GRADUATE SCHOOL OF BUSINESS AND ADVANCED TECHNOLOGY MANAGEMENT
Co-hosted by

How Much Is Clean Air Worth? A Case Study of South Delhi Regions in India

Rani Tyagi

Abstract

Air pollution is one of the most pressing problems in India, taking millions of lives annually. Despite unprecedented air quality deterioration, little is known about individuals' preferences for air quality improvement in India. As a first step, this study presents results from the preferences for air quality improvement of inhabitants in South Delhi, India, which is part of the city of Delhi and where air pollution is causing extensive health hazards. Adequate knowledge about individuals' preferences can help in designing more effective health and environmental policies. Overall, we find a significant willingness to pay for improving the air quality in South Delhi. As expected, people with a higher level of education and a higher income are more willing to pay to alleviate and prevent the effects of air pollution. At the same time, significant gender effects are identified; women seem to have more homogeneous preferences regarding air quality than men. Furthermore, due to income inequalities, a significant number of respondents are not willing to pay.

Keywords: Air quality improvement, CVM, Willingness to pay, South Delhi Individuals' preferences

INTRODUCTION

Ambient air pollution is the world's biggest environmental health threat (World Health Organization, 2016). The recent State of Global Air 2020 Report estimated that air pollution caused 6.67 million premature deaths globally in 2019 and that 58 per cent of these global deaths occurred in China and India (Health Effects Institute, 2020). This implies that controlling air pollution is a major concern across developing countries. In India, for instance, the annual concentration of fine particulate matter (PM2.5) was the highest in the world, and it contributed around 17.8 per cent (1.67 million) of the total death toll in 2019 (Pandey et al., 2020). According to the Swiss Air Quality Index (2020), 35 of the world's top 50 cities in 2020 in terms of the highest levels of annual PM2.5 were in India, and its capital territory, Delhi, was the 10th most air-polluted city in the world.

To alleviate the unprecedented impact of air pollution on big cities, the Indian government has launched a series of control measures together with a substantial increase in the total investment of INR44 billion (US$600 million) in the annual budget 2020–21 to improve air quality (Chatterji, 2020). For instance, an initial INR3 billion (US$42.6 million) was directly allocated to the five-year National Clean Air Programme (NCAP) initiated in 2019 to curb PM2.5 levels by 20–30per cent by 2024, with 2017 as the base year. The NCAP mitigation programme focused on 102 cities in India that had crossed the limit of the National Ambient Air Quality Standards (NAAQSs). Moreover, the central government announced the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) programme in India with an outlay of INR85 billion (US$1.15 billion) in 2015.

In recent years, the Indian government has introduced several measures to combat air pollution. Firstly, in 2015, it introduced the air quality index to analyse the day's air quality based on a set of air quality descriptors along with health advice, and comprehensive air monitoring stations were installed in public areas (Central Pollution Control Board, 2015). Secondly, in 2017, the government introduced an emergency and comprehensive action plan called the Graded Response Action Plan (GRAP) (Chatterji, 2020). The purpose of the GRAP was to enforce emergency measures, such as suspending construction sites, restricting heavy vehicles in the city and imposing odd–even rules when the air pollution exceeds a dangerous level. Moreover, the aforementioned NCAP mitigation strategy followed the prevailing policies and strategies, such as the National Action Plan on Climate Change, promoting electric transportation and the smart cities plan.

Finally, in April 2020, the Indian government imposed the Euro VI emission standards (referred to in India as Bharat Stage VI) to regulate the emission of air pollutants by motor vehicles (Centre for Science and Environment, 2018).

Nonetheless, none of the above measures have been effective in reducing air pollution in India, and it remains a major concern for policymakers due to its huge economic cost in terms of air pollution-related mortality and morbidity (Balakrishnan et al., 2019; Watts et al., 2020). Pandey et al. (2020) showed that air pollution causes economic losses of nearly INR2,714.46 billion (=C30.2 billion), which is 1.36 per cent of India's gross domestic product. Moreover, additional co-benefits of improving the air quality are closely linked to other environment-related issues, such as greenhouse gas emissions, climate change and technological innovation (Bollen, 2015).

For the city of Delhi, the Delhi Pollution Control Committee appointed by the Government of Delhi is committed to sustainable development and thus is also responsible for dealing with the air pollution problem in this area. It implements policies set by the Delhi division of the Ministry of Urban Development. According to Ministry of Urban Development, Delhi Division (2007), the future air pollution mitigation plans must include public transportation planning (frequency, intermodal integration, single ticketing system, parking policy) and policy measures related to the operation of existing power plants and other industries.

However, little information is available about individuals' preferences regarding air pollution that could be used in economic evaluations, such as a cost–benefit analysis. In this paper, as a step towards mapping individuals' preferences for air quality improvement in India, we therefore conducted a survey in South Delhi, India because, especially in the megacities, air pollution is an extensive health hazard (Vohra et al., 2021). Focusing on the second-largest urban district of Delhi, i.e. South Delhi, we provide data related to the benefits of air pollution reduction for a largely unexplored region of the world.

The application of these techniques in developing and transition economies can be however related to local conditions and culture that may be very different from developed economies where these techniques have been applied and their results used in policy making for decades (Navrud and Mungatana, 1994; Rakotonarivo et al., 2016; Quah, 2013). This can be one of the reasons of the lack of environmental studies in these economies and it also increases the importance of an environmental valuation study focused on the severe problem of air pollution carried out in the second most populous country with a rapid growth economy.

2. The Case Study

According to the Census of India (2011), South Delhi has a population of over 2.7 million permanent residents and a population density of 11,000 people per square km. Moreover, 86.60 per cent of the population of South Delhi is literate, meaning that the majority of respondents are able to understand and answer potentially complex DCE surveys. In addition, South Delhi's residents are aware of the level of air pollution in their neighbourhood and can easily think of a monetary value for reducing the level of pollution to a level that they would like. The main reason for this is that there are 10 air quality monitoring stations in Delhi, and three of them are located in the district of South Delhi; they provide people with comprehensive and real-time information about the current air pollution levels (Central Pollution Control Board, 2016).

The economic liberalisation policy of 1991, which brought about rapid industrialisation and urban mobilisation in South Delhi, is considered to be the main reason for its negative trend in air quality. This alone led to a huge increase in industrial emissions, accounting for 35 per cent of the total air pollution in the city Delhi, which includes the analysed area of South Delhi (Ishita and Dholakia, 2019). Moreover, this led to rapid growth in the real estate, power and transportation sectors, coupled with an increase in planned and unplanned urbanisation (Gordon et al., 2018). The steep increase in the number of motor vehicles from 4.2 million in 2004 to 10.9 million in 2018 Economic Survey (2019) has further exacerbated the deterioration of the air quality. As a result, vehicular emissions are now recognised as one of the major contributors, accounting for 30 per cent of Delhi's total air pollution (Ishita and Dholakia, 2019).

3.Survey Design

The objective of the survey was to analyse individuals' preferences for improving the air quality in South Delhi. The survey consisted of four parts. The first part contained an introduction to environmental policies to reduce the air pollution in South Delhi and general questions regarding this issue. The second part was devoted to the DCE, and the third part asked some contingent valuation (CV)-type questions that are not analysed in this study. Finally, some attitudinal questions were posed, and basic socio-demographic information about the interviewees was collected in the fourth part.

The study was based on face-to-face survey of randomly selected 250 households. The survey was conducted in September, 2023. Out of 250, 232 respondents agreed to participate in the study, hence the response rate was 93%. About 32 questionnaires were not filled completely, thus, they were excluded from the study, and the data of 200 respondents were finalized and analyzed.

The questionnaire was divided into 3 sections. Section I consisted of questions regarding demographics including gender, age, monthly income, marital status, number of household members, profession. Section II comprised of respondent's subjective view about the air quality of their area, and their respiratory health. While the final section contained the contingent valuation question. As is well known, these types of questions have been often discussed in CVM literature (Arrow et al., 1993; Hanemann, 1994). Following CVM question was asked. Considering the monthly household income is respondent is willing to pay the cost so that the aim can be achieved?
What is the maximum amount one would be able to pay to improve air quality?
a) Yes b) No

4. Statistical tool and methods

Statistical package SPSS 20.0 was applied to calculate the relationship between WTP and influential factors. After initial statistical analysis, linear regression was used to identify the variables that effect the respondent's final decision on WTP. Afterwards stepwise linear regression model was constructed to determine the amount of positive WTP and to predict mean value of WTP.

5. Results and Discussion

About 64.5 % respondents were female while 35.5% were male. Average age was 27.37, the mean education was 12 years, about 59.5% people were single, average number of children was 1.13 and mean number of family members was 5.60, while the average monthly income was $776.04 (Table 1). In short the respondents were more likely to be female, young, more educated, with more family members and relative average monthly household income.

Characteristic	Frequency	Percentage%	Mean± S.D
Gender			
Male=1	71	35.5	1.64±0.47
Female=2	129	64.5	
Age			
14-20	64	32	
21-26	60	30	27.37±10.75
27-33	31	15.5	
34-40	13	6.5	
41-47	17	8.5	
48-53	15	7.5	
Educational years			
5=1	15	8	3.27±3.23
8=2	57	28.5	
12=3	17	8.5	
16=4	81	40	
18=5	30	15	
Marital Status			
Married=1	79	39.5	3.39±1.95
Divorced=2	2	1.0	
Single=3	119	59.5	
Number of Children			
0-1	133	66.5	
2-3	46	23	1.13±1.72
4-5	17	8.5	
6-7	4	2	
Number of House members			
1-5	111	55.5	
6-10	87	43.5	5.60±1.92
11-15	1	0.5	
16-20	1	0.5	
Monthly Income			
<500$	90	45	
<1000$	84	42	Mean: $776.04
<1500$	7	3.5	
<2000$	11	5.5	
<2500$	3	1.5	
>2500$	5	2.5	
Self-reported air pollution			
*Severe Air Pollution =1	181	90.5	
(Easily observable)	19	9.5	0.90±0.29
Other=0			
Respiratory Disease	90	45	
Yes = 1	110	55	0.45±0.49
No = 0			

Table 1: Demographic results of selected respondents

Factors effecting negativity and positivity of WTP

Out of total 200 valid respondents, 185 responded positively (WTP>0) to valuation response question. Hence the positive response rate was 92.5%. The study area is among the most polluted areas of South Delhi, with significant number of automobiles and ongoing mega-construction projects which are not managed well. Hence the extremely high level of PM, and other pollutants affects the daily life of people who live there, work and walk in the area for several reasons; therefore be various explanations, the major justification which true zeroes gave in open ended question was that the government should take active actions to overcome most of the individuals were concerned for air quality and its consequences on their health. The respondents were split into seven groups, which were based on the money they would be willing to pay (Table 2). The share of negative WTP the true zeros (WTP=0) is quite smaller, only 7.5% of total respondents were not willing to pay a penny to improve air quality of study area.

The other explanation for negative response is unawareness or insensitivity of people regarding air pollution and other environmental issues and low monthly income as well. A possible explanation is that people think that as they are paying taxes, the authorities should manage to control air pollution rather than to ask for more money to improve air quality.

Table 2: People WTP for improvement in Air quality in South Delhi

Variables	Coefficient	S.E
Gender	.021	.020
Age	.004	.002
Education level	.004	.009
Marital Status	.000	.009
Number of children	-.014	.009
Number of household members	-.001	0.005
Suffering From Disease	.016	0.020**
Monthly income	.012	.001*
Air Quality of Area	.077	.032**

Table 3: Linear regression model of positivity of WTP

*P ≤ 0.05; **P ≤ 0.01

WTP/month ($)	Frequency	Percentage
0	15	7.5
1-5	57	28.5
6-10	64	32
11-15	27	13.5
16-20	25	12.5
21-30	5	2.5
>30	7	3.5
Total	200	100

T test, regression models are often used to check the effects of various independent variables on dependent factor. T test can only determine the relationship of one independent and dependent variable. Hence, simple linear regression was applied to determine the relationship of several independent factors on positive WTP. The independent variable expected to have effect on respondent's WTP were age, gender, education level, monthly income, number of household members, number of children, respiratory diseases and self-reported pollution in the city (Akhtar et al., 2017). Statistical analysis (Table 3) demonstrated the results of linear regression, which revealed statistically significant positive association with monthly income (P ≤ 0.05), self-reported air pollution (P≤ 0.01), and one's suffering from air pollution (P ≤ 0.01). It is assumed that individuals with higher monthly income, better socio-economic conditions were more willing to pay for emission reductions, reducing pollution load and improved air quality as compared to those with less income and poor socio-economic conditions which conforms to economic theory (Wang et al., 2006).

*P ≤ 0.05; **P ≤ 0.01

Table 3: Linear regression model of positivity of WTP

Variables	Coefficient	S.E
Gender	.021	.020
Age	.004	.002
Education level	.004	.009
Marital Status	.000	.009
Number of children	-.014	.009
Number of household members	-.001	0.005
Suffering From Disease	.016	0.020**
Monthly income	.012	.001*
Air Quality of Area	.077	.032**

Determinants Amount of WTP

Regression models have been widely used in environmental valuation studies to predict the outcomes (Maloma, 2014). To determine the amount of WTP stepwise regression model was constructed using Statistical package SPSS 20.0 to define the most essential independent variables in prediction equation, ($Y= \beta 0+\beta nXn$). Variables having a significant impact on positive WTP included monthly income, self-reported air pollution and symptoms of respiratory diseases with significance level of 0.05 (Table 4). Analysis of the results shown that residues of WTP were normally distributed forming a normal P-P Plot hence explaining a better estimation of WTP value. The prediction Eq. 1 is:

WTP=-243.973+811(Respiratory disease symptoms) +779.407(Self-reported air pollution) +0.003 (Monthly income) (1)

WTP=9.86/ month

Hence predicted mean value obtained from the model (equation 1) is 9.86/ month the range lies $-1.42 to $27.96. Hence keeping in view the above values annual WTP can be calculated.

$9.86* 12

WTP/ annum= $118 (Rs. 9676 per annum)

Hence concluded that people of South Delhi willing to pay $118 per annum to improve air quality. The predicted WTP per household per month is 1.27% of the mean monthly income of people of South Delhi. Similar results were found in another study conducted in Sweden, the mean WTP for 50% reduction of harmful contaminants was about $227.66 per annum (Carlsson, Johansson-Stenman, 2010). The study conducted in Maxico concluded that people were willing to pay to reduce pollution load was about $262 per annum (Filippini and Martínez-Cruz, 2016). The study conducted in Cotonou, Benin, which is among less income countries, reported WTP of per person per year to improve air quality was $1.04 (Gbinlo, 2006).

CONCLUSION

This survey included open-ended CVM to measure individual's WTP for air quality improvement. In South Delhi and disclosed appealing results regarding WTP of residents for air quality betterment. Among 250 questionnaires that were filled by residents, 93% showed positive response as they were in favor of WTP for improved air quality and this showed their great concern about this rising issue. Only 7% of respondents were not willing to pay the cost for improvement in air quality. Most of negative respondents seemed to be unaware of environmental conservation as they raised this concern that it is duty of government to pay for cost. Important factors including household income, symptoms of respiratory illnesses and opinions on current air quality governed respondent's decision to pay. The analysis disclosed that gender, age and household size differences did not govern and influence on chances of a positive WTP which were hypothesized to explain the results. The results revealed that CVM is applicable in South Delhi and the features of urban resident's WTP gained from this study is quite beneficial since the resulting information records both the direction and the strength of a respondent's priorities.

REFERENCES

Akhtar, S.;Ahmad,A.S.; Qureshi, M.I.; Shahraz, S., (2017). Households' willingness to pay for improved solid waste management. Global J. Environ. Sci. Manage., 3(2): 143-152 (10 pages).

Alberini, A., (1997). Valuing health effects of air pollution in developing countries: The case of Taiwan. J. Environ. Econ. Manage. 34: 107-126 (20 pages).

Ali, Z.; Rauf, A.; Sidra, S.; Nasir, Z.A.; Colbeck, I., (2015). Air quality particulate matter at heavy traffic sites in Lahore, lahore. J. Animal Plant Sci., 25(3 S2): 644-648 (5 pages).

Arrow, K.; Solow, R.; Portney, P. R.; Leamer, E. E.; Radner, R.; Schuman, H., (1993) Report of the NOAA panel on contingent valuation, resources for the future, Washington 58(10): 4601-4614 (14 pages).

Carlsson, F; Johansson-Stenman, O., (2000). Willingness to pay for improved air quality 5`in Sweden. Appl. Econ. 32(6):661-669 (9 pages).

Choe, K.; Whittington, D.; Lauria, D.T., (1996). The economic benefits of surface water quality improvements in developing countries: A case study of Dauao, Philippines. Land Econ., 72: 519-537 (19 pages).

Greenstone, M.; Jack, B.K., (2013). Envirodevonomics: A research agenda for a young field. NBER Working Paper (19426).

Hausman, J.A., (1993). Contingent valuation: A critical assessment. Emerald Group Publishing Limited.

Hanemann, M., (1994). Valuing the environment through contingent valuation, Journal of Economic Perspectives 8(1), 19-43 (25 pages). Huang, R.; Zhang, Y.; Bozzetti, C.; Ho, K.F.; Cao, J.J.; Han, Y.; Zotter,

P., (2014). High secondary aerosol contribution to particulate pollution during haze events in China. Nature.

Krupnick, A.J.; Rowe, R.D.; Lang, C.M., (1997). Transportation and air pollution: the environmental damages. In the full costs and benefits of transportation. Springer Berlin Heidelb. 1: 337-369 (33 pages).

Shahnoushi Froshani, N.; Motallebi, M.; Yazdan Bakhsh, S.A.R.A.; Ashktorab, N., (2010). Estimation of willingness to pay for air quality improvements (Case study: Mashhad, Iran) 5th International conference Social Responsibility and Current Challenges (7 pages). Smith, V., (1992). Arbitrary values, good causes, and premature verdicts: Comment. J. Environ. Econ. Manage. 22: 71-89 (19 pages).

Solomon, P., (2012). Introduction: special issue of air quality, atmosphere and health for air pollution and health: bridging the gap from sources-to-health outcomes. Air Qual. Atmos. Health 5(1): 3-8 (6 pages).

Van der Wall, E., (2015). Air pollution: 6.6 million premature deaths in 2050. Netherland Heart J, 23(12): 557-558 (2 pages).

Wang, Y.; Zhang, Y., (2009). Air quality assessment by contingent valuation in Ji'nan, China. J. Environ. Manage. 90(2): 1022-1029 (8 pages).

Wang, X.J.; Zhang, W.; Li, Y.; Yang, K.Z.; Bai, M., (2006). Air quality improvement estimation and assessment using contingent valuation method: a case study in Beijing. Environ. Monit. Assess. 120(1): 153-168 (16 pages).

Yamamoto, S.; Phalkey, R.; Malik, A., (2014). A systematic review of air pollution as a risk factor for cardiovascular disease in South Asia: Limited evidence from India and Pakistan. Int. J. Hygiene Environ. Health 217(2-3): 133-144 (12 pages).