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An Estimation of Health Production Function in Selected Industrial Agglomeration of Gujarat

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Abstract: ***In this paper, we described the nature and sources of pollution in study area and indicated the possible consequences of an increase in the levels of pollution to human health and urban property values in selected areas of Gujarat.***

Key Words: Health Production Function Model, Spatial Distribution, Mitigating Costs.

I. INTRODUCTION

The nature and sources of pollution in study area and indicated the possible consequences of an increase in the levels of pollution to human health and urban property values. Constant exposure to polluted environment due to pollution, most often, leads to morbidityand sometimes mortality. As a matter of fact, a million of the industrial workforce who participate directly in various production processes and post- production activities in these factories and the general public settled in and around the agglomeration is the direct victims of this social evil. Since the deterioration of air quality ruins their health and welfare, they try to avert the negative influences of pollution. This aversive behavior of individual households is to be seen as part of their attempts to regain the welfare losses due to pollution. It is therefore significant and necessary that we value the welfare losses / benefits due to pollution. The main focus of this chapter, hence,is to estimate values of health effects due to pollution in the study area industrial agglomeration. We adopt the Revealed Preference Approach and Contingent Valuation Methods to estimate monetary values of changes in human health associated with the reduction in environmental quality. This chapter is divided into 5 sections. In section 1 we present the health production function model which is used for estimating the household's willingness to pay for reduced morbidity. In section 2, we present a detailed description of how the environmental variables are related to different socio economic characteristics of sample households in the study area. Section 3 deals with the estimation of willingness to pay using Health production Function. In section 4, we estimate the willingness to pay using the Contingent Valuation Method. An attempt is made in section 5 to compare this willingness to pay estimates. The last section gives a summary of this chapter.

II. ESTIMATION OF HEALTH PRODUCTION FUNCTION

To estimate health production function, 'restrictive movement times' (RMT) is used as the dependent variable. RMT was then hypothesized to be a function of various socio-economic variables, such as, monthly income, doctor visits, pollution dummies, occurrence of diseases dummies, education, smoking, insurance and age. Two Stage Least Square (TSLS) was selected as the appropriate regression method to estimate mitigating activity and health production function simultaneously. The data were checked for identification problem. The following regression equation is used to estimate health production function:

$$RMT = b_0 + b_1\,MI + b_2 MTGC + b_3 PDUMMY\,1 + b_4 PDUMMY\,2 + b_5 AS + b_6 BR + b_7 EI + b_8 RC + b_9 EDDUMMY\,1 + b_{10} EDUMMY\,2 + b_{11} EDDUMMY\,3 + b_{12}\,IN + \epsilon$$

Where,

b_0 = Constant,
RMT = Restricted movement times
MTGC= Mitigating cost
PDUMMY1 = Pollution dummy for moderate polluted areas

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PDUMMY2 = Pollution dummy for highly polluted areas
RC= Recurrent fever
EDUMMY1 = Education dummy for SSLC / PDC
EDUMMY2 = Education dummy for graduate/engineering
EDUMMY3 = Education dummy for post graduate/professional.
AS = Asthma
BR = Bronchitis
EI = Eye Irritation
IN = Insurance
ϵ = Error Terms

Table: 1.1Estimation of Health Production Function in Study Area Industrial Agglomeration

Dependent Variable: RMT				
Method: Two-Stage Least Squares				
Sample: 600				
Included observations: 600				
Instrument list: Doctors visit, Month Income, Mitigation Cost, Pdummy1, Pdummy2, Asthma, Bronchitis, Eye Irritation, Recurrent fever, Eddummy1, Eddummy2, Eddummy3, Smoking, Insurance, Age				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	4.359812	2.719414	1.603218	0.1094
MONTHLY INCOME	0.000189	0.000109	1.730367	0.0841
DOCVISIT	0.235822	0.069660	3.385345	0.0008
PDUMMY 1	11.87259	1.004159	11.82342	0.0000
PDUMMY2	17.75279	1.278687	13.88361	0.0000
ASTHMA	0.293934	0.808914	0.363368	0.7165
BRONCHITIS	1.842179	1.012895	1.818727	0.0695
EYE IRRITATION	-0.864014	0.867066	-0.996481	0.3194
RECFEVER	2.426465	0.863909	2.808705	0.0051
EDDUMMY 1	-1.866929	1.321697	-1.412524	0.1583
EDDUMMY2	-4.199711	1.432279	-2.932189	0.0035
EDDUMMY3	-5.897743	2.036497	-2.896024	0.0039
SMOKING	1.891167	0.827494	2.285414	0.0226
INSURANCE	1.334894	0.751577	1.776123	0.0762
AGE	-0.009845	0.036955	-0.266408	0.7900
R-squared	0.542899	Mean dependent var		20.70000
Adjusted R-squared	0.531960	S.D. dependent var		13.06552
S.E. of regression	8.938576	Sum squared resid		46740.41
F-statistic	49.62889	Durbin-Watson stat		1.651992

Source: Regression results

The major inferences of this relationship are the following:
The coefficients of pollution dummy in TSLS estimates remain positive and highly significant.

- In moderate pollution areas, restrictive activity days (RMT) are higher by nearly 12 percent compared to less polluted area, where as in highly polluted area, restrictive activity days are higher by 18 percent.
- Coefficient of income variable is significant at 8 percent; however income has less influence on restrictive activity days.
- Co efficient of mitigating demand is significant at 1 percent and positively related to RMT.
- Significance of disease dummy also follow the same pattern of mitigating demand. Bronchitis (1.84) and recurrent fever (2.42) are significantly related to number of RMT. Among these, coefficient of recurrent fever is higher, indicating that recurrent fever causes more RMT. In case of education, dummy for SSLC class is significant only at 15 percent level. Other two classes are significant at 1 percent level. All three are negatively related to RMT, as in the case of demand for mitigating activity.
- Co-efficient of smoking and insurance are significant at 2 and 7 percent levels respectively, indicating that RMT are higher for smoking people and insurance holders. Asthma, eye irritation and age are not significant.

III. ESTIMATING WILLINGNESS TO PAY

As explained in section 4.1 above, the individual household's willingness to pay for health benefits due to the reduction in the levels of pollution is the sum of value of lost working time, observed changes in mitigating activities and the monetary equivalent of disutility of illness due to pollution and is estimated using the following equation.

$$EWP = \frac{\partial I}{\partial c} = P_w \frac{\partial S}{\partial c} + P_M \frac{\partial M}{\partial c} - \frac{\partial U/\partial S}{\lambda} \frac{\partial S}{\partial c}$$

where, *X* the marginal utility of income, converts the disutility of illness into monetary terms and gives the optimal adjustments of M (demand for mitigatingactivities) to a change in pollution. The first two terms in the equation can be approximated by using the observed changes in illness and mitigating expendituresas the last term, representing the effects of disutility of illness could not be estimated.Descriptive statistics for area wise estimate of willingness to pay is given in the table 1.2 below:

Table: 1.2 Willingness to Pay of Sample Households of Study area Industrial Agglomeration by Stations

Area	No of households	Min.	Max.	Mean	Median	Mode	SD
Ankleshwar	100	1356.3	8083.8	4413.7	4487.8	2712.5	1711.7
Sarigam	100	735.37	6557.5	2997.1	2409	4170.7	1372.7
Maroli	100	0	0	0	0	0	0
Umargam	100	1391.4	9929.3	6273.7	6337.4	7204.4	1985.4
Nargol	100	893.51	6572.9	3617.3	3580.2	5381	1469.3
WTP Whole Sample	500	0	9929.3	2883.6	2675.4	0	2642.3

The table reveals the following:

- The mean willingness to pay for the highly polluted areas (Ankleshwar and Sarigam) of the Study area industrial agglomeration, for the six months from 2001 June to January 2002 is Rs. 4413.71 and Rs. 6273.70 respectively.
- For moderate polluted areas (Maroli and Umargam) mean values are Rs. 2997.08 and Rs. 3617.29 respectively.
- WTP for the less polluted area (Nargol) is assumed to be zero as pollution dummy these areas is assumed as zero.
- Similar trends are noted in the case of median and moral values.

The frequency distribution of sample household's willingness to pay is summarized in table 1.3 below:

Table: 1.3 Frequency Distribution of willingness to pay of sample households in Study area Industrial Agglomeration

Class	Frequency	Percent
00	200	33.3
500- 1000	6	1.0
1000-2000	52	8.7
2000 - 3000	74	12.3
3000 - 5000	119	19.8
5000 - 7000	102	17.0
above 7000	47	7.8
Total	600	100.0

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This table above shows that:

- Highest percentage (19.8) of the people on the sample households are willing to pay between Rs. 3000-5000.
- On an average, households at study area industrial agglomeration prefer an average willingness to pay between Rs. 2000 to Rs. 7000, for a period of six months.

IV. FACTORS INFLUENCING WILLINGNESS TO PAY

So far, we have estimated the willingness to pay of the sample households, had they been affected by pollution. Since this measure has been influenced by the environmental and socioeconomic characteristics, a detailed examination of the extent of influence of these variables on the WTP is essential. This is attempted by regressing the estimated WTP values on selected environmental and socioeconomic variables using the method of ordinary least squares. The regression result is given below in table 1.4

Table 1.4Results of Regression of Estimated WTP on Selected Environmental and Socio Economic Variables

Dependent Variable: WTP3				
Method: Least Squares				
Sample: 600				
Included observations: 600				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2311.400	251.1152	-9.204544	0.0000
MONTH LY INCOME	0.340920	0.010218	33.36505	0.0000
MTGCOST	0.089587	0.032362	2.768312	0.0058
PDUMMY1	3203.941	92.44630	34.65732	0.0000
PDUMMY2	4946.188	113.2363	43.68023	0.0000
ASTHMA	-18.83137	75.10368	-0.250738	0.8021
BRONCHITIS	-48.08653	92.63681	-0.519087	0.6039
EYE IRRITATION	-15.02321	80.61985	-0.186346	0.8522
RECFEVER	-37.17153	79.08402	-0.470026	0.6385
EDDUMMY1	-226.4089	122.0652	-1.854819	0.0641
EDDUMMY2	-334.5617	132.1674	-2.531347	0.0116
EDDUMMY3	-290.6264	186.4907	-1.558397	0.1197
SMOKING	-24.16349	76.91624	-0.314153	0.7535
INSURANCE	-93.81452	69.98430	-1.340508	0.1806
AGE	-2.642915	3.436144	-0.769151	0.4421
R-squared	0.903723	Mean dependent var		2883.632
Adjusted R-squared	0.901419	S.D.dependentvar		2642.320
S.E. of regression	829.6269	Akaike info criterion		16.30451
Sum squared resid	4.03E+08	Schwarz criterion		16.41443
Log likelihood	-4876.353	F-statistic		392.2286
Durbin-Watson stat	1.738653	Prob(F-statistic)		0.000000

It is found that:

- The monthly Income, mitigating cost and pollution dummies had positive and significant impacts on WTP.
- The pollution coefficients for the moderate polluted areas (Ankleshwar and Sarigamh) showed that people in these areas are willing to pay Rs. 3204 more than those in low polluted areas.
- In highly polluted areas (Maroli and Nargol), people are willing to pay Rs. 4946 at 1% level of significance.
- Monthly income and mitigating costs influence WTP positively.
- All variables other than mitigating cost, monthly income and pollution dummies, showed a negative relationship. However, all, except education dummies, are not statistically significant

In this section so far, we undertook a detailed analysis of the factors influencing the willingness to pay using the household's production function approach and observed that the WTP estimates reflects the social cost of illness However, the expression of WTP given above ignores the social value of averting expenditures and the cost of leisure foregone due to illness (Cropper and Freeman, 199 l).This necessitates the use of Contingent Valuation Method for eliciting WTP. The next seel ion undertakes this task.

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V. CONTINGENT VALUATION SURVEYS AND ESTIMATION OF WILLINGNESS TO PAY

The contingent valuation method (CVM) is used to estimate values for environmental amenities and other non-market goods and services. CVM surveys ask respondents directly about their monetary values for non-market goods contingent upon the creation of a market or other means of payment. Therefore all transactions are hypothetical (Bishop *et al*, 1995). In this study, Contingent Valuation surveys were organized to measure the willingness to Pay directly. As part of the study, a survey was conducted on a representative sample of 600 households in six selected centers. The purpose of the survey was to elicit their willingness to pay (WTP) to avoid additional 'symptom days'. First, people were asked to reveal their judgment on pollution in the area. They were then asked about their health status and Restrictive Movement Times (RMT) due to pollution. They were also asked about the averting and mitigating activities and the respective costs for avoiding illness during the last six months. Data on socio economic and demographic variables such as, income, education, age, habits etc. were collected as part of the survey. After describing the exposure response relationship, with the help of other studies, like Gujarat ShastraSaahityaParishat, Green Peace, Pollution Control Board etc. sample households were reminded about possibilities of preventive expenditures and reductions in their budget. Then the individuals were asked whether they would be willing to pay Rs. 200. The bids were raised for positive answers up to Rs. 3500 and lowered, if the answer was negative.Area-wise WTP values per household from the CVM survey is given in table 1.6 below.

Table: 1.6 Distribution of Willingness to Pay of the residents of Study area Industrial Agglomeration to Avoid 'Symptom Days Using Contingent Valuation Survey 2012-2013

Area	N	Min.	Max.	Mean	Median	Mode	SD
Ankleshwar	100	0	3500	932	600	600	822.2
Sarigam	100	0	3000	552.5	450	0	504.1
Maroli	100	0	1500	359.5	400	0	300.9
Umargam	100	0	2800	1059	1000	1000	592.7
Nargol	100	0	2500	636.3	500	500	458.9
WTTP	500	0	3500	670	500	500	581.9

One strategy to check the validity of CVM is to develop different scenarios to test hypothesis about the effects of the mean values of the Sample (Freeman, 1993). This test can be evolved by combining mean responses across the sample groups given in different scenarios, which is provided by different environmental characteristics. The sample mean varies in a consistent fashion with relevant and meaningful variations in the scenario.

The CVMsurvey reveals that

- Mean WTP to avoid symptom days in high polluted areas (Eloor and Ambalamugal is greater than moderate (Irumpanam and Ernakulam North) and less polluted areas (CSIR Complex and Port Trust).
- For instance, highly polluted areas (Eloor and Ambalamugal) the mean WTP values are Rs. 932 and Rs. 1059 respectively.
- For moderate polluted areas (Irumpanam and Ernakulam North) mean WTP values are Rs. 552.50 and Rs. 636 respectively.
- For less polluted areas (CSIR Complex and Port Trust) the respective mean WTP values are Rs. 359 and Rs. 481.

The frequency distribution of the WTP of the residents of Study area industrial agglomeration for avoiding symptoms days is given in table 1.7 below.

WTP (in Rs.)	Frequency	Percent
200 - 500	224	44.8
500- 1000	173	34.6
1000- 1500	64	12.8
1500-2000	24	4.8
More than 2000	15	3
Total	500	100

The table reveals that:

- Around 83 percent of the respondents were willing to pay an amount less than Rs. one thousand to avoid symptom days. The highest percentage, 28.8 are willing to pay a sum of Rupees between 500 and 1000.

In order to verify the influence of environmental and socio economic variables on the respondent's willingness to pay (WTP), the

elicited willingness to pay (WTP)bids were regressed on these variables. The regression result is given below in table 1.8

Table: 1.8 Regression coefficients of WTP

Dependent Variable: WTTP				
Method: Least Squares				
Sample: 1600				
Included observations: 600				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-692.5020	108.3867	-6.389176	0.0000
MONTHLY INCOME	0.109610	0.004410	24.85347	0.0000
MTGCOST	0.030984	0.013968	2.218175	0.0269
PDUMMY1	131.0385	39.90182	3.284023	0.0011
PDUMMY2	507.0181	48.87524	10.37372	0.0000
ASTHMA	-21.83021	32.41637	-0.673432	0.5009
BRONCHITIS	14.48385	39.98405	0.362241	0.7173
EYE IRRITATION	2.120831	34.79727	0.060948	0.9514
RECFEVER	-84.62102	34.13438	-2.479056	0.0135
EDDUMMY1	46.61173	52.68599	0.884708	0.3767
EDDUMMY2	144.8482	57.04632	2.539133	0.0114
EDDUMMY3	80.44716	80.49340	0.999425	0.3180
SMOKING	-69.35044	33.19872	-2.088949	0.0371
INSURANCE	45.41080	30.20674	1.503333	0.1333
AGE	3.141314	1.483114	2.118052	0.0346
R-squared	0.630106	Mean dependent var		670.0417
Adjusted R-squared	0.621254	S.D.dependentvar		581.8515
S.E. of regression	358.0849	Akaike info criterion		14.62410
Sum squared resid	75011519	Schwarz criterion		14.73402
Log likelihood	-4372.230	F-statistic		71.18112
Durbin-Watson stat	1.762449	Prob(F-statistic)		0.000000

The estimates indicate that:

- Monthly income, mitigating cost, pollution dummies and education dummyl have positive and significant impact on willingness to pay (WTP)Income is highly significant and is positively related to the willingness to pay (WTP) of the people, that is, unit increase in income increase willingness to pay (WTP) by 10 percent.
- Mitigating cost has also positive impact on willingness to pay (WTP) and is significant at 2 percent level.
- Coefficients of pollution dummy shows that people in the moderate polluted areas were willing to pay Rs. 131 more than those in low polluted areas.
- In high polluted areas residents were willing to pay Rs. 507 more than those in the low polluted areas. Both the coefficients are significant at 1 percent level.
- Except recurrent fever, all other coefficients of disease were not statistically significant and are negatively related to willingness to pay (WTP).
- Among the education dummy, all coefficients except graduate class were statistically insignificant.
- Coefficients of smoking and age are significant at a level of 3 percent. Coefficient of smoking is negatively related while age and insurance are positively related.

VI. WTP FROM HOUSEHOLD PRODUCTION FUNCTION AND CONTINGENT VALUATION SURVEY APPROACHES: A COMPARISON

In order to assess the validity of CVM results, two approaches are generally suggested in the literature. The former involved a careful assessment of the survey instrument and scenario to verify whether all known sources of bias had been removed or avoided. The other strategy suggested a comparison of the empirical analysis and results of WTP estimates from alternate methods (Freeman, 1993). In this study, however, our strategy is to compare WTP values derivedthrough contingent surveys with measures derived from the production function estimates

(Brookshire et al.,1982) compared CV measures of the value of improved air quality with values derived from production

function model'. A comparison of WTP estimated from both approaches is given in table 1.9.

Table: 1.9WTP Estimates from Household Production Function and Contingent Valuation survey Approaches.

STATIONS	Production Function	CVM
Ankleshwar	4413.71	932.00
Sarigam	2997.08	552.50
Maroli	2400	359.50
Umargam	6273.70	1059.00
Nargol	3617.29	636.25
WTP Whole Sample	2883.63	670.04

Source: Survey data, 2012-13

An important difference between WTP from production function approach and CVM approach is that in CVM, WTP is a function of total derivative of illness with respect to pollution,which incorporates effects of pollution on defensive behavior to illness. To compareunder CVM, it is not necessary to estimate the Household production function, rather it ispossible to estimate a dose-response function which is a reduced form of relationship between illness, ambient air quality and variables that affect defensive expenditures. In a household production function, dose response function is obtained by substituting the demand functions for mitigating activities in to the household production function (Cropper and Freeman, 1991).From the table above, it is observed that willingness to pay (WTP) values in both the household production function and contingent valuation survey approaches are higher in Ankleshwar and Umargam, respectively, which were considered as highly polluted areas. Nargoland Sarigam showed moderate willingness to pay (WTP) values compared to less polluted areas. In both the approaches, it is seen that willingness to pay (WTP) values are greater in highly polluted areas while they are lower in less polluted areas.Willingness to pay estimates for production function is higher than the willingness to pay estimates directly collected from the market. This could be explained by the possibility of existence of strategic bias, in CVM, in which case, the respondents may under state their WTP due to the common good nature of air quality.The above analysis reinforces the validity of our approaches for estimating the household's willingness to pay to avoid symptom days in Study area industrial agglomeration in Gujarat.

VII. SUMMARY AND CONCLUSIONS

In this Chapter, we made an attempt to estimate the willingness to pay for avoiding 'symptom days' of selected households in the study area. This is calculated using the household production function and contingent valuation approaches. In the former approach, willingness to pay was estimated in a two stage regression analysis. The results showed that the coefficient of pollution is positive and highly significant to doctor visits and restrictive activity days. The average for the highly polluted areas of the Study area industrial agglomeration, for the six months from December 2001 to June 2002 was Rs. 4413.71 and Rs. 6273.70 respectively. For moderate polluted areas these values were Rs. 2997.08 and Rs. 3617.29 respectively, showing clear evidence that average willingness to pay is positively influence by pollution. It is also observed that monthly income and mitigating cost have positive and significant impacts on WTP.WTP is estimated by directly asking people how much they are willing to pay to reduce pollution. The major results provided by the analysis were the average WTP to avoid symptom days in high polluted areas is greater than moderate and less polluted areas. In highly polluted areas the mean WTP values are Rs. 932 and Rs. 1059 respectively, while in moderate polluted areas these values are Rs. 552.50 and Rs. 636 and in less polluted areas were Rs. 359 and Rs.481, respectively. In general, the two approaches provide evidence that households in the Study area Industrial Agglomeration value health reduction due to change in air quality.

Then for testing validity the two approaches were compared and found that the both methods generating similar results. It is hence observed that the CV surveys can be successfully conducted in cities of developing countries. From a policy perspective, the results can be used to frame appropriate compensation strategies. In short, this chapter provides two sets of evidence. First, the mean WTP for high and moderate polluted areas are different as per the changes in the level of pollution. The second set of evidence comes from the estimated household production function model, where doctor visits and restricted activity days have significant positive coefficient on two pollution dummies.

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