Working Paper 551

Assessing Commuter's Willingness to Pay to Reduce Traffic Congestion Induced Air Pollution in Bengaluru, India

Vijayalakshmi S
Krishna Raj

Assessing Commuter's Willingness to Pay to Reduce Traffic Congestion Induced Air Pollution in Bengaluru, India

Vijayalakshmi S and Krishna Raj

Published and Printed by: Institute for Social and Economic Change
Dr V K R V Rao Road, Nagarabhavi Post,
Bangalore - 560072, Karnataka, India.

ISEC Working Paper No. 551 December 2022

Institute for Social and Economic Change (ISEC) is engaged in interdisciplinary research in analytical and applied areas of the social sciences, encompassing diverse aspects of development. ISEC works with central, state and local governments as well as international agencies by undertaking systematic studies of resource potential, identifying factors influencing growth and examining measures for reducing poverty. The thrust areas of research include state and local economic policies, issues relating to sociological and demographic transition, environmental issues and fiscal, administrative and political decentralization and governance. It pursues fruitful contacts with other institutions and scholars devoted to social science research through collaborative research programmes, seminars, etc.

The Working Paper Series provides an opportunity for ISEC faculty, visiting fellows and PhD scholars to discuss their ideas and research work before publication and to get feedback from their peer group. Papers selected for publication in the series present empirical analyses and generally deal with wider issues of public policy at a sectoral, regional or national level. These working papers undergo external review but typically do not present final research results, and constitute works in progress.

ISEC working papers can be downloaded from the website (www.isec.ac.in).

ISBN 978-93-93879-23-3

Working Paper Series Editor: **M Balasubramanian**

ASSESSING COMMUTER'S WILLINGNESS TO PAY TO REDUCE TRAFFIC CONGESTION INDUCED AIR POLLUTION IN BENGALURU, INDIA

Vijayalakshmi S[1] and Krishna Raj[2]

Abstract

Traffic congestion is a serious urban menace of the world. Time stuck in traffic causes huge productivity loss and creates irreversible damage to the environment and economy. One such major negative impact is the vehicular emissions which affect both road users and non-users. The main objective of the current study is to examine the Willingness to Pay (WTP) among people for the reduction in traffic-induced air pollution which would explore probable policy options.

For this, the study selected Bengaluru city of India, which is notorious for its traffic menace and vehicular emissions. The result showed that the mean WTP is about Rs. 376 per person. Further, using Heckman's Two-Step Model, the study showed that traffic exposure, illness, workdays loss and awareness regarding the impact of air pollution are the key factors affecting the WTP and WTP amount. This indicates that it is high time for the city planners to consider the options to reduce traffic emissions.

Keywords: Contingent Valuation Method; Traffic Congestion; Willingness To Pay; Heckman's Two-Step Model; Air pollution.

Introduction

The urban world is hit by a menace in the form of traffic congestion. Longer travel time and increased fuel expenses are not the only by-products of traffic congestion; alarming levels of air pollution have become a cause of concern. Even World Health Organization (2015) reported that 80 percent of the urban world is exposed to air pollution above the WHO standard, half of which can be attributed to vehicular pollution. The incidence of vehicular emission and its impact on health has become a grave concern, especially in developing countries like India. It is estimated that nearly 72 percent of the total urban air pollution in the country is caused by vehicular emission (TERI, 2015)[3]. Among the various sources, a major contribution comes from increasing private vehicular ownership (CPCB, 2011).

Among the growing metropolitan cities of India, Bengaluru has received global attention for its traffic and air pollution. The city is growing in terms of both population and size and also has been a forerunner in attracting major MNCs of the world. Due to lack of better public transportation systems to cater to the growing mobility demand, city dwellers tend to resort to private commuting options. It is estimated that the city's private vehicular population is growing at the rate of 10 percent per annum (2001 to 2019), whereas the public transportation is lagging behind with an annual growth rate of less than one percent (RTO, 2020). This clearly indicates the severity of traffic congestion and resultant vehicular emission in the city. It is reported that among all the major metropolitan cities in the country, it is only in Bengaluru that a majority of the air pollution is contributed by vehicular emission (nearly 40%) (TERI, 2015). One key impact of prolonged traffic time is higher vehicular emission and exposure.

[1] Research Associate, Centre for Economic Studies and Policy, Institute for Social and Economic Change, Bengaluru, India

[2] Professor in Economics, Centre for Economic Studies and Policy, Institute for Social and Economic Change, Bengaluru, India

[3] Industries 20 percent and domestic activities 8 percent.

Epidemiological evidence has proved that the long exposure to vehicular emission has a severe impact on the health of daily commuters. Various studies have proved the relationship between exposure to traffic-related air pollution and the global burden of mortality (HEI, 2010). Even though such scientific evidence is lacking in the case of developing countries, studies like Cropper *et al* (1997) and TERI (2015) have examined the impact of air pollution on human health for Indian cities. Further, it is proved that in traffic junctions, due to the higher concentration of vehicular population, the pollutants' impact is severe. For example, the average concentration of $PM_{2.5}$ in-vehicle is 2.5 times higher, and CO is six times higher than the concentration at nearby urban site (Chan *et al*, 1991; Adams *et al*, 2001; Kaur *et al*, 2005). This indicates that commuters in the traffic junctions have higher exposure and hence, are more prone to illnesses. Studies have proved that motor vehicle emissions have a variety of effects on human health which ranges from itchy eyes to chronic lung disease to heart failure (McCubbin and Delucchi, 1999). WHO (2013) reported that increased PM pollution created a substantial burden of disease which can take the form of productivity loss, morbidity and even death.

In the case of Bengaluru, air quality is deteriorating due to increase in personal vehicles (41% of PM from vehicles) and improper management. The concentration of $PM_{2.5}$ in the city ranges from 156μg/m^3 to 458 μg/m^3 (for 2017-18), which is 4-11 times higher than the national standard of 40 μg/m^3. Several studies have found that there has been increase in incidents of asthma, bronchitis, and cardiovascular disease due to increase in air pollution in the city. The studies conducted in Delhi have shown that 100μg/Nm^3 increase in total suspended matter (TSP) will increase the non-trauma deaths by 2.3%. On the other hand, Ostro (1994) found that 1% reduction in TSP could lead to 0.45% reduction in working days loss.

Hence it is clear that air pollution reduction will definitely help to improve the health of the people which in turn reduces extra expenditure on health. On these lines, the present study aims at determining the Willingness To Pay (WTP) among people to reduce traffic-induced air pollution in the city. For this, the current paper is structured as follows: Section 2 reviews the relevant literature. Section 3 explains the data and methodology and section 4 reports the empirical result. Section 5 discusses the policy implications of the findings and concludes the paper.

Review of Literature

A large number of studies have used the Willingness To Pay approach for the reduction in air pollution. But the current study focuses on those studies which have applied it for the reduction of vehicular air pollution and improvement in the health of the people.

Alberni and Chiabia (2007) estimated people's Willingness to Pay to avoid health risk from road transport related pollution in Italy. They found the WTP was at least 950 euros per year for the health risk reduction.A similar study was conducted by Vlachokostas *et al* (2011) in Greece. The study reported that the WTP to save one year of life was approximately 920 euros per person per year.

Dziegielewska and Mendelsohn (2005) estimated the WTP for reduction of vehicular air pollution below EU standard and the result showed that the WTP value is about 1 percent of the GDP per capita in 2004. Lera-López *et al* (2014) used the WTP approach to measure the impact of road transport externalities in Western Pyrenees mountains. Their result showed that households near the main road experienced welfare loss of around 45 euros per year.

To examine the Willingness To Pay for cleaner vehicles which reduce air pollution, Poder and He (2017) calculated the WTP in Canada. The result showed that people's Willingness to Pay ranged from 3000 to 8000 CAD to buy cleaner vehicles. In an effort to estimate the impact of transport on the environment, Filippini and Martinez-Cruz (2016) used the contingent valuation method in Mexico City. The study found that due to transport-related pollution, there was a welfare loss of approximately 262 USD per person per year. Ligus (2018) estimated the WTP for clean air in Poland. The result showed that people were willing to pay 21,172 PLN per month for the clean air. Alberni and Krupnick (2002) adopted the contingent valuation method (CVM) and COI for Taiwan. They estimated the direct cost of medical expense as around US$ 510,491 for 100μg/m3 reductions in PM10 and productivity loss of around US$ 117,575 - $244, 477 (using CVM).

Many studies in Southeast Asia have used WTP to estimate the air pollution reduction. Masahina *et al* (2012) estimated the WTP for averting air pollution related illness in Klang Valley, Malaysia. A similar study was conducted by Bazrbachi *et al* (2017). Lee *et al* (2011) evaluated the WTP for reducing the mortality rate associated with vehicular emission in Seoul. Mahirah *et al* (2015) used the CVM method to value road user's WTP to reduce traffic congestion in Klang Valley, Malaysia. The results demonstrate that the mean Willingness to Pay is about RM1.95 for toll payment in Klang Valley highways. The results also showed that household income, respondents' occupation and price bid toll payment have significant effects on the Willingness To Pay to reduce traffic congestion.

Data and Methodology

The reduction of air pollution requires a collective approach, and hence needs the interest of the commuters. The best method to derive this is to elicit their Willingness to Pay for the reduction of traffic-induced air pollution. This method is called the Contingent Valuation Method. It is a stated preference approach to elicit the hypothetical choices in a well-administered sample survey (Hanemann, 1984). The method is popularly used to value the non-market goods. The principle underlying WTP is the belief that in market economies, the social cost of a change in economic outcomes is measured by the sum of the individual's WTP for that change (World Bank, 1992). In this method, a hypothetical situation (market) is created by asking the respondents whether they are willing to pay as well as the amount that they are willing to pay for certain non-market goods (Bengochea-Morancho *et al*, 2005). CVM method overcomes the limitations of travel cost method (revealed preference approach) by measuring both use and non-use values. Even though some researchers have identified some caveats of the method by pointing out that it is a poor indicator of actual values of Willingness to Pay (Carson and Mitchell, 1993), and may not be a valid measure for economic valuation of public goods (Johnson *et al*, 2012), many researchers supported this, saying it can be used if there is a careful elicitation of the values (Sattout *et al*, 2007).

The method involves a survey-based technique of monetary valuation used to determine people's preferences expressed in terms of WTP. In this study, the method applies a proper design questionnaire in order to determine the valuations of road users about the reduction of traffic-induced air pollution in Bengaluru city so that there will be an improvement in the health condition of city commuters. With this information, the respondents are probed to reveal their preference regarding state intervention with a policy to reduce vehicular pollution. The basis for their willingness (whether health expenses or income) are also taken.

In order to minimize the missing responses, the situation has been explained more clearly to the respondents using both face-to-face interviews and telephonic interviews. An open-ended question is also provided to elicit the maximum amount that the respondents are willing to pay. Responses to open-ended question are likely to minimize the standard error and lower the estimates of central tendency and prevent bias (O'Conor *et al*, 1999; Boyle *et al*, 1996).

The study adopted the health production model which models the impact of traffic emissions on the health condition.

Willingness to Pay Model

The study assumes that the utility is derived from goods consumed X, leisure time L, workdays loss due to traffic-induced illness H and level of air pollution Q. The individual derives utility from consumption of X and L and disutility from H and Q.

$$U = U(X, L, H, Q) \quad \ldots \text{(a)}$$

Further individual adopts certain mitigating activities which improve or maintain his health status given Q and other socio-economic characteristics Z. The health production function can be written as,

$$H = H(M, Q, Z) \quad \ldots \text{(b)}$$

The workdays loss H, enters the budget constraint by influencing the amount of productive time available for work. Thus, the budget constraint can be formed as,

$$Y + w(T\text{-}L\text{-}H) = PxX + PmM \quad \ldots \text{(c)}$$

where Y is non-wage income, w is the wage rate, T is the total time available, and terms in parenthesis is time spent in working. P is the price of X and M. The health production model assumes that the individual allocates time between work and leisure; and income between medicine and other goods to maximize the utility is subject to the budget constraint (eq. c).

The study has hypothesized a policy intervention[4] which would reduce traffic emissions in the city and has a positive impact on morbidity and mortality. An individual's Willingness to Pay the amount would be the amount that can be taken from him for reducing the vehicular emissions and keep his utility constant. This can be equivalent to the change in H. The value of change in H may be defined using a pseudo-expenditure function (Cropper and Freeman, 1991). This is the minimum value of expenditure minus wage income necessary to keep utility at U^0, or

$$E = \min \{PxX + PmM - w(T\text{-}L\text{-}H) + \lambda [U^0 - U(X, L, H, Q)]\} \quad \ldots \text{(d)}$$

[4] Hypothetical policies are provided to respondents to elicit their opinion.

where λ is a Lagrange multiplier. Willingness To Pay for a non-marginal change in H may be defined as the expenditure necessary to achieve U^0 at the original workdays loss H^0, minus the expenditure necessary to achieve U^0 at the new (lower) workdays loss H^1

$$WTP = E(Px, Pm, Y, w, H^0, U^0) - E(Px, Pm, Y, w, H^1, U^0) \quad \text{… (e)}$$

Equation (e) implies that Willingness to Pay should vary with income, prices of goods and medicines, individual characteristics, treatment undertaken and workdays loss. To validate the WTP responses, we regress it on these variables. In addition, WTP values are calculated based on mathematical expectations (discrete variables), and the formula is (Kong *et al*, 2014):

$$E = WTP = \sum_{i=1}^{n} \alpha_i Pr_i \quad \text{… (f)}$$

Where α_i stands for the amount respondents *i* willing to pay, Pr_i is the probability that respondents will pay the amount; n is the sample size of the respondents whose WTP is positive.

Heckman's Two-step Model: The Heckman's Two-step Model is preferred for two main reasons. Firstly, the logit and probit models cannot examine the factors affecting Willingness to Pay and the amount simultaneously. Further, these models could not eliminate the interference of 'WTP=0' samples while averaging the factors of respondents' payout levels (Sellers-Rubio & Nicolau-Gonzalbez, 2016). In Heckman's model, the factors affecting the WTP and the amount that respondents are willing to pay can be simultaneously determined in a single model which prevents the disturbance of respondents whose WTP is zero. Secondly, the model could explicitly resolve the potential sample selection bias (Kim and Jang, 2010; Kong *et al*, 2014). In the Heckman's Two-step Model, the first step uses the probit model to examine the factors affecting the Willingness to Pay which can be expressed as:

$$Z = \partial_0 + \partial_1 X_1 + \partial_2 X_2 + \partial_3 X_3 + \cdots + \partial n Xn + \varphi \quad \text{… (g)}$$

Z is the explained variable that is the probability of respondents' WTP; X_1, X_2, X_3,…Xn are the explanatory variables, and φ is the residual term. The second step uses the multiple linear regression model to determine the factors influencing the payment level (Baum, 2006). This can be written as:

$$Y = \beta_0 + \beta_1 X_1 + + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + \delta\lambda + \mu \quad \text{… (h)}$$

Y is the dependent variable which examines the factors affecting the respondents' payment level. The Mills ratio (λ) is used to overcome the sample selection bias (Johnson *et al*, 2012), β_1, β_2, β_3,… βn and δ are the coefficients to be estimated. X_1, X_2, X_3… Xn are the independent variables, and μ is the residual term.

Sampling Procedure

For deriving the WTP, the study relied on the primary survey. For collecting the data, the city was classified into four zones viz., Central Business District (CBD), adjacent CBD, Inner Peripheral and Peripheral zones. The study mainly included daily commuters of the city. Both private vehicle users and public vehicle users were interviewed for the study. Using a random sampling technique for each zone, a total of 452 responses were taken. Out of this, 427 responses were considered after looking at the missing responses. While conducting the interview, the respondents were informed about the situation of vehicular traffic in the city and its impact on air quality. In a structured questionnaire, the respondents were also informed that reduction in vehicular emission would improve the health of commuters in the city. For eliciting the WTP, a hypothetical policy intervention was introduced.

The values of Willingness to Pay for the reduction in traffic-related air pollution are based on certain socio-demographic features. In this section, the study provides a descriptive analysis of the perception of WTP based on age, income, education levels, which will aid infurther analysis of the same.

Before examining the socio-economic variables, it is important to consider the zone-wise Willingness to Pay values (Table 1). This provides an analysis by relating the WTP values to zonal characteristics like the income level and air pollution quality of each zone. The average per capita income and average annual $PM_{2.5}$ are taken for the year 2018-19.

Table 1: Zonal wise WTP values with their Income and Air Pollution Level

Zones	Average per capita income (Rs./year)	Average annual $PM_{2.5}$ level (μg/m^3)	WTP (% of respondents)	
			Yes	No
CBD	5, 05, 368	70.9	90.6	9.3
Adj.CBD	5, 21, 100	120	92.4	7.5
Inner Periphery	5, 02, 716	95	85.1	14.8
Periphery	4, 37, 176	113	63.2	36.7
All zones	4, 19, 424	87.91	82.9	17.1

Source: Authors' analysis based on primary data

It is observed from Table 1 that among the zones, the percentage of respondents who are willing to pay for the reduction of traffic-induced air pollution is more in Zone 1 and 2 as compared to Zone 3 and 4. This can be attributed to high vehicular density in these zones. Further, among different age groups, a maximum number of respondents belonging to the age group above 45 years (90% of the age group) are willing to pay than the respondents belonging to the age group below 45 years (70% of the age group) which can be linked to their travel and health history.

Another significant variable influencing the WTP is income. Generally, income tends to have a positive impact on the Willingness to Pay for the reduction in the air pollution. For instance, among the respondents of the income-class less than Rs. 10000, only 28 percent were willing to pay for the reduction of traffic-related air pollution. In contrast, in the case of the income group of above Rs. 55000, all the respondents replied positively. In Table 2, these responses are provided for each income group.

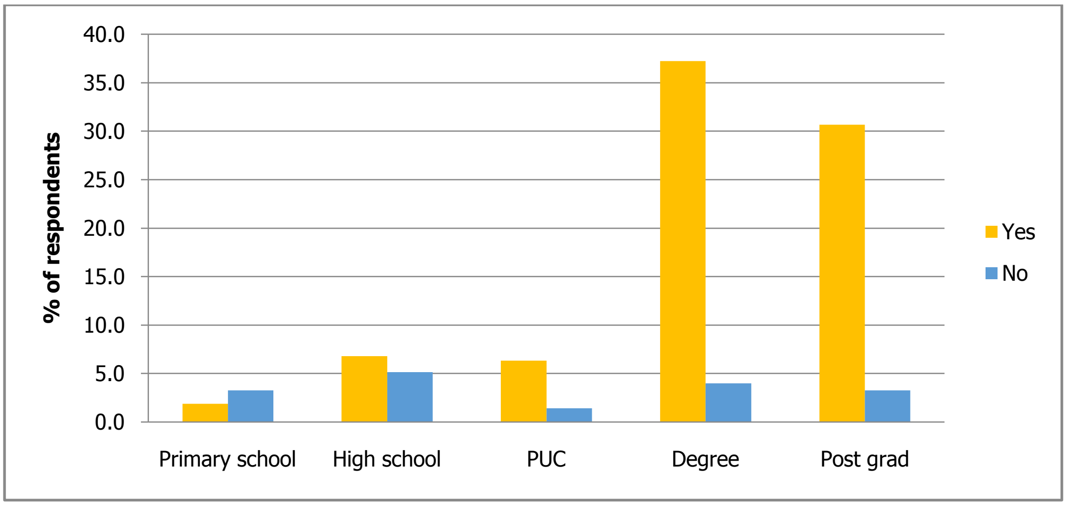
Table 2: Income-wise WTP

Income Groups	% of Respondents	
	Yes	**No**
<10000	28	72
10001-25000	79.6	21
25001-40000	90.3	9.6
40001-55000	84.9	15
55001-70000	100	0
70001-85000	100	0
85001-100000	100	0
>1 Lakh	100	0

Source: Authors' analysis based on primary data

Another important factor affecting WTP is the level of education. From Figure 1, it is evident that as education level increase people understand the problem and elicit their WTP.

Figure 1: Education's influence on WTP



Source: Authors' analysis based on primary data

It may be possible that the elicitation of values of WTP may depend on the health issue suffered by the respondents. During the interviews, it has been clearly established that a reduction in traffic-related air pollution would increase their health condition, which in turn would reduce the probability of mortality. With this information, respondents provided their WTP values which are provided in Table 3.

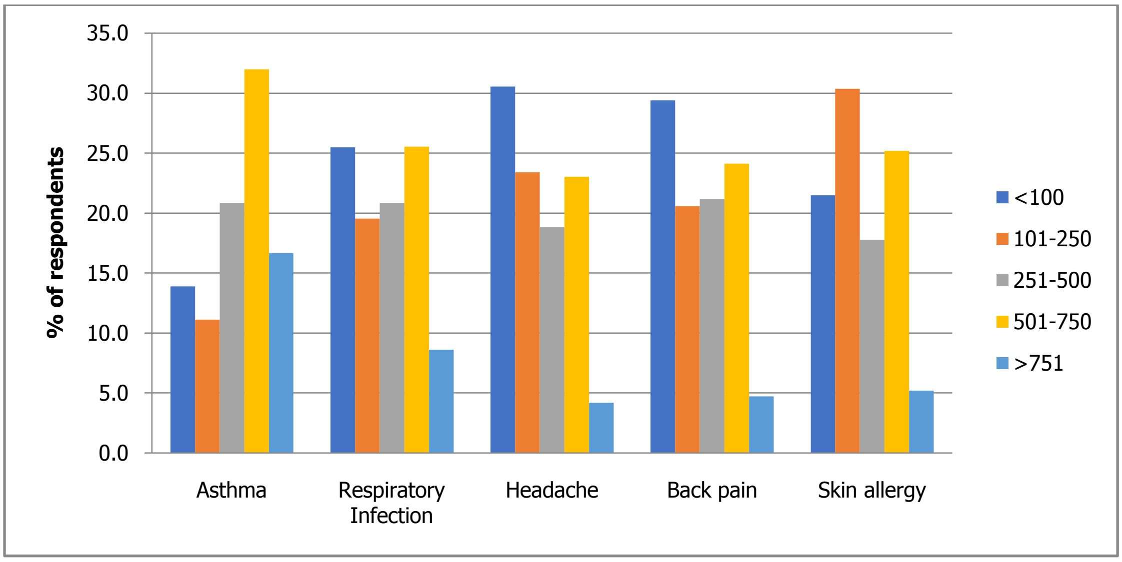
Table 3: Health issue-wise WTP

Health issues	% of Respondents	
	Yes	No
No disease	70.5	29.5
Asthma	91.3	8.6
Respiratory infections	92.8	7.14
Cough	88.8	11.11
BP and Stress	90.6	9.3
Headache	89	11

Source: Primary Data

It is interesting to know from Table 3 that the total respondents who reported that they do not suffer from any travel-related health issue (70.5%) are still willing to pay for the reduction in traffic-related air pollution. From this, it can be inferred that the respondents are aware of the probable impact of pollution and are willing to make contributions for their betterment. Further, among each disease type, a majority (above 80%) of the respondents are willing to pay for the reduction in traffic-related air pollution, which would reduce the related mortality.

Figure 2: WTP values based on disease type



Source: Authors' analysis based on primary data

Factors affecting WTP: Heckman's Two-step Model

The effort to model an individual's Willingness to Pay for the reduction in air pollution which improves health condition is well established in the literature (Cropper and Freeman, 1991; Alberni *et al*, 1997). In this section, the study analyzed the factors affecting WTP and WTP amount.

Econometric Specification

To investigate the factors influencing Willingness to Pay for a reduction in traffic-related emissions, the study used Heckman's Two-step Model. In the Heckman's Two-step Model, the first step uses the probit model to examine the factors affecting the Willingness to Pay and the second step uses the factors influencing the payment level using multiple linear regression model.

Description and descriptive statistics of the variables used in the model are provided in Table 4:

Table 4: Description and Descriptive Statisticsof Variables used in the model

Variables	**Description**	**Mean**	**Std.dev**	**Min.**	**Max.**
WTP (Dependent variable)	Willingness to pay for a reduction in traffic-related emission: yes=1; No=0	0.82	0.37	0	1
WTP Amount(dependent variable)	WTP amount (Rs./year)	376.5	397	0	3000
Income	Annual Income of commuters (in Rs.)	419423	300144	96000	3000000
Gender	Sex of commuter: 1=male; 0 =female	0.64	0.47	0	1
Age	Age of the respondents: Dummy variables are: Dage1: Age below 25 years (Reference category) Dage2: Age between 26-45 years Dage3: Age above 46 years	0.18 0.66 0.14	0.39 0.47 0.35	0 0 0	1 1 1
Education	Education of the respondents: Dummy variables are: Dedu1: Education below graduation (Reference category) Dedu2: Graduation level Dedu3: After graduation level	0.24 0.41 0.33	0.43 0.49 0.47	0 0 0	1 1 1
Exposure	Time exposed (spent) in traffic emission (in minutes/day)	38.81	18.98	0	130
Treatment	Travel related health issue treated yes=1(if treatment is taken); no=0	0.50	0.50	0	1
WDL	Workdays loss due to travel-induced health issue	0.25	0.51	0	4
Awareness	Awareness regarding traffic-induced air pollution causing mortality risk 1= yes; 0 = otherwise	0.84	0.36	0	1
Traffic_Illness	Traffic-related illness suffering by the respondents 1=Yes; 0=No	0.12	0.33	0	1
Zones of the city	Z1=Zone 1=CBD (Reference Category) Z2=Zone 2=Adjacent CBD Z3= Zone 3=Inner periphery Z4= Zone 4=Periphery	0.25 0.24 0.25 0.24	0.43 0.43 0.43 0.43	0 0 0 0	1 1 1 1

Empirical Results and Discussion

The frequency of Willingness to Pay for the reduction of air pollution induced by traffic congestion is provided in Table 5. Almost 83 percent of the respondents from the survey are willing to pay for the reduction in traffic-induced air pollution in the city, and 17 percent of them have reported that they are not willing to pay.

Table 6: Frequency of WTP

WTP	Sample Size	Percentage
Yes = 1	73	17.1
No = 0	354	82.9

Heckman's two-step model is applied using Stata 10.1. Table 7 presents the parameter estimates for the factors affecting WTP and the amount to reduce traffic emission. It should be noted that the probit model in Table 7 has 14 explanatory variables (first stage) and 10 explanatory variables[5] are introduced in the second stage (Table 8). This is because Heckman's model should include at least one variable in the first stage that is different from the variables included in the second stage (Baum, 2006). Based on this principle, the second stage is regressed with statistically significant variables. According to Table 6, it can be observed that the value of Wald is 112.96 and P-value is zero, indicating the whole model is effective in explaining the dependent variable.

Table 6: Model Validity Analysis

Observations	Restricted obs.	Unrestricted obs.	Wald	P>|z|
427	73	354	112.96	0.000

Factors affecting WTP: Probit Model

The probit model in Table 7 explains that the WTP is significantly influenced by income, education level, age, exposure, traffic-related illness, treatment, awareness and zonal dummy variables. Though the gender variable has a positive sign, it is not statistically significant. Even studies on WTP in relation to air pollution like one by Alberni *et al* (1997) reveal similar results. The age dummy variables, namely, dage2 and dage3, are found statistically significant with the positive coefficient sign. This infers that respondents with higher age groups, here those who belong to the age group of 26-45 years and 46 years and above, are more likely to reveal their Willingness to Pay for the reduction in traffic-induced air pollution as compared to the base category of respondents who are below the age group of 25 years.

Likewise, the income variable is found statistically significant, and the coefficient is positive, which infers that respondents with higher income have stronger WTP for a reduction in traffic-induced air pollution. This is expected theoretically and observed by other studies like Abdullah and Jeanty (2011) and Del Salazan *et al* (2015). In a similar manner, the education variables in their dummies viz., dedu2 and dedu3 are positive and statistically significant in explaining the factors affecting the WTP. This indicates that respondents who belong to education category of graduation and above are more

[5] As other variables are not found significant.

likely to pay for the reduction in traffic-induced air pollution as compared to the respondents who belong to the education category of less than graduation[6].

Table 7: First-stage Probit Analysis: Factors affecting WTP

Variables	WTP (Yes=1; No=0)	
	Coefficient	Z (Std. Error)
Gender	0.103	0.188
Dage2	0.974***	0.247
Dage3	0.786**	0.418
Income	0.002***	0.001
Dedu2	0.640***	0.230
Dedu3	0.419*	0.274
Exposure	0.021***	0.006
Traffic illness	0.490***	0.243
Treatment	0.539**	0.229
Awareness	0.502**	0.257
WDL	0.032	0.020
Z2	0.358	0.310
Z3	-0.810***	0.295
Z4	-1.336***	0.281
Constant	0.386	0.471

***Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

One of the key variables of the present study is the traffic exposure variable. From Table 7.19, it is clear that the variable is statistically significant at 1 percent, and its coefficient has a positive sign. This indicates that the respondents who are exposed to longer duration to the traffic emissions are more likely to provide their WTP for the reduction of the same. Similarly, the traffic-related variables like the respondents suffering from any traffic-related illness (like cough, asthma, respiratory infections and so on) and respondents who have taken treatment for any such illness, are found statistically significant, and the coefficient is positive. This can be explained as respondents who suffer from any such illness and who undergo treatment for the same have a higher probability to reveal their WTP for the reduction of traffic emissions in the city.

The findings from Del Salazon *et al* (2015) explained that awareness regarding the implications of air pollution might have a significant impact on the WTP values. A similar result is found by the current study. The awareness variable is found statistically significant with a positive coefficient sign. This indicates that respondents who are aware of the traffic-related illness due to traffic emission are more likely to provide their WTP as compared to those who are not aware of the same. Another important variable for the study is the zonal dummies. The coefficients of zone 3 and 4 are found statistically significant with a negative sign. This infers that the respondents who belong to these zones (3 and 4) are less likely to provide their WTP as compared to respondents who belong to zone 1. This

[6]Further it is found in the literature that, graduates and higher than graduate commuters tend to travel more than the commuters with less education than graduation.

may be related to their comparatively low income level as against respondents of zone 1 (as reported in Table 1).

Factors affecting payment levels: Multiple Linear Regression Model

The multiple linear regression model in Table 8 indicates that income, education, traffic illness, awareness, and WDL are found statistically significant when related to the WTP amount. The income variable has a positive coefficient and is found statistically significant with WTP amount. This indicates that there is a high probability that as income increases, the payment level (WTP amounts) may also increase. On similar lines, education variables have statistical significance with WTP amounts. The positive sign for these variables (dedu2 and dedu3) indicates that the respondents who belong to higher educational qualification (mainly graduation and post-graduation and above) are more willing to pay a higher amount to reduce traffic-induced air pollution, as compared to the respondents with education qualification less than graduation.

The key variables like traffic-related illness, awareness and WDL are found significant by the study. Respondents who reported that they are suffering from any sort of traffic-related illness are willing to pay higher amounts to reduce traffic-induced air pollution. The work-days loss is found statistically significant with a positive sign indicating that respondents who face a high number of days of work loss would like to provide higher amounts of their WTP. The reason may be that respondents with the illness and who lose their work-days may perceive that any reduction in traffic emission may improve their health status and work productivity. On the other hand, respondents who are aware of the traffic-related impacts on the health and environment provide higher amounts of WTP as compared to respondents who are not. The zonal variables are found insignificant in influencing the payment level of WTP.

Table 8: Multiple Linear Regression Analysis: Factors affecting WTP amount

Variables	**WTP Amount**	
	Coefficient	**Z (Std. Error)**
Gender	-5.328	39.339
Income	0.006***	0.0008
Dedu2	113.604**	58.033
Dedu3	163.921***	61.764
Trafficillness	144.754***	54.770
Awareness	124.405**	56.799
WDL	68.310**	38.104
Z2	89.591**	49.207
Z3	-30.864	56.732
Z4	78.530	61.926
Constant	113.071	89.707
λ	48.167	97.610

***Significant at 1% level; ** Significant at 5% level; * Significant at 10%level

Source: Authors' calculation based on a primary survey

The inverse mills ratio (λ) is positive and not statistically significant from zero, suggesting that there is no sample selection bias in the model. These results are found consistent with the other studies related to air pollution (Alberni *et al*, 1997; Landefeld and Seskin, 1982; Vlavhokostas *et al*, 2011).

The study used Equation (f) to estimate the payment level in each zone of the city. The result is provided as:

$WTP_{z1} = \sum_{i=1}^{n} \alpha_i Pr_i = 393$ (i)

$WTP_{Z2} = \sum_{i=1}^{n} \alpha_i Pr_i = 534$ (ii)

$WTP_{Z3} = \sum_{i=1}^{n} \alpha_i Pr_i = 499$ (iii)

$WTP_{Z4} = \sum_{i=1}^{n} \alpha_i Pr_i = 288$ (iv)

$WTP_{All} = \sum_{i=1}^{n} \alpha_i Pr_i = 376$ (v)

The result from (i) to (v) it can be inferred that in zone 2, the Willingness to Pay is highest with Rs. 534/person per year and least in zone 4 with Rs. 288/person per year. Zone 1 and Zone 3 have the WTP value of Rs. 393 and Rs. 499/person per year, respectively. This result indicates that the zone with the highest $PM_{2.5}$ level (Table 1) and highest per capita income would be willing to pay the higher amount as compared to other zones. The annual mean WTP of the study area is estimated as Rs. 376 per person and jointly, the average WTP for the sample would be Rs. 1, 60, 552. The value represents an aggregation of individual values for reduction in vehicular air pollution in the city.

Policy Implication and Conclusion

The main focus of this study is to determine road user's Willingness to Pay for the reduction in vehicular emissions, which will improve their health condition. Most of the respondents were willing to pay for the policy which will reduce the air pollution in the city and this has resulted in a mean WTP of Rs. 376 per person. Among variables which have influence on the WTP of commuters, key variables like WDL, traffic exposure, its related illness and awareness regarding its ill-effects are found statistically significant. Further, zones with higher $PM_{2.5}$ have high WTP, which is indicating the intensity of air pollution in those areas.

This result highlights the need to take immediate measures to reduce vehicular emissions in the city. The study supports improving the public transportation system in the city. The main contention of the study is that there is a need to make public transportation more accessible and affordable. Further, there is a need to reduce the vehicular density in the CBD and adjacent CBD of the city where the pollution is high due to high vehicular movement.

It is interesting to observe that commuters who do not suffer from any traffic-related illness are also willing to pay for the reduction of emission in the city. This highlight that commuters are aware of the probable effects of the air pollution in the city and hence, ready to make the contributions for the betterment of air quality. As the study derived the WTP from a policy intervention, it highlights that it is the main responsibility of city planners to take suitable action to improve the air quality in the city. This can be done by improving the public transportation, promoting clean vehicles in city CBD and also making emission check certificate compulsory to all vehicles in the city.

References

Abdullah, S and W P Jeanty (2011). Willingness to pay for renewable energy: Evidence from a contingent valuation survey in Kenya. *Renewable and Sustainable Energy Reviews*, 15: 2974-83.

Adams, H S, L C Kenny, M J Nieuwenhuijsen, R N Colvile and R A Gussman (2001). Design and Validation of a High Flow Personal Sampler for PM2.5. *Exposure Anal Environment Epidemiology*, 11: 5-11.

Alberni, A and A Krupnick (2002). Cost of Illness and Willingness to Pay Estimates of the Benefits of Improved Air Quality: Evidence from Taiwan. *Land Economics*, 76 (1): 37-53.

Alberni, A and A Chiabai (2007). Urban Environmental Health and Sensitive Population: How much are the Italians Willing to pay to reduce their risk? *Regional Science and Urban Economics*, 37: 239-58.

Alberni, A, M Cropper, F Tsu-Tan, A Krupnick, Jin Tan Liu, D Shaw and W Harrington (1997). Valuing Health Effects of Air Pollution in Developing Countries: The case of Taiwan. *Journal of Environmental Economics and Management,* 34: 107-126.

Baum, C F (2006). *An Introduction to Modern Econometrics using Stata*. Tx, USA: Stata Press.

Bazrbachi, A, S F Sidique, M N Shamsudin, A Radam, S Kaffashi, S U Adam (2017). Willingness to pay to improve air quality: A study of private vehicles owners in Klang Valley, Malayasia. *Journal of Cleaner Production*, 148: 73-83.

Bengochea-Morancho, A, A M Fuertes-Eugenio, S del Saz-Salazar (2005). A comparison of empirical models used to infer the Willingness to Pay in contingent valuation. *Empirical Economics*, 30: 235-44.

Boyle, K J, F R Johnson, D W McCollum, W H Desvousges, R W Dunford, S P Hudson (1996). Valuing public goods: Discrete versus continuous contingent-valuation responses. *Land Economics*, 72: 381-96.

Carson, R T and R C Mitchell (1993). The issue of scope in contingent valuation studies. *American Journal of Agricultural Economics*, 75: 1263-67.

Chan, C C, H Ozkaynak, J D Spengler, L Sheldon (1991). Driver Exposure to Volatile Organic Compounds, CO, Ozone and NO2 under different driving conditions. *Environment Science Technology*, 25: 964-72.

CPCB (Central Pollution Control Board) (2011). Air quality monitoring, emission inventory and source apportionment study for Indian cities. Retrieved from www.indiaenvironmentportal.org.in.

Cropper, M L and A M Freeman (1991). Environmental Health Effects. In J B Braden and C Kolstad (eds), Measuring The Demand For Environmental Quality. Amsterdam: Elsevier Science Publishers.

Cropper, M L, N B Simon, A Alberini, S Arora and P K Sharma (1997). The Health Benefits of Air Pollution Control in Delhi. *American Journal of Agricultural Economics*, 79 (5): Proceedings Issue: 1625-1629.

Del Salazan, S, F González-Gómez, F Guardiola (2015). Willingness to pay to improve urban water supply: The case of Sucre, Bolivia. *Water Policy*, 17 (1): 112-25.

Dziegielewska, D A P and R Mendelsohn (2005). Valuing Air Quality in Poland. *Environmental Resource Economics*, 30: 131-63.

Filippini, M and A L Martinez-Cruz (2016). Impact of environmental and Social attitudes and family concerns on Willingness to Pay for improved air quality: A contingent valuation application in Mexican City. *Latin American Economic Association*, 26: 7.

Hanemann, M W (1984). Discrete/continuous models of consumer demand. *Econometrica*, 52: 541-62.

Health Effect Institute (HEI) (2010). Traffic-Related Air Pollution: A critical review of the literature on emission, exposure and health effects. HEI Special Report 17. Health Effect Institute: Boston. MA.

Johnson, B K, J C Whitehead, D S Mason, G J Walker (2012). Willingness to pay for downtown public goods generated by large, sports-anchored development projects: The CVM approach. *City, Culture and Society*, 3: 201-208.

Kaur, S *et al* (2005). Personal exposure of street canyon intersection users to PM2.5, ultrafine particle counts and carbon monoxide in Central London. UK. *Atmospheric Environment*, 39: 3629-41.

Kim, J and S C Jang (2010). Dividend behaviour of lodging firms: Heckman's two-step approach. *International Journal of Hospital Management*, 29: 413-20.

Kong, F, K Xiong and N Zhang (2014). Determinants of Farmers' Willingness to Pay and its level for ecological compensation of Poyang Lake Wetland, China: A household-level survey. *Sustainability*, 6: 6714-28. Doi: 10.3390/su6106714.

Landefeld, S J and P E Seskin (1982). The Economic Value of Life: Linking Theory to Practice. *American Journal of Public Health*, 72 (6): 555-65.

Lee, Y J, Y W Lim, J Y Yang, C S Kim, Y C Shin, D C Shin (2011). Evaluating the PM damage cost due to urban air pollution and vehicular emission in Seoul. *Journal of Environment Management*, 92: 603-609.

Lera-Lopez, M Sanchex, J Faulin and L Cacciolatti (2014). Rural envirornmental stakeholder and policy making: Willingness to pay to reduce road transportation pollution: impact in the Western Pyrenees. *Transport Research. Part-D Transportation Environment*, 32: 29-142.

Ligus, M (2018). Measuring the Willingness to Pay for Improved Air quality: A contingent valuation survey. *Polish Journal of Environmental Studies*, 27 (2): 763-71.

Masahina, S, R Afroz, J Duasa, N Mohammed (2012). A framework to estimate the Willingness to Pay of household for air quality improvement: A case study in Klang Valley, Malaysia, *OIDA International Journal of Sustainable Development*, 4 (9): 11-16.

McCubbin, R D and M A Delucci (1999). The health cost of motor vehicle related air pollution. *Journal of Transport Economics and Policy*, 33 (3): 253-86.

McFadden, D (1974). The measurement of urban travel demand. *Journal of Public Economics*, 5: 303-328.

O'Conor, R M, M Johannesson, P Johannesson (1999). Stated preferences, real behaviour and anchoring: Some empirical evidence. *Environmental Economics*, 13: 235-48.

Ostro, B (1994).*Estimating the health effects of air pollutants – a method with an application to Jakarta*. World Bank Policy Research Working Paper: 1301.World Bank Publication Division. Geneva.

Poder, T G and He, J (2017). Willingness to pay for cleaner air: The case of Car Pollution in Quebec and France, *Energy*, *130*, 48-54.

RTO (Regional Transport Office) (2019). Annual report of the transport department of Karnataka compiled from RTOs. Retrieved from www.rto.kar.nic.in

Sattout, E J, S N Talhouk, P D S Caligari (2007). Economic value of ceder relics in Lebanon: An application of contingent valuation method for conservation. *Ecological Economics*, 61: 315-22.

Sellers-Rubio, R and J L Nicolau-Gonzalbez (2016). Estimating the Willingness to Pay for a sustainable wine using a Heckit model. *Wine Economic Policy*, 5: 96-104.

TERI (The Energy and Resource Institute) (2013-17). Energy Data Yearbook and Directory 2012-13. New Delhi: TERI.

Vlachokostas, C, C Achillas, T Slini, N Moussiopoulous, G Banias, R Dimitrakis (2011). Willingness to Pay for Reducing the Risk of Premature Mortality attributed to Air Pollution: A Contingent Valuation study for Greece. *Atmospheric Pollution Research*, 2: 275-82.

WHO (World Health Organization) (2013). Review of Evidence on health aspects of air pollution: REVIHAAP project. Technical report. Copenhagen: WHO Regional office for Europe. Retrieved from www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf

WHO Regional Office for Europe, OECD (2015). Economic cost of health impact of air pollution in Europe: Clean air, health and wealth. Copenhagen: WHO Regional Office for Europe.

Recent Working Papers

525 Essentiality of Package of Practices (PoPs) of Tomato Cultivation in Semi-arid Region of Karnataka – A Bird's Eye View
M Govindappa

526 Job-Seeking Behaviour, Employment, Labour Employability Skills, Dissatisfaction and Job Mobility: A Study of North-East Migrant Workers in Bengaluru
Reimeingam Marchang

527 Socio-Economic Characteristics and Land Particulars of Ginger Farmers in Karnataka
Pesala Peter and I Maruthi

528 How Civic Groups are Meeting the Challenges of Saving Bengaluru Lakes: A Study
Dipak Mandal and S Manasi

529 Revisiting India's SEZs Policy
Malini L Tantri

530 TATA Motors Singur: Narratives of Development Projects, Politics and Land Acquisition in West Bengal
Pallav Karmakar and V Anil Kumar

531 Migration, Reverse Migration, Employment and Unemployment Crises During the First Wave of COVID-19 Pandemic in India
Reimeingam Marchang

532 Women, Employment and Stigma of Crime: Narratives of Former Female Convicts From West Bengal
Shreejata Niyogi

533 Cost Benefit Analysis of System of Wheat Intensification Method of Cultivation Vis-à-Vis the Traditional Method: A Case Study of Gaya, Bihar
Shikha Pandey

534 Did Skill Development Policies Promote Participation in and Benefits from Skill Education? Evidence from a Nation-wide Survey
Andrea Vincent and D Rajasekhar

535 Implications of Infrastructure on Human Development in North East India: A Review
T Thangjahao Haokip and Reimeingam Marchang

536 Domestic Violence Against Women – A Case Study and the Role of Civil Societies from the Sundarbans Region of West Bengal
Anamika Das and C M Lakshmana

537 Impact of Skill Development Infrastructures: A Study of Manipur
T Thangjahao Haokip and Reimeingam Marchang

538 Why Do Farmers Not Adopt Crop Insurance in India?
Meenakshi Rajeev

539 Comprehending Landslides, MGNREGS and Decentralised Government: A Study in Sikkim and Darjeeling
Shikha Subba

540 Locating Married Women in Urban Labour Force: How India is Faring in 21st Century
Jyoti Thakur and and Reimeingam Marchang

541 A Critical Study on the Impact of ICT on Interactive Service Workers in the Hotel Industry
Jina Sarmah

542 Intergenerational Transfers in India: Who Receives Money and Who Gives Money?
Kinkar Mandal and Lekha Subaiya

543 Karnataka Administration: A Historical Review
K Gayithri, B V Kulkarni, Khalil Shaha and R S Deshpande

544 Understanding the Pathways from Victimisation to Offending: Voices from the Field
Shreejata Niyogi

545 Civic Activism in Urban Waste Management in Bengaluru City, India
Dipak Mandal and S Manasi

546 Ward Committees as "Invited Space": Is It Successful? A Literature Review of Urban India
Riya Bhattacharya

547 Service with a Smile: A Study Examining Interactive Service Work and Workers (ISW) in India
Jina Sarmah

548 Religion and State in Sikkim: The Place of the Buddhist Sangha
Pooja Thapa and Anand Inbanathan

549 Time Allocation and Gender Inequalities: A time-use Comparison
Jyoti Thakur and Reimeingam Marchang

550 Agrarian Distress: Role of Political Regimes in Kerala
Ance Teresa Varghese

Price: ` 30.00

ISBN 978-93-93879-23-3

INSTITUTE FOR SOCIAL AND ECONOMIC CHANGE
(ISEC is an ICSSR Research Institute, Government of India
and the Grant-in-Aid Institute, Government of Karnataka)
Dr V K R V Rao Road, Nagarabhavi P.O., Bangalore - 560 072, India
Phone: 0091-80-23215468, 23215519, 23215592; Fax: 0091-80-23217008
E-mail: balasubramanian@isec.ac.in; Web: www.isec.ac.in