kong.*]

## S&P Sensex and Air Pollution: Methodology

### OMX Helsinki 25 & Hang Seng:

First, pollution value has been matched with the corresponding stock return for each trading day. Second, the trading days are divided into two groups, Good and Unhealthy, based on the daily PM threshold values imposed by HSY. The cut-offs are as follows: 40  $\mu\text{g}/\text{m}^3$  for Kallio, 50  $\mu\text{g}/\text{m}^3$  for Mannerheimintie and 100  $\mu\text{g}/\text{m}^3$  for Hong Kong. Different cutoffs are chosen for the stations to as this allows the data to account for the differences in the average level of pollution, which stems from the nature of each location. Based on these thresholds, the proportion of negative trading days in the sample is 2.3, 7.5, and 4.9 percentage for Kallio, Mannerheimintie and Hong Kong respectively. Regression analysis of the following form has been used to evaluate the relationship between air pollution and stock returns:

$$r_t = \beta_0 + \beta_1 PM_{t-k} + \beta_2 \text{Monday} + \beta_3 \text{January} + \beta_4 r_{t-1} + \varepsilon_t,$$

where,  $r_t$  is the daily stock return for the given index and  $PM_{t-k}$  represents the daily air pollution level. In the variables,  $t$  denotes the day and  $k$  determines the lag between any given days returns and pollution. For majority of this study  $k$  takes the value of one. Monday and January are controlling variables that take the value of one on Mondays and in January respectively to control for weekend and January anomalies. The variable  $r_{t-1}$  is used to purge the time series of stock returns from any intrinsic autocorrelations.

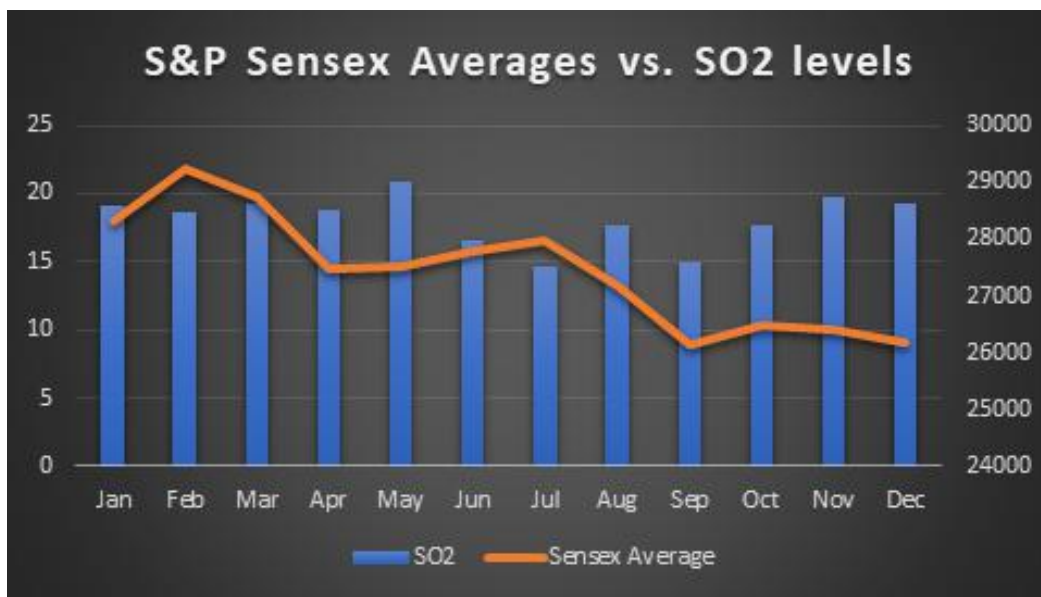
### S&P Sensex:

A simple methodology has been followed owing to data gaps. Firstly, weekly pollution data has been taken from six different stations in Navi Mumbai, Maharashtra. The average of four weeks of data has been averaged per station. Post that, the average data from all six stations has been aggregated to arrive to a monthly figure for all the three pollutants. This has been conducted for all months for the year 2015. For the stock index, the highest and lowest values for each month have been aggregated to arrive at a mean value for the month. The pollution value for each month has then been matched with the corresponding index value for each month.

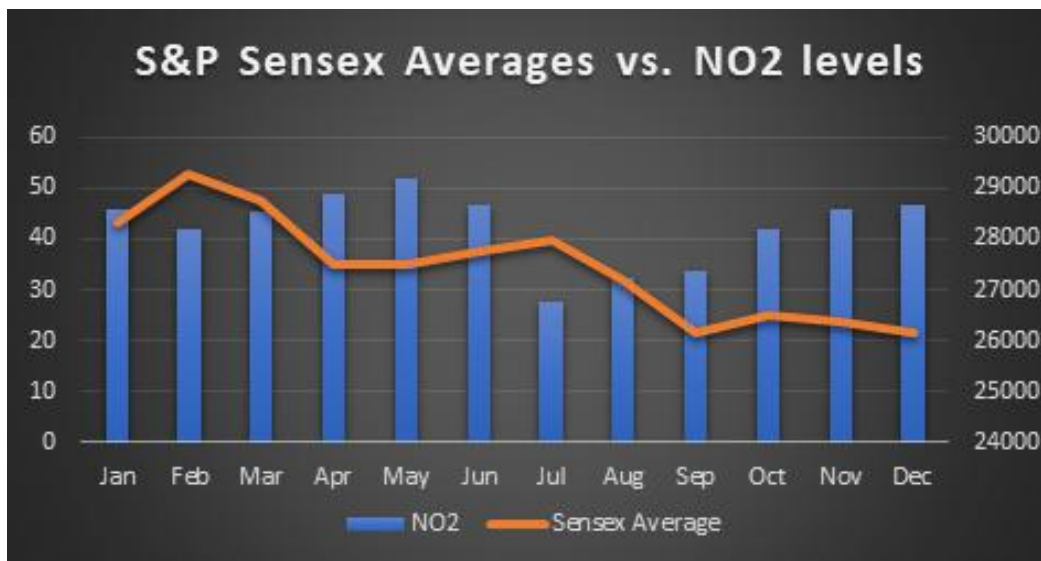


## S&P Sensex and Air Pollution

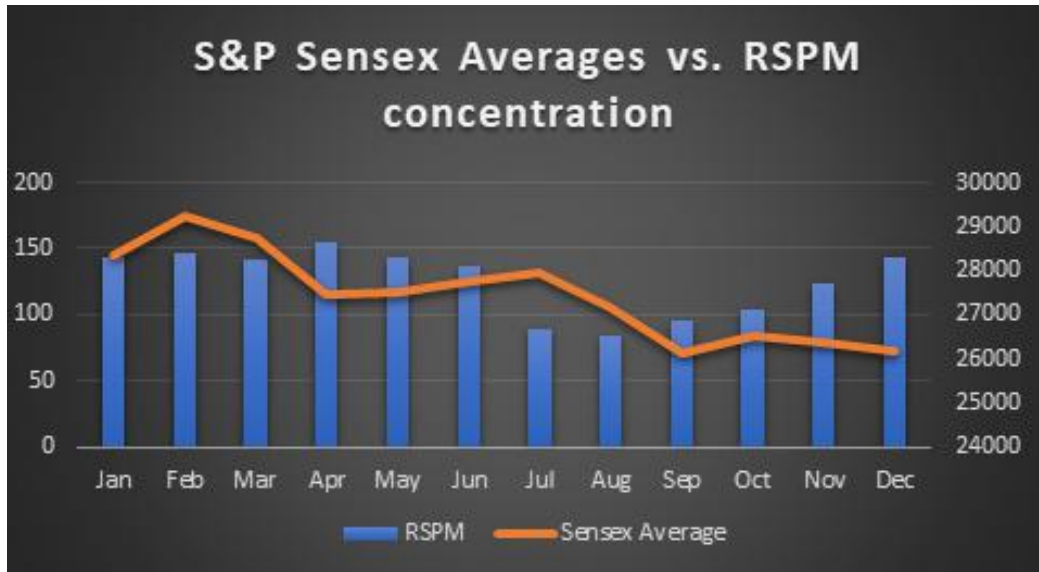
To show a tangible impact in India, a comparison of the Indian Benchmark Index, S&P Sensex and the SO<sub>2</sub>, NO<sub>2</sub> and RSPM levels in Mumbai, Maharashtra has been done.



[Data of S&P Sensex is sourced from BSE.  
Data for Air Pollutant concentrations are sourced from Kaggle. All data is for 2015]



[Data of S&P Sensex is sourced from BSE.  
Data for Air Pollutant concentrations are sourced from Kaggle. All data is for 2015]



[Data of S&P Sensex is sourced from BSE.  
Data for Air Pollutant concentrations are sourced from Kaggle. All data is for 2015]

It is clearly visible from all the three graphs that an increase in the level of pollutants has an adverse effect on the index. To deal with this in numbers, we may take the case of RSPM concentrations.

When RSPM concentrations have their highest upward fluctuation, from March (141.1524) to April (154.5741) the value of the index is knocked down from Rs. 28745.46 to Rs. 27483.09, a difference of Rs. 1262.37. Over a larger time period, August to December from where the RSPM concentrations start an upward trend, values of the index see a hit of Rs. 1026.885. On the flip side, the largest decrease in the RSPM concentrations from June to July see an upward trend in the values of Sensex - an increase of Rs. 193.295.

Similar trends can be observed for the other pollutants in the form of SO<sub>2</sub> and NO<sub>2</sub>. The quarterly data related to NO<sub>2</sub> and Sensex for the year 2015 shows a correlation of -0.215. This also successfully matches the hypothesis that air pollution has an adverse impact on the stock markets in India.

# REAL ESTATE



## Air Pollution and Real Estate

Air pollution seems to be the most relevant to real estate industry amongst all other environmental issues given its scientifically proven health damage. Experts say that location is the most important force driving consumer demand towards real estate yet people overlook the air they breathe just outside their homes when looking for a house. WHO estimates 7 million people die every year due to exposure to fine particles in polluted air. A significant question here remains if air pollution levels affect property value.

### Impact on property value

Unfortunately for urban dwellers specially, living in a greener environment and breathing clean air comes with a cost. Housing is generally expensive in urban areas combined with a rapidly deteriorating environment due to constant developments, but the peculiar thing to note is that people don't often chose to migrate outwards due to environmental concerns let alone air pollution. The reasons are not specific, but according to studies, people are more encouraged to remain at a property due to factors like neighbourhood, good accessibility, near to work place, amenities, utilities and others. People tend to compromise on something to get something else, which in this case, the quality of the environment they live in. Such is the case of india where real estate prices are not driven by environmental factors but by affordability and their accessibility to workplaces.



## Indian Real Estate Market

### Property demand and air pollution

As per a new analysis by Anarock Research, the impact of pollution on property demand in India is almost negligible, like a seasonal phenomenon, urban dwellers are accustomed to pollution and it forms an accepted feature. Looking closely at the example of the national capital and the hub of administration, Delhi which sees record breaking air pollution levels every year is almost unmoved with respect to its real estate demand. As the major government institutions and large business houses operate in the capital city, it creates huge employment opportunities that greatly derives the demand side. Most parts of NCR continue to see multi-fold investments into real estate, including from multi-nationals otherwise known to be very concerned about environmental factors.

But it would be wrong to say that air pollution has absolutely no effect on real estate. Certain A grade office buildings with air purification systems and residential area with similar facilities definitely have an edge over others. Regardless, people are becoming more aware about environmental impacts coupled with a steep curve of AQI levels in the region every year which has nearly made it inhospitable in the winter months, it is yet to see if this has a significant impact on the real estate market.

Although, in another study it has been noted that air quality levels differ second home buyers, senior citizen home buyers and NRIs to chose cities like Pune and Ahmedabad. "Retirees and long-term investors are also now exploring real estate options in nearby forthcoming smart cities, including Mohali and Chandigarh due to increasing pollution issues in Delhi NCR. Yet, a segment of buyers continue to take interest in Delhi due its high rental value and ROI", feels Sushil Raheja, Chief Executive Officer, Raheja Homes Builders & Developers.

It is also relevant to note here that other major cities like Mumbai, Kolkata, Bengaluru follow the example of Delhi due to economic benefits these places provide overpowering health costs which are not immediate.

Amongst various measures to combat air pollution, Delhi government bans construction activities in desperate times which also takes us to another aspect of real estate market – construction and the supply side.

---

**[5] Construction Times (2019). Pollution-hazardous to real estate, Retrieved from:**

<https://constructiontimes.co.in/pollution-hazardous-to-real-estate-health/>

**[6] 99 acres (2017). How are alarming air pollution levels impacting delhi's realty**

**Retrieved from:** <https://www.99acres.com/articles/how-are-alarming-air-pollution-levels-impacting-delhi-ncrs-realty.html>

## The Supply Side - Construction

### Construction Ban

According to a report in economic times, New Delhi's real estate industry was facing a loss of about 1 crore per day due to the construction ban owing to hazardous air pollution levels. "The construction ban has impacted all ongoing real estate projects, but the impact is most severe on projects which are nearing completion as the delivery of such projects is likely to be delayed," said Pankaj Jain, managing director, Realistic Realtors, a real estate advisory firm. Halting of construction also adversely affects the buyer sentiments. At the same time, developers also need to take care of their fixed expenditure such as salary, rent and interest. Customers and daily wagers are among others who are affected by construction ban. It also pushes delivery of ongoing projects specially mega malls which not only loses rent but also business for retailers. But prices does not fluctuate because of few days ban on construction.

### Property value as a variable

Property value is a dependent variable and it can get affected due to predetermined factors like location, facilities, etc but environmental factor does not find a place here as it is important for it to become the determinant of consumer sentiment when buying property, which is so far not in sight.



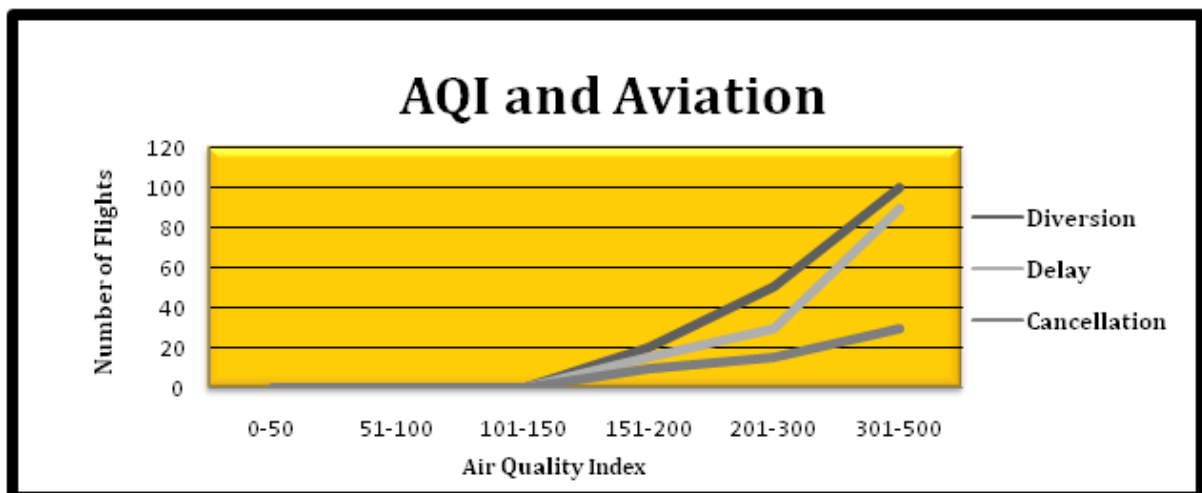
# AVIATION



## Air Pollution and Aviation

In a world, which is in a mire of socio-political and environmental issues, one problem that poses a big threat to mankind is Air Pollution. Numerous measures have been adopted and many agreements have been signed to tackle this menace, but every attempt has largely turned out to be futile. While the reckless exploitation of natural resources by humans heightens the problem of air pollution, air pollution also adversely affects human health and occupations. The noxious air aggravates respiratory ailments and stalls the operation of many pivotal sectors in the economy. One such sector which heavily suffers due to air pollution is the Aviation Sector.

The Aviation sector in India currently contributes \$72 billion to the GDP. Considering its enormous contribution, this sector is clearly indispensable to ensure economic growth. However, every year, as winter approaches, the air lines suffer huge loss in revenue due to air pollution. Though this is particularly relevant in the national capital, Delhi, it still majorly affects the aviation industry and is a cause of concern. New Delhi has been ranked the most polluted city in the world, according to Greenpeace and AirVisual[8]. The heavy smog that settles like a blanket in the city disrupts the smooth operation of airlines. This is mainly because smog, which is a combination of fog and smoke, affects air quality and visibility, and thus, leads to flight diversions.



The graph above represents the positive correlation between Air Quality Index and Flight diversion, delay and cancellation. The higher the air quality index, the more severe is its impact on the aviation industry.

\*GRAPH ABOVE IS ONLY REPRESENTATIVE.

[8] CNN (2019). Flights diverted as New Delhi chokes on heavy pollution. Retrieved from: <https://edition.cnn.com/2019/11/03/india/delhi-flights-pollution-intl-scli/index.html>



## Air Pollution and India's Busiest Airport

Delhi is India's busiest airport and handles around 1,400 aircraft per day. Last year, when air pollution in Delhi reached unprecedented levels, as many as 50 flights were diverted on a single day causing huge losses in revenue and inconvenience to passengers. On another day, more than 250 departures and 300 arrivals were delayed due to low visibility, affecting thousands of flyers. While air experts view diversion as a grave concern, delay and cancellation of flights is an even more serious issue as it irks the passengers, burdens the airline to compensate the passengers for the trouble caused, affects the schedule of flights, and on some occasions even taints the image of the airlines due to failure in offering proper services during such uncertain times.

The cost of diverting an aircraft affects finances and operations of an airline and points to the impact the air pollution crisis can have on the economy. While diverting an aircraft burns fuel, duty hours of pilots also get extended, posing operational and cash burn issues for firms. In order to continue with flight operations in low visibility conditions, airlines will have to train a larger pool of pilots for which they will have to incur an additional cost of Rs. 25 lakh per pilot[9]. This not only burdens the aviation industry with larger costs, but also significantly reduces their profits.



[9] Business Standard (2019). Delhi air pollution: 19 flights cancelled, over 550 delayed and 37 diverted. Retrieved from: [https://www.business-standard.com/article/current-affairs/delhi-pollution-37-flights-diverted-100-delayed-and-19-cancelled-119110300695\\_1.html](https://www.business-standard.com/article/current-affairs/delhi-pollution-37-flights-diverted-100-delayed-and-19-cancelled-119110300695_1.html)



Besides, with the national capital rapidly becoming a hotspot of pollution, it has drawn international attention. The city is seen as one of the most polluted ones in the world with foreign tourists thinking twice before landing into the city. This also affects the revenue of the airlines in terms of the loss in the number of potential passengers. While many claim air pollution to be a natural phenomenon, aviation experts see this as a largely man-made issue. They blame vehicular emission, large cluster of industries, stubble burning in the neighboring states and burning of crackers during festive season for the rising level of air pollution in the capital city[10]. From our study, we can deduce that there exists a positive correlation between the air quality index and flight diversion, delay and cancellation. As the quality of air deteriorates, the opportunity cost of flying an aircraft increases.



[10] Livemint (2019). Toxic smog in Delhi emerges as a new challenge for airlines. Retrieved from: <https://www.livemint.com/news/india/toxic-smog-in-delhi-emerges-as-a-new-challenge-for-airlines-11572885857064.html>

## CONCLUSION

As we have seen, air pollution severely deteriorates not only human health but the devastation also spreads to numerous other fields, the cost of which, if calculated, would be alarmingly huge. Hence, pollution has posed a grave threat on mankind for a while now and it's only fair to judge the economic aspect for mitigation purposes as it causes greater loss every passing day, unknowing to most.

To explain the same, this Policy Brief goes through three sectors with a detailed analysis on how it is affected by air pollution. While sectors like capital markets and aviation faced a greater share of impact, with direct relation, real estate shows a more stoic reaction towards the same. Nonetheless, the fact stands that air pollution is slowly changing everything around us, from where we live to how we invest to how we travel.

**Capital markets** represented a direct negative relation to air pollution which has been illustrated with the help of a comparison between S&P Sensex values and AQI levels through a suitable methodology. It has been fairly concluded that air pollution as rises, the stock markets are affected adversely.

**Real Estate** on the other hand did not show any significant response to air pollution, we looked into both demand and supply side of the industry and deduced that property values are not ruled by pollution yet. The absence of immediate effect of air pollution on humans have led to this inference.

**Aviation** evidently took a hit due to air pollution because of the obvious grounds of visibility and tourism. While the national capital of India continues to experience dangerous levels of pollution, people now avoid visiting. It has staged a threat to the industry as stranded, cancelled or delayed flights on the ports results into financial burden and increased costs for the airlines.

Economies around the globe are controlled and run by manpower or as we refer to them, 'labour force'. Even the slightest change in this number can result into catastrophic consequences on the economy. Pollution is ubiquitous in today's world, and people are not resilient enough, once affected. Therefore, the onus of saving us lies on us, and looking at the statistics, we have to be quick.

It is not an issue to be dealt with only in the national capital or in India; whole world should be willing to contribute in this fight against pollution since the earth isn't ours to spoil, it can very well take care of its own, we should interfere as little as possible or it'll command a price we can't afford.



## Team Members:

Aaradhya Daga  
Aarchi Agarwal  
Amogh Sangewar  
Anudhii Sundaram



The Economics  
Society, SRCC



[ecosocsrcc.com](http://ecosocsrcc.com)



[contact@ecosocsrcc.com](mailto:contact@ecosocsrcc.com)

## Contact:

Nakul Gupta  
+91-85278-30518  
Aaradhya Daga  
+91-70030-47308