Valuing Damage to Historic Buildings Using a Contingent Market: A Case Study of Road Traffic Externalities

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ABSTRACT Pricing of road transport at social marginal cost should make users aware of the cost of damaging the environment (external costs). Such an approach, however, requires a monetary estimate of this damage which can be difficult to derive. On the basis of a study carried out at Neuchâtel (Switzerland), the contingent valuation method was used to estimate the damage caused to buildings of historical and cultural value by traffic-caused air pollution. In a survey, individuals were asked to contribute to a fund set up to finance the maintenance of pre-selected historic buildings. A valuation function to predict willingness-to-pay responses is estimated.

Introduction

The problems encountered in urban road traffic management are growing in number. In addition to the old concerns connected with the management of transport infrastructure, there is a need to provide solutions to congestion problems and to reduce environmental damage. In order to bring traffic to an optimal volume, the idea of pricing at social marginal cost is gaining ground. Such an approach has the advantage of being based on the causal principle of the 'polluter pays'. Transport users would be required to pay for the external costs imposed on the community, in addition to the private costs (vehicle use, fatigue, etc.) and infrastructure costs that they already pay for. They would then make a journey only if the benefit they derive from it was at least equivalent to the social cost incurred.

However, the external portion of the social cost of motor-vehicle traffic remains difficult to evaluate. The damage caused to buildings of historic and cultural value by traffic-caused air pollution is an obvious example of this (e.g. Lichfield, 1988). Unlike other types of building, this cost is not confined to upkeep expenses. In the longer term, such damage threatens the very existence of the building stock. For individuals, the loss extends not only to the reduction in the utility of admiring them (use value) but also to the fact that neither they nor future generations can be certain of being able, in the future, to admire these
buildings in their original condition (non-use value). The technique of contingent valuation is usually used to measure total value (use value plus non-use value). It involves confronting respondents, usually in survey settings, with a hypothetical (i.e. contingent) but structured market on which environmental goods (e.g. the appearance of historic buildings) are exchanged. Individuals are then asked to reveal their valuation and their willingness-to-pay (WTP) for the good of interest. The approach has enjoyed widespread popularity since the early 1980s, particularly in connection with evaluating natural sites for recreational use (Cummings et al., 1986; Mitchell & Carson, 1989). It was applied to evaluate the damage to 16 historic buildings directly exposed to traffic-caused air pollution in the town of Neuchâtel.

Definition of the Contingent Market and Organisation of the Survey

Even though the stock of historic buildings is recorded by the Department for the Conservation of Monuments and Historic Sites (DCMHS), it is a broadly subjective notion. In the context of this valuation it was therefore advisable, first of all, to define precisely what was being traded on the proposed hypothetical market. To do so, we took three objective criteria as a basis: (1) the historic character of the buildings selected; (2) the type of construction material used; and (3) their exposure to traffic nuisance.

The 16 buildings under consideration are: (1) recorded by the DCMHS; (2) made of Hauterive stone (yellow limestone typical in the Neuchâtel region); and (3) directly exposed to road traffic air pollution (i.e. exposed to daytime noise in excess of 65 dB(A)). A few studies present some dose-response functions between air pollution and the deterioration of building surfaces (e.g. Economic Commission for Europe, 1982; Horst et al., 1986). None of these studies however provide any relationship between increases in air pollution specifically caused by road traffic and reductions in the stock of historic buildings. Assuming for simplicity that historic buildings directly exposed to road traffic air pollution are at the same time exposed to excessive noise levels accounts for the fact that both nuisances depend on the same variables (volume, speed, direction and composition of the traffic flow, street width, distance from the roadway, etc.). Although other sources of air pollution (e.g. factories and domestic burning of fossil fuels) may impact on the depletion of these particular historic buildings, their influence is marginal.

The contingent market was presented in two stages. Respondents were presented with a 15 cm × 21 cm card for each building, each showing two recent 13 cm × 9 cm colour photographs taken from the road (a general view of the entrance facade and a close-up of about 2 m² representative of the mean degree of dirt of this facade). All photographs were taken under the same light conditions within a couple of days (late November, 1991). A A4-map was used to show where the buildings are located. Individuals were first asked which out of the 16 buildings should be maintained:

These photographs give you an accurate picture of the present state of these buildings. As you can see, the aesthetic condition varies from one building to the other, as well as the satisfaction you experience looking at them. Would you please separate the buildings whose present
condition is still acceptable for you from those which you would like to see maintained soon?

The cards showing buildings which were not selected to be maintained were then withdrawn. An open-ended question was introduced to elicit the compensating value associated with the selected buildings to be maintained, arguing that:

In the present state, the public authorities cannot afford on their own to guarantee the maintenance of these 16 buildings. Imagine therefore that a fund has been set up to finance this maintenance work. The town’s inhabitants would be asked each year to contribute to this fund and to choose the buildings that would have to be maintained in the course of the year, just as you did. How much are you willing to contribute to this fund, every month and within the limits of your household’s budget? Take into account, in your assessment, the aesthetic and historic interest of the buildings you have selected.²

If respondents could not state themselves their WTP, the interviewer proposed a starting bid of two francs per building selected and tried to refine this sum by an iterative process. The iteration step was one Swiss franc. Both amounts were fixed on the basis of a pre-test of 30 interviews. The low starting point was chosen in order to ensure a homogenous increasing iterative process.

Respondents whose offer was zero were then debriefed with an open question to find the reason why they were not prepared to contribute to the fund. These explanations allow the respondents to be grouped subsequently into homogenous categories and thereby to distinguish the differences in behaviour vis-à-vis the proposed market. When the bid was positive, respondents were faced with the possibility that their contribution might not be high enough to allow the selected buildings to be maintained. The interviewer then increased the first bid in one-franc increments (this step also came from the pre-test) until respondents declared that they did not wish to go any higher. With this further question, the interviewer attempted to elicit a genuine maximum WTP.

The non-probability quota sampling technique was used to build up a sample of 200 respondents (i.e. one interview for about each 160 inhabitants). Four criteria were taken into consideration to find the required cases: place of residence, sex, age and social class. This means, first, that in the town’s eight districts, the number of interviews conducted was proportional to the size of the population; secondly, that for each district the composition of the sample by sex, age and social class was identical to that of the population. Eight interviewers (one per district) conducted the interviews in 20 days (17 February to 13 March, 1992)³.

Analysis of the Results

Conduct Adopted vis-à-vis the Contingent Market

When confronted with a hypothetical market, respondents did not all react in a similar way. For example, when the WTP is zero, respondents could be facing a strong budgetary constraint or could be acting strategically. The open debriefing question is used to separate these different types of behaviour; they must be clearly distinguishable to allow useful analysis (Figure 1).
Of the 200 interviews retained for the analysis, a distinction is drawn between the *indifferents* and the *receptives*. The *indifferents* include respondents who consider that damage to historic buildings is not a problem or who are not interested in the contingent market proposed to them. The *receptives*, on the other hand, think the problem raised is a significant one. Therefore they are willing, *a priori*, to participate financially in this market. However, as the good proposed is a public good, some of them are encouraged to conceal the real utility they derive from it (real WTP > 0) behind strategic behaviour (acknowledged WTP = 0): according to them they already pay enough taxes and the state or the road users should be charged. They are referred to as *free riders*. Those *receptive* respondents who do not adopt strategic behaviour are regarded as *volunteers*. Their WTP is then either positive for persons having a weak budgetary constraint (*solvents*) or zero for persons who cannot afford to make a higher bid (*non-solvents*).

On average, six out of the 16 historic buildings were selected for immediate maintenance. This average is higher if one considers only the *receptive* respondents (6.2) and lower for the *indifferents* (4.9). These differences are consistent with the behaviour shown during the valuation process.

Less than half of the *volunteers* revised their offer upwards after having been informed of the possibility that their first contribution might be insufficient. The increase was never greater than 50% of the initial WTP. The SFr22.0 overall mean
bid including the revision is not statistically greater than the SFr18.7 mean starting offer. When respondents were unable to give a first amount on their own, the mean value achieved at the end of the first iterative process (SFr12.1) is significantly lower from the 20.4 francs given by ‘self-respondents.’ However, this difference does not prove that the relatively low starting point introduced a bias as five respondents bid lower than the proposed amount.

Econometric Analysis

Only the receptives (i.e. 178 interviews) are retained for the analysis. The indifferents are removed since they are useless in explaining the relationship between disutility and the WTP. As suggested by Pommerehne & Roemer, 1992, and in order to limit the risk of strategic bias without reducing the sample size, a distinction is drawn between the volunteers and the free riders by introducing a dummy variable FREE. This variable takes the value 1 for the free riders and the value 0 in all other cases.

A Box–Cox transformation is applied to the dependent variable (Box & Cox, 1964).

\[
Y^{(\lambda)} = \begin{cases} 
\frac{Y^\lambda - 1}{\lambda_1}, & \lambda_1 \neq 0, \ Y > 0 \\
\ln Y, & \lambda_1 = 0, \ Y > 0 
\end{cases} \tag{1a}
\]

where: \( Y \) = the revealed WTP vector

\((\lambda)\) = a Box-Cox transformation

\(\lambda_1\) = the Box-Cox parameter to be searched for.

For \(\lambda_1\) equal to 1, the specification is linear. If \(\lambda_1 = 0\), it is log-linear. However, this formulation is valid only for values of \( Y \) greater than zero. Hence a parameter \(\lambda_2 > 0\) is added to \( Y \). Thus we obtain:

\[
Y^{(\lambda)} = \begin{cases} 
\frac{(Y + \lambda_2)^{\lambda_1} - 1}{\lambda_1}, & \lambda_1 \neq 0, Y > 0 \\
\ln(Y + \lambda_2), & \lambda_1 = 0, Y > 0 
\end{cases} \tag{2a}
\]

For \(\lambda_2\) a value of 1 is arbitrarily taken (Mitchell & Carson, 1989, p. 372); \(\lambda_1\) is retained, for which the likelihood is maximum, that is:

\[
L_{\max}(\lambda) = -\frac{1}{2}n\ln\left(\frac{RSS}{n}\right) + (\lambda_1 - 1)\sum_{i=1}^{n}\ln(Y + \lambda_2) \tag{3}
\]

where: \( n \) = the number of observations

RSS = the residual sum of squares.

This specification offers the advantage of correcting the effect of large bids implied by hypothetical bias. It limits the influence of these bids by making the distribution of residuals as normal as possible.

Apart from the dummy variable FREE, four independent variables are retained: the number of historic buildings cited (REN), the respondent’s age (AGE) and sex (SEX), and the household’s net income (NETINC). For the regression analysis, the ordinary least squares method is used. The dependent variable undergoes a Box–Cox transformation where \(\lambda_1 = -0.19\) and \(\lambda_2 = 1\). Table 1
Table 1. Estimation of the coefficients of the function of willingness to pay in order to repair the damage caused to historic buildings

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Equation 1&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Equation 2&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.665**</td>
<td>1.656**</td>
</tr>
<tr>
<td>(7.401)</td>
<td>(11.112)</td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>-0.00792**</td>
<td>-0.00824**</td>
</tr>
<tr>
<td>(−2.652)</td>
<td>(−3.176)</td>
<td></td>
</tr>
<tr>
<td>FREE</td>
<td>-1.861**</td>
<td>-1.706**</td>
</tr>
<tr>
<td>(−15.823)</td>
<td>(−21.255)</td>
<td></td>
</tr>
<tr>
<td>REN</td>
<td>0.0397**</td>
<td>0.0186</td>
</tr>
<tr>
<td>(2.339)</td>
<td>(1.659)</td>
<td></td>
</tr>
<tr>
<td>NETINC</td>
<td>Difference between the household’s acknowledged net monthly income and the acknowledged monthly rent.</td>
<td>0.0000623**</td>
</tr>
<tr>
<td></td>
<td>(2.399)</td>
<td>(2.353)</td>
</tr>
<tr>
<td>SEX</td>
<td>Dummy variable taking the value 1 if the respondent is a man and 0 if it is a woman.</td>
<td>0.180</td>
</tr>
<tr>
<td></td>
<td>(1.739)</td>
<td>(1.798)</td>
</tr>
<tr>
<td>λ&lt;sub&gt;1&lt;/sub&gt;</td>
<td>-0.190</td>
<td>-0.320</td>
</tr>
<tr>
<td></td>
<td>(1.000)</td>
<td>(1.000)</td>
</tr>
<tr>
<td>λ&lt;sub&gt;2&lt;/sub&gt;</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

| n                     | 178                    | 178                    |
| R<sup>2</sup>         | 0.635                  | 0.838                  |
| R<sup>2</sup>         | 0.624                  | 0.833                  |
| Standard-error        | 0.680                  | 0.0121                 |
| Value of F            | 59.752                 | 178.081                |
| L<sub>max</sub> (λ)   | -313.339               | 360.525                |

<sup>a</sup>The dependent variable is the monthly WTP to maintain the selected historical buildings, transformed according to the Box–Cox model (Y<sup>(λ)</sup>). The numbers shown in brackets beneath the estimated parameters represent the values of t. The coefficients marked with a double asterisk are significant at 99% (two-sided test).

<sup>b</sup>Before correction of the heteroscedasticity problem (ordinary least squares).

<sup>c</sup>After correction of the heteroscedasticity problem (weighted least squares).

(equation 1) shows the principal results of the analysis. The coefficient of determination R<sup>2</sup> is 0.624<sup>b</sup>. The F-test allows the zero hypothesis (R<sup>2</sup> = 0) to be rejected with a confidence threshold of more than 99%. The expected direction (sign) of the correlation is verified for each explanatory variable and the estimated parameters almost all turn out to be significant at more than 99%. The analysis of the covariance matrix confirms the absence of noticeable dependencies between the variables selected. It may therefore be concluded that no serious collinearity problem encumbers the estimated function.

However the results of the Goldfeld–Quandt test oblige us to reject the hypothesis of homoscedasticity at the 95% level of significance for the AGE variable<sup>c</sup>. This observation implies that, even if the evaluated parameters are not biased by the heteroscedastic structure, they are not efficient for the population.

To solve this problem, each term in the regression is divided by the offending variable (weighted least squares). Equation (1) then takes the form:

\[
\frac{Y^{(\lambda)}}{AGE} = \beta X + \varepsilon
\]

(4)
Table 2. Observed and predicted monthly WTP (equation 2) to repair the damage caused to historic buildings (SFr)

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Average</th>
<th>Median</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed bids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sample</td>
<td>200</td>
<td>14.3</td>
<td>5.0</td>
<td>27.1</td>
<td>0.0</td>
<td>250.0</td>
</tr>
<tr>
<td>Indifferent</td>
<td>22</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Receptives</td>
<td>178</td>
<td>16.0</td>
<td>7.5</td>
<td>28.2</td>
<td>0.0</td>
<td>250.0</td>
</tr>
<tr>
<td>Volunteers</td>
<td>130</td>
<td>22.0</td>
<td>12.0</td>
<td>31.0</td>
<td>0.0</td>
<td>250.0</td>
</tr>
<tr>
<td>Free riders</td>
<td>48</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Predicted bids (FREE = 0 ∀ n)

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptives</td>
<td>178</td>
<td>10.1</td>
<td>9.0</td>
<td>4.9</td>
<td>2.4</td>
<td>30.4</td>
</tr>
<tr>
<td>Volunteers</td>
<td>130</td>
<td>10.4</td>
<td>9.2</td>
<td>5.1</td>
<td>2.4</td>
<td>28.2</td>
</tr>
<tr>
<td>Free riders</td>
<td>48</td>
<td>9.3</td>
<td>9.3</td>
<td>3.8</td>
<td>2.7</td>
<td>19.6</td>
</tr>
</tbody>
</table>

Table 1 (equation 2) shows the results of the regression analysis carried out following these modifications. Both the coefficient of determination ($\bar{R}^2 = 0.83$) and the value of $F$ ($F = 178.081$) increase compared with the results of the first analysis. The significance ($t$) of independent variables is also generally better. According to the maximum probability test, $\lambda_1$ is situated with a 95% probability in the range $-0.43 < \lambda_1 < -0.21$.

The values of $Y^{(2)}$ and $Y$ are then estimated from the regression function. To obtain the free riders’ true WTP, the FREE variable is given a zero value. The observed (and predicted) results are shown in Table 2. The average WTP is 16.04 francs (predicted = 10.1) for all the receptives. As was to be expected, it is lower for the free riders than for the volunteers. Whether one considers the average, the median or the mode, the observed results are higher than the predicted results, despite the corrections made to the free riders’ bids. This reflects the influence of the Box–Cox transformation on large bids.

To extrapolate to the population, the predicted mean offer of 10 francs per month is taken as representative of the receptives’ WTP. In 1992, 15,769 households were living in the town of Neuchâtel. If one considers, according to our survey, that 11% of the population is indifferent to the damage caused to historic buildings, 14,034 households may be regarded as receptive. Since the annual WTP per household is SFr121, the annual cost of the damage caused to historic buildings by road traffic air pollution is SFr1.7 million. Considering that six historic buildings on average were said to need maintenance, the annual cost per historic building is about SFr283,000.

**Conclusion**

In this study the contingent valuation method was used to estimate the damage caused to historic buildings by traffic-caused air pollution in the town of Neuchâtel. We measured the willingness to contribute to a fund (i.e. the compensating measure of value) set up to finance the maintenance of historic buildings.
A doubt often hangs over the results of any contingent valuation due to the fear of potential biases. In our case, the transformation of the revealed WTP for preserving the aspect of historic buildings in Neuchâtel by a Box–Cox model allows the effect of large bids on the regression analysis to be reduced and therefore the risk of hypothetical bias to be diminished. Further, the problem of bid refusal following strategic behaviour is taken into consideration and introduced through a dummy variable. This avoids a trimming process which could have removed useful observations.

Due to homogeneity of the population interviewed, to a face-to-face survey conducted in the respondent’s dwelling place and to the cancellation of all variables which do not offer sufficient statistical guarantee from the regression analysis, the estimated models offer a good explanatory power. The selected variables are largely consistent with those suggested by the theory (age, income, sex, etc.). These results provide evidence that the stated WTP values do not have a random character but depend on objective variables and that individuals are capable of linking their preference to maintain historic buildings to a WTP. The survey broadly meets the guidelines introduced by Arrow et al. (1993). A conservative design was favoured when possible using a WTP format with several visual documents and debriefing in an open question the respondents who bid zero or refused to bid. Choosing an open-ended elicitation question was not a conservative option (according to these authors) but this format might be more convenient when asking individuals their WTP on voluntary basis.

According to the estimated model, the annual WTP to avoid damage to historic buildings is SFr121 per household which suggests damage to historical buildings is a significant problem. The annual cost of this damage is SFr1.7 million for the whole town and SFr283 000 per building. These results are plausible in magnitude but we concede that they are indicative rather than precise estimations of this particular external cost of traffic. Since no dose response function showing the exact responsibility of the various sources of air pollution exists, the buildings taken into consideration are those directly exposed to road traffic pollution only and the assumption is made that the traffic is the only cause of damage. In this respect, the estimates might be slightly biased upwards. Nevertheless they can still be useful while trying to apply the ‘polluter pays’ principle in transport policy.

Acknowledgements

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Notes

1. The geographical position of this mid-sized Swiss town, namely on the edge of a lake and at the foot a mountain on the main road between Geneva/Lausanne and Basle/Zurich, brings it heavy transit traffic.
2. The choice of an open-ended format is disputable. Arrow et al. (1993) recommend the valuation question be posed as a vote on a referendum while warning that potential biases must still be
investigated if using double-bounded dichotomous choice form. If such an approach is realistic in a taxation or in a real market context, it might no longer be suitable when respondents are asked for a voluntary contribution. “Indeed, voluntary demand revelation performed as well as the more complex incentive-compatible demand revelation devices, and often better.” (Mitchell & Carson, 1989, p. 150).

3. To enter the sample, each questionnaire had to meet five validity conditions: (1) comply strictly with the sampling criteria; (2) comply strictly with the replies furnished by the respondents; (3) comprise the replies of one and the same person; (4) must not have been conducted on several persons from the same household; (5) must have been conducted within the set time-limits. Conditions (1) and (5) were checked for the whole sample. For conditions (2), (3) and (4) a telephone check was made on 30 persons, i.e. almost 15% of the questionnaires returned.

4. Some of the receptives might have concealed part of their true WTP partial free riders. Unfortunately the questionnaire does not allow us to test for this possibility. According to Pommerehne & Roemer (1992), about one-third out of the respondents may behave as partial free riders, although such behaviour appears statistically less significant and impacts three times less than full free riders’ one.

5. The $R^2$ obtained here is high compared with most of the contingent evaluations carried out to date. That is mainly attributable to the use of a clearly-defined contingent market, to the homogeneity of the population interviewed and to the form of the survey (personal interviews). It is not due to the inclusion of the dummy variable free, since the $R^2$ without this variable is 0.611.

6. The $F$-statistic linked to the AGE variable (3.938) is greater than the critical value (1.94).

7. If median values are used, the receptives’ WTP would be 9 francs per month and 108 francs per year. The annual cost of the damage would amount to SFr1.5 m, i.e. 252 000 francs per building. The estimates cannot be compared to any existing ones since, to our knowledge, it was the first time the damage caused specifically by road traffic air pollution to a group of buildings of historic and cultural value was evaluated. The study of the Old Nidaros Cathedral in Norway might be hitherto the only existing study in Europe (Navrud & Strand, 1992, pp. 110–111); however it was an attempt to cost the loss of originality of an isolated historic monument from corrosion due to the general air pollution.

References


