# Costing the Traffic Barrier Effect: A Contingent Valuation Survey

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**Abstract.** When considering the environmental damage caused by road traffic, one traditionally focuses attention on the consequences of accidents, or on the impact of air and noise pollution. This somewhat narrow definition should be enlarged to capture other, more psychological nuisances. The barrier effect created by heavily travelled streets belongs to this group of nuisances, rarely described and never estimated in monetary terms. It particularly affects children, the disabled and elderly people for whom the street becomes too large to cross. In a survey carried out at Neuchâtel, Switzerland, a contingent market was proposed to suppress the barrier effect around the city centre. A valuation function to predict the bids is estimated and used to infer the annual cost of the nuisance.

**Key words:** Contingent valuation, barrier effect, road traffic nuisance

## 1. The Barrier Effect: A Conflict between Pedestrians and Road Users

Monetary valuations of the environmental damage caused by road traffic have generally focused attention on well-known adverse effects such as accidents, and the impact of air and noise pollution. Assessments should include other, sometimes more psychological nuisances. The barrier or community severance effect created by heavily travelled streets belongs to this group of nuisances, rarely described and never estimated in monetary terms.

The barrier effect is traditionally connected with the parcelling of the fauna's territory by the extension of the road and railway networks. These networks create barriers which restrict animals habitat, thus increasing the risk of extinction. In urban areas, the barrier effect also affects pedestrians, but has an impact upon them in different ways. The difficulty of crossing the road is influenced by the width of the roadway, the volume, speed and composition of the traffic, and any street environment adjustments (e.g. traffic lights, pedestrian crossings, pedestrian traffic islands). As the difficulty increases, the roadway appears like a barrier; pedestrians can no longer move around freely and social interaction can suffer.

The barrier effect undermines both the movement function and the social (playing and strolling) function of the pedestrian network. At first the nuisance provokes essentially psychological effects (stress, insecurity, discomfort), but the behaviourial adaptation it implies leads to an additional loss of welfare.

If the pedestrian is an adult the barrier effect only involves a change in route or delays while crossing the street (Arbeitskreis Verkehr und Umwelt, 1987). Children, disabled and elderly people are more vulnerable and more threat-

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ened by the traffic. The barrier effect hinders the development of children's physical capability and social cognition. Parents must often accompany and chauffeur them, particularly to school, to lower the risk of accident (Hillman *et al.*, 1991). More generally residents' social relationships deteriorate. Appleyard (1981) shows that residents of San Francisco streets with light volumes of traffic have three times as many local friends and twice as many acquaintance as those on heavily travelled streets.

## 2. Designing and Implementing a Contingent Market for the Barrier Effect

Due to its local geography Neuchâtel is distinctly vulnerable to the barrier effect. This Swiss mid-size town (about 32,000 inhabitants and 15,800 households in 1992) is on the edge of a lake at the foot of a mountain on one of the main east-west roads between Geneva/Lausanne and Basel/Zurich. The nuisance is especially marked around the pedestrian city centre. In the south the flow of traffic hampers access to the nearby recreational lakeside and in the east to the main municipal garden. Contingent valuation emerges from the different techniques for environmental valuation as the only one likely to provide a sensible costing of the nuisance.

The contingent market was constructed to elicit the willingness to pay to avoid the barrier effect in this particular area although the nuisance may also appear elsewhere in town. The road section concerned is made up of five streets totalling 750 m in length. A traffic ban was not proposed as road users could have been inconvenienced and might have biased their bid. An underground bypass was assumed to exist which entirely absorbed the flow of traffic whilst maintaining the existing traffic framework and parking facilities. Assuming that the underpass already existed ensured that respondents did not consider the nuisances caused by its construction or that they estimated their bids on the basis of hypothetical building costs. To assist respondents, interviewers had a number of visual aids contrasting the barrier effect with the absence of such an effect showing an enlargement of the pedestrian zone.

To introduce the elicitation question respondents were told to 'assume that all the households living in the town are financially solicited so that they can benefit from the absence of the barrier effect'. Then respondents were asked 'how much the absence of the barrier effect is worth to them and how much they would be willing to pay for this benefit'. Respondents themselves had to state the monthly starting bid. Then they were informed that their bid might not be enough for them to enjoy the absence of the barrier effect. An iterative process followed to assess the actual maximum willingness to pay. The respondents' bid was increased in one-franc increments until they declared themselves unwilling to pay any more. An open question was designed to debrief any respondent who bid zero.[1]

The choice of an open-ended format followed by a bidding game is arguable. Lack of experience and difficulties in the valuing process are likely to lead respondents either not to respond or to overestimate their true WTP (hypothetical bias). Arrow *et al.* (1993) recommend the valuation question be posed as a vote on a referendum (answer yes or no to a given value). However, there is a risk that people tend to anchor their WTP on the value proposed. Furthermore, a referendum question necessitates significantly larger samples than the open-ended format. Therefore, this latter solution was chosen in conjunction with a specific econometric analysis to correct the hypothetical bias.

The non-probability quota sampling technique was used to build up a sample of 200 respondents – one in every 160 inhabitants. The interviews were conducted between February 17 and March 13, 1992 by eight interviewers. Each interviewer was allocated a district that entered the sample proportionally to its size; in each district the quotas were then representative of sex, age and social stratum (i.e. education level).

## 3. Response to the Elicitation Question

Individuals can adopt various attitudes towards a contingent market. For example, the open debriefing question revealed that offers could be zero for different reasons, i.e. bid refusal, strategic behaviour or strong budgetary constraint.

Out of the 200 respondents, 64 individuals (32%) refused to bid, saying that they did not judge the barrier effect to be a relevant problem. Since they were not interested in the contingent market, they were considered as 'indifferents'. However, 136 respondents ('receptives') thought that the barrier effect was a significant problem.[2] Unfortunately 20 (15%) of the 'receptives' concealed their true utility and bid nothing even though they recognised that a suppression of the barrier effect would have increased their well-being. They justified their refusal saying that, since they were not responsible for the nuisance, they should not be asked to pay anything to suppress it; the State or the road users should be charged. The elicited value was zero (i.e. reported WTP = 0) although the actual willingness to pay should have been higher (actual WTP > 0). This strategic behaviour is typical of 'free riders' who refuse to pay for a right – easy access to the lakeside and to the municipal garden – they consider they already should have.[3] The 116 respondents out of the 'receptives' who did not adopt strategic behaviour were regarded as 'volunteers'. Their willingness to pay was either strictly positive for the 107 people (92%) with a low budgetary constraint ('solvents') or zero for the 9 who could not afford to offer a higher bid ('non-solvents').[4]

## 4. A Valuation Function for Predicting the Cost of the Barrier Effect

The frequency distribution of receptives' bids shows an extended right-hand tail which might be due to large and potentially excessive bids (Pearson's coefficient of skewness = 1.91). When estimating the valuation function the problem of large bids must be addressed to avoid non symmetrically distributed errors in the regression analysis. Given the general transformation proposed by Box and Cox (1964), the elicited willingness to pay (WTP) values were transformed according to the formula $WTP^{(\lambda)} = [(WTP + \lambda_2)^{\lambda_1} - 1]/\lambda_1$ where $\lambda_1$ is a Box-Cox parameter determined to normalise the error distribution.[5] It is possible for the transformation to be linear ($\lambda_1 = 1$) or a natural logarithm ($\lambda_1 = 0$) (McClelland *et al.*, 1991). A second Box-Cox parameter, $\lambda_2$, must be introduced in the case where reported willingness to pay equals zero. The search for values of both Box-Cox parameters that maximise the likelihood function requires a particularly complex procedure. A value of 1 for $\lambda_2$ was therefore arbitrarily added to the dependent variable (Mitchell and Carson, 1990: p. 372). The Box-Cox procedure is preferred as it has the advantage of lowering the risk of hypothetical bias by reducing the influence of large bids whereas trimming procedures remove outliers even though these observations could help to explain bid variance. The transformation also permits a great deal of flexibility in the search for an appropriate functional form.

The strategic bias due to free riders had also to be dealt with. The solution suggested by Pommerehne and Roemer (1991) prevents the removal of zero bids that could explain a genuine willingness to pay. The free riders are kept in the sample but their impact on the estimated willingness to pay is captured through a dummy variable which takes the value 1 if the respondent behaves strategically and 0 otherwise. Table I (Box-Cox) shows the estimated valuation function based on a sample including receptives only (i.e. 136 observations). The indifferents were removed since they are considered to be useless in explaining the relationship between disutility and the WTP.

'Age' was found to be the most consistent predictor; in general the older the respondent, the lower the willingness to pay. As always the household's income was positively correlated with WTP. The car owner respondents might have felt responsible for the barrier effect and have lowered their bid due to a defensive reaction.[6] The quantitative assessment of housing exposure to road traffic nuisance (measured in decibels) and the qualitative importance given to this nuisance were expected to be positively related to willingness to pay. These two variables threaten to be closely correlated. However, the risk of colinearity is small since their single correlation coefficient is low. Behaving strategically, like a free rider, is undoubtedly negatively correlated with the bids. The fairly high level of explanatory power (63%) is obtained with $\lambda_1 = 0$ (log-linear specification). According to the maximum likelihood function, the parameter $\lambda_1$ lies with a 95% probability within the range $-0.12 < \lambda_1 < 0.10$.

Table I. Box-Cox and Tobit regression coefficients.[a]

| Independent variables | Box-Cox[b] | Tobit[c] |
|---|---|---|
| *Constant* | 2.835** (6.208) | 22.105 (1.222) |
| *Income* (household's reported disposable monthly income net the reported monthly rent, in Sfr.) | 0.000121** (2.794) | 0.00354 (1.884) |
| *Age* (of the respondent, in years) | –0.0292** (–5.958) | –1.026** (–4.902) |
| *Car ownership* (dummy taking on the value 1 if the respondent owns at least one car) | –0.435* (–2.228) | –29.806** (–3.535) |
| *Exposure level* (quantitative measure of the household's exposure to road nuisance measured by the housing road noise exposure: <60 dB = 1, 60–65 = 2, 65–70 = 3, >75 = 4) | 0.166 (1.963) | 7.483* (2.074) |
| *Road nuisance* (reported qualitative assessment compared to other social issues: not important = 1, little imp. = 2, fairly imp. = 3, imp. = 4, very imp. = 5) | 0.246* (3.186) | 5.165 (1.625) |
| *Free rider* (dummy taking on the value 1 if the individual behaves as a free rider) | –2.964** (–12.464) | – – |
| $\lambda_1$ | 0.000 | – |
| $\lambda_2$ | 1.000 | – |
| $n$ | 136 | 200 |
| $L_{max}$ | –330.667 | –618.805 |

[a] The numbers shown in parenthesis beneath the estimated parameters represent the values of $\hat{t}$. The coefficients marked with a double asterisk are significant at the 99% level, those with a single asterisk at 95% (two-sided test).
[b] The dependent variable is the monthly willingness to pay to suppress the barrier effect in Swiss francs, transformed according to the Box-Cox model ($WTP^{(\lambda_1)}$).
[c] The dependent variable is the monthly willingness to pay to suppress the barrier effect.

The Tobit model is a more common way of estimating the valuation function. This censored regression model allows the self-selection bias introduced by zero-bids which represent potential truncated WTP to be addressed. Turning away from the Box-Cox model to the Tobit estimation also avoids enforcing a different WTP from the one stated and discarding the indifferents' responses. However, the latter model does not allow us to limit the influence of hypothetical bias. Estimates are presented in Table I (Tobit). The free rider covariate must then be removed.

Table II contains descriptive statistics for reported and predicted willingness to pay to suppress the barrier effect around Neuchâtel city centre. The values predicted by the Box-Cox model are not fundamentally different from those fitted from the Tobit model. The predicted mean willingness to pay for a household sensitive to the barrier effect problem amounts to 21.9 francs

Table II. Statistics for monthly WTP to suppress the barrier effect in Swiss francs.

| | $n$ | Mean | Median | Std. dev. |
|---|---|---|---|---|
| *Bids reported* | | | | |
| Respondents | 200 | 19.4 | 5.0 | 33.0 |
| Receptives | 136 | 28.5 | 15.0 | 36.7 |
| Volunteers | 116 | 33.4 | 20.0 | 37.6 |
| Solvents | 107 | 36.3 | 20.0 | 37.8 |
| Non-Solvents | 9 | 0.0 | 0.0 | 0.0 |
| Free Riders | 20 | 0.0 | 0.0 | 0.0 |
| *Bids predicted, Box-Cox ('free rider' = 0 $\forall$ n)* | | | | |
| Respondents | – | – | – | – |
| Receptives | 136 | 21.9 | 17.8 | 14.0 |
| Volunteers | 116 | 22.2 | 17.8 | 14.8 |
| Solvents | 107 | 23.4 | 18.7 | 14.6 |
| Non-Solvents | 9 | 7.2 | 5.6 | 5.2 |
| Free Riders | 20 | 20.1 | 19.2 | 8.0 |
| *Bids predicted, Tobit* | | | | |
| Respondents | 200 | 20.9 | 18.5 | 12.6 |
| Receptives | 136 | 22.4 | 20.2 | 13.0 |
| Volunteers | 116 | 22.8 | 20.7 | 13.4 |
| Solvents | 107 | 24.0 | 21.5 | 13.2 |
| Non-Solvents | 9 | 9.5 | 5.8 | 6.7 |
| Free Riders | 20 | 19.8 | 18.2 | 10.1 |

per month and 262.8 francs per year (Box-Cox). However, the cost is null if the respondent is not interested in the contingent market and belongs to the indifferents group. Taking account of the probability (32%) that a respondent belongs to this latter group lowers the mean WTP to 14.9 francs, compared to 20.9 francs with the Tobit model. To some extent these amounts can be regarded as lower and upper bounds, leading to a monthly cost of 235,000 to 330,000 francs (Sfr.2.8–4.0 m per year). If the simplifying assumption that the nuisance is evenly distributed throughout the streets considered (i.e. on 750 m) is made, then each metre would cost about 3800 to 5300 francs per year to the community.[7]

## 5. Concluding Comments

Since it is the first time to our knowledge that the barrier effect has been evaluated, the reliability of the estimate must be considered with care. Founding the contingent market on the assumption that an underground bypass would have absorbed the flow of traffic may have given respondents the incentive to bid for a simultaneous removal of other traffic-related problems along with the barrier effect. Thus the value derived would tend to overstate the willingness to pay for the barrier effect suppression only.

These figures are strongly geographically dependent. They refer to a situation where a city centre is deprived of its free access to the nearby recreational lakeside and to the main municipal garden. They might not be suitable for extrapolation to other streets, either in Neuchâtel or anywhere else, with other features or other functions, even though the volume or the speed of the traffic seem to be comparable.

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## Notes

[1] In case respondents could not manage to give a willingness to pay on their own, the interviewer suggested a first bid of 5 Swiss francs. An iterative procedure with increments of 2 francs was introduced to achieve a bid similar to a self-elicited offer. The outcome of a pretest on 30 respondents was used to choose the starting point bid for individuals who needed one, and both iterative steps.

[2] Referring to introductory questions, the indifferents attach significantly less importance to road nuisance, relative to other social issues, than the receptives.

[3] Unsurprisingly nine out of the 20 free riders were living in the central district itself. They might have considered that their right to move freely should be granted. It was also suggested that some individuals were free riders because they failed to understand that they simply had to make a comparison between two states of welfare: with and without the barrier effect. They may have imagined a construction project which needed funding.

[4] The non-solvents' income (net of the rent) is substantially lower than the solvents' one.

[5] A large variance in the bids does not necessarily imply skewness if the variance results from a skewed income distribution and an inability to report negative willingness to pay. However, the sample income (net of the rent) distribution is only slightly positively skewed (Pearson's coefficient = 0.45). It is also necessary to assume that willingness to pay amounts must be non-negative.

[6] It was suggested that road users might have, at least partially, misunderstood the scenario since it was stressed that the existing traffic framework and parking facilities would be maintained.

[7] If median figures are used, the annual cost of the nuisance would amount to Sfr. 2.3–3.5 m, i.e. 3000–4700 for each metre.

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