

Valuing a Road Network Improvement using Stated Preferences Methods

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In this paper we address, from a double perspective, the social valuation of transport improvements caused by the construction of a new motorway. First, we estimate the value citizens confer on this infrastructure as a whole. Second, we assess the time savings and the reduction in the risk of accidents the new motorway might be expected to bring about in relation to roads used at the moment. To do this, we use two approaches based on individuals' stated preferences: the contingent valuation method and conjoint analysis. The results show the social benefits of this project to be positive, although to what extent depends on initial assumptions. The information provided in this study will be useful to public managers since it can be incorporated in a cost-benefit analysis on the social profitability of this public investment.

Keywords: Road endowments valuation, Transport improvements appraisal, Stated preferences methods, Contingent valuation, Choice experiments.

1. Introduction

The assessment of improvement in citizens' welfare derived from an increase in public infrastructures, such as the construction of a new motorway, presents certain difficulties.

From an economic point of view, the provision of this type of goods takes on the characteristics of a public good and, consequently, it lacks a market price. This fact has caused the social valuation of certain public projects to be frequently ignored in cost-benefit analysis, hereby seriously impairing the accuracy and relevance of the results.

Economic science has developed specific methods that enable us to assess the social welfare changes caused by variations in the quantity or quality of public goods which became part of the individuals' utility function. Although they have no market price, the value of these public goods can be inferred in several ways. In a broad sense, we can distinguish between indirect and direct methods of valuation (Freeman, 1993). The first category includes all those techniques based on demand functions, observed cost functions, changes in commodities or inputs prices, transactions made in the market such as the purchase of housing or the observation of individual behavior related to certain recreational activities. The second category covers those methods where the value of the public good is obtained by directly asking people how much they are willing to pay for the good. The theoretical background of both categories can be found in the neoclassical consumer theory, according to which the value assigned to a good or service is based on the individual preferences. The social benefit is obtained by aggregation of the individual values. From this perspective, the value afforded by the provision of a public good can be inferred from the analysis of revealed preferences (indirect methods) or from stated preferences (direct methods).

In this paper we use two approaches from the second category (the contingent valuation method and the choice experiment) to value the social benefits derived from a new motorway in Castellón (Spain). This new road will ease traffic between the ceramic industrial district and the Port of Castellón, an area that currently experiences very high flows of both passenger and commodity transport, with daily average intensities sometimes exceeding the existing capacity of the transport network. Determining the potential benefits of this investment provides useful information for a cost-benefit analysis on its social profitability.

The paper is structured as follows: the first sections describe the methodology, section four introduces the scenarios presented and section five sets out the results. Finally, section six summarizes the main conclusions of our study.

2. The contingent valuation method

The theoretical foundations of the contingent valuation method are based on the consumer rational choice theory. This assumes that individuals take consumption decisions which maximize their welfare and that consumers' preferences are defined for private and public goods.

Following Braden, Kolstad and Miltz (1991), let us suppose that q is the amount of a public good, v is its quality, Y the personal available income and, finally, x the amount of a combination of private goods. It is also assumed that p is the price of the public good and that the price of the composed good is one. We also suppose p to be a normalized price with respect to the private good. The consumer attempts to maximize the following utility function:

$$\begin{aligned} \max_{q,x} u(q, x, v) \\ \text{s.a. } pq + x \leq Y \\ q, x \geq 0 \end{aligned} \quad (1)$$

From a theoretical point of view, the accurate measure of the change in the individual's welfare is the amount of money that would cause him or her to be indifferent to whether or not there is a variation in the quantity or quality of the public good. Let us suppose that the consumer spends all his or her income. For a certain level of Y and v , the consumer solves the equation (1) obtaining an utility u^* and an optimum consumption basket (q^*, x^*) depending on p , Y and v . By totally differentiating the utility function in its optimum values ($u^* = u(q^*, x^*, v)$) and considering the budget constriction [$Y = pq^* + x^*$] we obtain the following expressions:

$$du = \frac{\partial u}{\partial q} dq + \frac{\partial u}{\partial v} dv + \frac{\partial u}{\partial x} dx \quad (2)$$

$$dY = q dp + p dq + dx \quad (3)$$

If we attempt to see how the changes in the variables q and v can be compensated by changes in the variable Y , then $du = 0$ and, at the same time, if we suppose prices to be fixed, then $dp = 0$ and this term disappears from the equation (3). If we reorder the two previous equations, we have:

$$- dx = \frac{\partial u / \partial q}{\partial u / \partial x} dq + \frac{\partial u / \partial v}{\partial u / \partial x} dv \quad (4)$$

$$- dx = p dq - dY \quad (5)$$

Let us now suppose v to be the attribute for which a change is contemplated. By equaling terms and reordering equations (4) and (5), we obtain

$$\frac{\partial u / \partial q}{\partial u / \partial x} dq + \frac{\partial u / \partial v}{\partial u / \partial x} dv - p dq = -dY \quad (6)$$

This equation shows that the payment should equal the difference between the value the individual places on the change in the quantity and quality (the first two terms of the left hand side in the previous equation) and the change in the money spent in q (the last term of the left hand side).

A fundamental condition in consumer theory is that individuals, to maximize their welfare, equal the substitution marginal relation to the products prices relation, which means that

$$\frac{\partial u / \partial q}{\partial u / \partial x} = p \quad (7)$$

Now, by replacing (7) in (6) we obtain the following equation:

$$\frac{\partial u / \partial v}{\partial u / \partial x} = - \frac{dY}{dv} \quad (8)$$

This expression indicates that the substitution marginal relation between the quality of the public good (v) and the private good (x) should equal the change in the individual's income (the amount he or she would be willing to pay) to maintain the utility constant when v is changing. Hence, if the change in quality is positive, then the consumer would be willing to reduce his level of income to keep the utility constant and vice versa if the change is negative. Thus, the substitution marginal relation coincides with the monetary variation that would cause the consumer to be indifferent to whether or not there is a change in the quality of the public good.

3. The choice experiment technique

The choice experiment is an approach based on conjoint analysis, another stated preferences method. Its purpose is to obtain an indirect utility function in which the utility yielded by the consumption of a good depends on the level of its attributes. The first applications of this technique appeared in the seventies, mainly in transport economics (Louviere *et al.*, 1974; Norman and Louviere, 1974), but over recent decades its use has been extended to other fields such as marketing, health economics and environmental economics.

As stated by Louviere (1988), the decision process followed by consumers of comparing available alternatives until they make their final choice is a complicated one, due to the high number of factors that influence their assessments. The individual observes the actual situation and devices certain psycho-physical trials that will lead him or her, depending on his or her beliefs and perceptions, to value the characteristics of the good being considered in a certain way. By evaluating the total set of attributes, the individual comes up with an overall valuation on which the final decision will be based. This choice can be modelled as follows: Let us start from a situation in which there are J complete profile alternatives (X_1, X_2, \dots, X_J). The researcher selects M of these profiles to form a choice set $C = \{j_1, j_2, \dots, j_M\}$ which is presented to the respondents. They are asked to select one of the profiles in the set. Following Laitila (2001), the decision problem that the respondent faces can be formulated as an optimizing problem within the consumer's utility theory framework.

$$\begin{aligned} \max_{Z, m} U_i^*(Z, X_m) \\ \text{s.t. } ZP \leq Y_i - c_m \end{aligned} \quad (9)$$

where U_i^* is the utility function, Y_i is the income of individual i , Z is a set of goods he or she consumes with a corresponding price vector P , X_m is the attribute vector of profile m where cost c_m is also included.

The indirect utility function, conditional on choosing the profile m can be specified as:

$$U_{im}(P, Y_i - c_m, X_m) \quad (10)$$

Assuming that the respondent chooses the profile yielding the highest utility, we can state that

$$U_{im} > U_{ij} \dots \forall j \in C \dots j \neq m \quad (11)$$

If the utility function is linear, then

$$U_{im} = P\lambda + X_m \beta + \gamma(Y_i - c_m) + \alpha_i + \varepsilon_{im} \quad (12)$$

where λ and β are parameter vectors, γ is the marginal utility of income, α_i is an individual specific component and ε_{im} is a unknown individual specific component corresponding to profile m . Since $P\lambda$, γY_i and α_i are constant over the alternatives in the choice set C , they do not affect the decision the respondent eventually made, therefore the decisional rule can be restated as: The respondent chooses profile m if

$$X_m \beta - \gamma c_m + \varepsilon_{im} > X_j \beta - \gamma c_j + \varepsilon_{ij} \dots \forall j \in C \dots j \neq m \quad (13)$$

Assuming respondents are randomly chosen, the unknown individual component corresponding to profile m can be interpreted as a random disturbance term. The probability of obtaining a respondent choosing profile m is

$$P(m: C, \beta, \gamma) = P(X_m \beta - \gamma c_m + \varepsilon_{im} > X_j \beta - \gamma c_j + \varepsilon_{ij}) \dots \forall j \in C \dots j \neq m \quad (14)$$

If the disturbances ε_{i1} , ε_{i2} , ..., ε_{iM} are independent and identically distributed with density function $g(\varepsilon)$, then

$$P(m: C, \beta, \gamma) = \int_{-\infty}^{+\infty} g(u - X_m \beta + \gamma c_m) \prod_{j \neq m} G(u - X_j \beta + \gamma c_j) du \quad (15)$$

In the case that disturbances are extreme value distributed, we obtain

$$P(m: C, \beta; \gamma) = \frac{e^{X_m \beta - \gamma c_m}}{\sum_{j \in C} e^{X_j \beta - \gamma c_j}} \quad (16)$$

Parameters β and γ can be estimated using the maximum likelihood procedure and the willingness to pay for a certain profile can be obtained with the following formula:

$$WTP_{profile \dots j} = \frac{X_j \beta}{\gamma} \quad (17)$$

The marginal value of a change in an attribute can be measured in terms of compensating variation, as stated by Roe *et al.* (1996), according to the following expression:

$$\frac{\beta_s}{\gamma} \quad (18)$$

where β_s is the coefficient corresponding to attribute s and γ is the cost coefficient.

4. Scenarios presented

As mentioned above, direct valuation methods are based on stated individual preferences and the value of the public good is inferred from the choice respondents made when facing different hypothetical alternatives designed by the researcher.

Therefore, an essential element in empirical applications is the questionnaire presented to the respondents. The survey used in this study was structured in four parts. The first one introduced the individual to the valuation, it outlined the fact that the questionnaire was both anonymous and voluntary, in order to put respondents at ease for providing truthful answers. A verbal description of the current situation and the proposed project was illustrated with pictures, maps and a plan of the layout of the new road.

The first questions picked up the respondents' previous knowledge on the projected motorway and their personal opinion related to the need for and the potential advantages of this communication infrastructure. The advantages considered referred to the level of noise, number of traffic accidents, atmospheric pollution, time savings on journeys and, finally, the expected use of this new infrastructure by the interviewee.

Once the public good to be valued had been defined, the second part of the questionnaire contained the elements needed in a hypothetical market simulation: the amount of the public good, the mean of provision, the payment vehicle and the elicitation question. The payment vehicle consisted of a voluntary contribution to a special fund for carrying out the works over the foreseen period of execution (2002-2005)¹ until the project was complete. This payment vehicle was chosen because it appeared the most neutral for the valuation of this kind of goods in Spain.

On the elicitation question, we followed the recommendations suggested by the Blue Ribbon Panel (NOAA, 1993). It was formulated in a closed-ended format and in terms of willingness to pay (equivalent variation), not in terms of required compensation. First, the interviewee was asked whether or not he or she would be willing to contribute to the financing of the project. With this we hope to discover whether or not the respondent was in the market for this public good². Next, a dichotomous question was formulated in which the respondent had to accept or reject a bid amount proposed as the payment for the provision of the new road. Finally, in an open question, respondents were asked about their maximum willingness to pay (WTP) for the good. If respondents stated that they were not willing to pay anything, they were asked to explain the reason for this position. The aim was to differentiate the "actual zero answers" from the "protest answers" (Portney, 1994)³. To avoid an overestimation of the WTP, the interviewee was reminded of his budgetary restriction as well as the fact that other

¹ As Azjen *et al.* (1996) suggest, it is important to remind the interviewee of the time period in which the public good will become available, since this reinforces the credibility of the hypothetical market. At the same time, the interviewee can judge whether or not this period of time is relevant to him or her.

² This question, together with the dichotomous enabled us to apply a *Spike model* (Kriström, 1997) to estimate the expected WTP.

³ In the contingent valuation context, "protest answers" are understood as unwillingness to pay which in fact does not mean that the respondent places zero value on the good, but rather the rejection has to do with fair-play in the hypothetical market. In contrast, when the refusal to pay reflects true preferences (because the respondent is not interested in the good valued) or it is the result of a low income, the answer is called "actual zero" as opposed to "protest zero".

public projects might also require monetary contribution. The simulation of the market was drafted as follows:

As you will be aware, it is increasingly important for public administration to take into account the opinion of citizens affected by certain public investment projects. Although the new motorway described will be financed through public funds, in order to find out the extent to which you value the project, we would like you to imagine that it had to be funded by the public through a special compulsory payment used to carry out the project within its execution period (two and a half years).

Q 9. In the light of your personal income and of the fact that there are other public projects for which financial contribution could be requested, would you be willing to pay any amount of money during the two and a half years the new road was being built?

- Yes No (Go to Q11)

Q 10. Given that you are willing to pay a certain amount of money, would you be willing to pay **X euros** per year?

- Yes (Go to Q10a) No (Go to Q10b)

Q 10a. Given that you would pay at least X euros, what is the maximum amount you would be willing to pay? (Go to Q12)

Q 10b. Given that you would not pay X euros, what is the minimum amount you would be willing to pay? (Go to Q12)

In the dichotomous question, five different bids were used: 6, 30, 60, 100 and 150 euros. Diversification of bids is a strategy to avoid the possible “starting point” bias. There is no universally accepted viewpoint in the literature on the number of different bids offered⁴; in our case, the choice of these bids was based on the amounts declared in the valuation open question formulated in the pilot survey.

The third part of the survey presented the choice experiment questions. As mentioned above, this method enables us to capture individual preferences referring to the characteristics that define certain goods and to express in monetary units the welfare variations associated to changes in the levels of the attributes that configure the evaluated profiles. In our case, following focus group discussions, the attributes considered were the reduction in the risk of accidents, journey time savings and the toll to be paid for using the new motorway⁵. Clearly, other aspects could have been considered but we tried to reduce the number of attributes to a minimum for avoiding inaccuracy in the estimation since, according to DeShazo and Fermo (2002), the inclusion of more attributes leads to an increase in the utility function error term variance. These authors also find that there is a quadratic relationship between the error variance and the number of profiles evaluated; in the first stage the variance falls and later it

⁴ See Alberini (1995) for an in-depth analysis on this subject.

⁵ Since the toll payment is expressed in monetary units, its inclusion among the attributes will allow us to deduce the monetary value of reducing the risk of accidents and also the value of the journey time savings.

increases as new attributes are added. In order to obtain the minimum variance, we included a moderate number of profiles in each subset presented to the respondents.

With regard to the levels of the attributes, we considered four levels, including the “status quo”. This gave us $4 \times 4 \times 4 = 64$ different combinations, 16 of which were evaluated through a distribution in subsets of four profiles with no dominant options in any subset. With respect to the range of the levels’ values, as far as possible, we tried to adjust the scenarios to the information picked up in the focus groups and to be realistic in order to make the situation credible. Thus, the intervals of time savings are not too long (from 0 to 15 minutes) since much greater savings cannot be expected over a distance of 11.5 kilometres. We were equally cautious when establishing the reduction in the risk of accidents (0% to 30%). As far as the toll payment was concerned, values range from a heavy toll to a light one (0.15 to 0.03 euros per kilometre respectively).

The scenarios constructed and the profiles evaluated are set out below. The interviewer read the following text:

We are particularly interested in finding out public opinion on the design of this new motorway, since we think that citizens know better than anybody else what their needs are. We would like you to imagine that it was possible to choose the characteristics of this new road concerning the risk of accidents, journey time savings and the toll cost. Bear in mind that as the risk of accidents decreases and journey time savings increase, the cost of the construction of the new road will also increase; therefore, the potential payment requested to use this motorway would also be higher. Next, we will show four possible alternatives with different combinations of these improvements. The amount in euros represents the toll we would have to pay to use the road⁶.

Subsequently a selection of four profiles was shown to each interviewee. As explained above, a set of 16 different orthogonal profiles were evaluated, grouped into four subsets, each of them containing the current *status quo*⁷. Each respondent valued only one subset of options where the levels of the attributes were combined in such a way that no one profile dominated another in the same subset. The valuation scenario was designed in this manner because eliminating the dominant alternatives improves the efficiency of the estimation, as Allenby and Arora (1995) demonstrated. The subsets evaluated were structured as follows:

⁶ In order to make the scenario credible, we stressed the fact that the potential payment requested to use the new motorway would increase as the risk of accidents decreases and time savings increase. However, this correlation do not appear in the hypothetical alternatives submitted to the respondents since their construction is based on a experimental design and we have selected an orthogonal subset from the possible combinations.

⁷ As an anonymous referee has pointed out, in fact they are not 16 profiles but only 13 since each of the four choice set includes three alternatives and one base alternative, which does not vary across the choice sets. The profiles were grouped in such a way that no one profile was “dominating” among the other profiles placed in the same subset.

SUBSET A

A1

Time saving: 0 minutes
Accident reduction: 0%
Toll: 0 euros

A2

Time saving: 10 minutes
Accident reduction: 10%
Toll: 1 euro

A3

Time saving: 0 minutes
Accident reduction: 10%
Toll: 0.60 euros

A4

Time saving: 0 minutes
Accident reduction: 30%
Toll: 1.5 euros

SUBSET B

B1

Time saving: 0 minutes
Accident reduction: 0%
Toll: 0 euros

B2

Time saving: 5 minutes
Accident reduction: 0%
Toll: 1 euro

B3

Time saving: 0 minutes
Accident reduction: 20%
Toll: 1 euro

B4

Time saving: 10 minutes
Accident reduction: 0%
Toll: 1.5 euros

SUBSET C

C1

Time saving: 0 minutes

Accident reduction: 0%

Toll: 0 euros

C2

Time saving: 15 minutes

Accident reduction: 0%

Toll: 0.60 euro

C3

Time saving: 5 minutes

Accident reduction: 10%

Toll: 1 euro

C4

Time saving: 15 minutes

Accident reduction: 30%

Toll: 1.5 euro

SUBSET D

D1

Time saving: 0 minutes

Accident reduction: 0%

Toll: 0 euros

D2

Time saving: 5 minutes

Accident reduction: 30%

Toll: 0.60 euro

D3

Time saving: 15 minutes

Accident reduction: 0%

Toll: 0.60 euros

D4

Time saving: 15 minutes

Accident reduction: 20%

Toll: 1.5 euro

Finally, the fourth part of the questionnaire was made up of a group of questions on respondents' socio-economic characteristics with the purpose of later estimating a validity function where the stated willingness to pay would be explained by these variables.

The survey process began in October 2002 with a pilot survey previously discussed in focus groups. After a few changes, the final surveys were carried out in December 2002. A sample of 405 respondents living near the future road were personally interviewed in their homes. The addresses were selected following random routes and matching the reference population's age and sex quotas to ensure the sample was representative of the citizens potentially affected by this new road. The interviews were conducted by professionals to avoid any interviewer bias caused by lack of training⁸.

5. Social benefits estimation

5.1 Overall valuation of the motorway provision

From the data gathered in the valuation questions, we estimated the social benefits derived from the provision of this new public infrastructure. The respondents faced a binary question, a bid they should accept or reject depending on whether the payment suggested was higher or lower than their willingness to pay. An open question was then asked to find out their maximum WTP.

In the contingent valuation studies with a binary or referendum format, the WTP is usually obtained from the parameters estimated in a logit or probit model. These formulations presuppose that the WTP is distributed following a logistic or a normal function and that all the respondents have a positive WTP for the public good being valued. Other distributions frequently used, such as the log-logistic, lognormal and the Weibull, also assume the WTP to be positive. However, it is possible that some people would not be willing to pay for the good; a discontinuity might then appear in the distribution of the WTP. Halvorsen and Saelensminde (1998) stated that when this fact is ignored, the model is heteroscedastic and the estimators are biased. Therefore, when there is a high percentage of "zero answers", other more appropriate empirical models should be used.

The model developed by Kriström (1997) allows individuals to have a $WTP=0$ for the public good. It is then possible that a "spike" might occur in the WTP distribution function, i.e., a discontinuity or a jump at zero value⁹. Yoo and Kwak (2002) state that the *Spike* model, by taking into account these possible zero answers, significantly improves on the approaches based on conventional models.

In this study the percentage of "zeros" was 72%, of which 35.8% were protest answers. Thus, the most suitable approach was to apply a *Spike* model. This model requires two valuation questions. The first determines whether the respondent is willing to contribute to the provision of the public good, in other words, it attempts to discover whether or not this

⁸ The survey was administered by Metra-Seis, a market consulting firm, and was made as a stratified probability sample by establishing quotas according to the population demographic structure.

⁹ A "spike" means that the empirical survival function does not have a smooth path along the whole range of probabilities, from zero to one. The fact of having a discontinuity, a spike, at zero value indicates that some individuals do not want to pay for the good, regardless of the price they would have to pay for it.

consumer is in the market for the good. If the individual agrees, a bid A is put forward in a second question. For each individual i , an indicator E_i is defined which reflects whether or not he or she is in the market:

$$E_i = 1 \text{ if } WTP > 0 \text{ (0 otherwise)} \quad (19)$$

and another indicator D_i which shows whether or not the respondent is willing to pay the suggested bid A :

$$D_i = 1 \text{ if } WTP > A \text{ (0 otherwise)} \quad (20)$$

The probability that an individual's WTP does not exceed an amount A is given by

$$\text{prob}(WTP \leq A) = F_{WTP}(A) \quad (21)$$

where $F_{WTP}(A)$ is a right, continuous, non-decreasing function. If we assume that WTP is distributed as a logistic on the positive axis, $F_{WTP}(A)$ can take the following values:

$$\begin{aligned} F_{WTP}(A) &= [1 + \exp(\alpha - \beta A)]^{-1} \text{ if } \dots A > 0 \\ F_{WTP}(A) &= [1 + \exp(\alpha)]^{-1} \dots \text{if } \dots A = 0 \\ F_{WTP}(A) &= 0 \dots \dots \dots \text{if } \dots A < 0 \end{aligned} \quad (22)$$

where α can be interpreted as the marginal utility of environmental improvements and β as the marginal utility of income. The log-likelihood function to be maximized is:

$$l = \sum_1^N E_i D_i \ln[1 - F_{WTP}(A)] + E_i (1 - D_i) \ln[F_{WTP}(A) - F_{WTP}(0)] + (1 - E_i) \ln[F_{WTP}(0)] \quad (23)$$

After estimating the relevant parameters, the expected WTP is obtained by solving the integral:

$$E(WTP) = \int_0^{\infty} \frac{\exp(\alpha - \beta A)}{1 + \exp(\alpha - \beta A)} \quad (24)$$

or solving the following equation if β is positive:

$$E(WTP) = \frac{1}{\beta} \ln[1 + \exp(\alpha)] \quad (25)$$

The *spike* is defined as the value for which $F_{WTP}(A) = 0$, which means the probability of the WTP equalling zero. Kriström (1997) demonstrates how this value can be obtained with the following formula:

$$\text{spike} = 1 - \frac{1}{[1 + \exp(\alpha)]} \quad (26)$$

We estimated the log-likelihood function (equation 23) using the econometric package LIMDEP. The mean of the WTP is 48.04 euros over the whole sample or 70.36 euros if the protest answers are excluded to leave only actual zeros. Exclusion of the protest zeros is normal practice in contingent valuation studies (Freeman, 1993), since otherwise, the valuation would be underestimated because zero values would be attributed to individuals

who value the good positively but do not accept the outlined hypothetical market. Table 1 presents the coefficients estimated and the WTP in each case.

Table 1. Spike model estimation

	α	β	Mean (euros)	Median (euros)
Protest zeros included	-0.975412 (-17.497)	0.006658 (11.156)	48.04	0
Protest zeros excluded	-0.298059 (-4.747)	0.007890 (11.533)	70.36	0

t-statistic in brackets.

To deal with the aggregation, the population considered was made up of inhabitants living in the municipalities nearest to the new infrastructure, as these citizens are the most immediate potential beneficiaries¹⁰. The aggregation of the individual valuations yields a social benefit of around the 37 million euros (specifically, 37,083,062 euros). Although this figure is lower than the budget for to the motorway construction, it must be borne in mind that this amount only picks up the valuation citizens make in their role as future users of the infrastructure. However, this new road will be heavily used by vans and trucks coming from the ceramic industrial district to the Port since it will provide them with a new quicker and less congested route. The incorporation of the benefits this new motorway provides to these stakeholders would increase the benefits obtained.

5.2 Benefits of the improvements in transport conditions

Respondents were questioned on the possible advantages of the ring roads on easing traffic congestion, the reduction of traffic accidents and lower pollution. The valuation scale for all these aspects was : a great deal, fairly high, not very high and none. Table 2 summarizes the answers obtained. Most interviewees considered ring roads can reduce the noise and lower the number of accidents but they were quite skeptical about cutting pollution levels down.

Table 2. Assessment of potential advantages of the by-pass

Assessment	Noise reduction		Accidents reduction		Reduction in pollution	
	frequency	%	frequency	%	frequency	%
A great deal	113	27.9	70	17.3	84	20.7
Fairly high	167	41.2	110	27.2	102	25.2
Not very high	72	17.8	114	28.1	78	19.3
None	37	9.1	62	15.3	116	28.6
No response	16	4.0	49	12.1	25	6.2
Total	405	100.0	405	100.0	405	100.0
Modal value	"Fairly high"		"Not very high"		"Not very high"	

¹⁰ A population of 256,159 was considered, although for the aggregation we only considered individuals over 18 (210,819) since they have the right to vote and, legally, they are able to decide.

A choice experiment was designed to estimate the benefits of journey time savings and reduced risk of accidents. The interviewees indicated their first choice option from four hypothetical alternatives that differed in their attributes levels.

As mentioned in section 3, if the consumer's preferences function is assumed to be linear and the price is one of the attributes, then the marginal value of a change in a certain attribute can be expressed in terms of compensating variation. Equation (16) was estimated and the results are shown in Table 3. The signs of the coefficients are as expected, positive for the variables corresponding to time savings and accidents reduction, negative for the variable cost. When formula (18) is applied, the WTP for reducing journey time by one minute would be 0.03 euros and the WTP for reducing the risk of accidents by one percentage point would be 0.06 euros. According to these figures, we estimate the WTP for various profiles by applying formula (17) (Table 4).

Table 3. Choice experiment: Coefficient estimates

Variable	Coefficient	t-statistic	P-value
Journey time reduction	0.099205	2.00	0.045
Risk of accidents reduction	0.189814	5.16	0.000
Cost	-3.310607	-4.65	0.000
Log L	-434.05261		
N ¹¹	812		

Table 4. Appraisal of a subset of four profiles (euros)

	Profile 1	Profile 2	Profile 3	Profile 4
	0 minutes	8 minutes	10 minutes	12 minutes
	0% risk reduction	10% risk reduction	15% risk reduction	25% risk reduction
WTP	0	0.84	1.2	1.86

Our results concerning time value are similar to those obtained in previous research. Calfee and Winston (1998) conducted a study on the value of automobile travel time in the major U.S. metropolitan areas. They focused on commuters who spend 40-60 minutes driving to work and usually face some congestion. The respondents did not perceive all time to be onerous since they were only willing to pay to reduce congested time (3.84 dollars per hour on average) and did not place value on uncongested time. In our study we estimate a lower value (1.8 euros per hour) but there are no distinctions between congested and uncongested time. This figure is more similar to those obtained by Bergkvist and Westin (1998) referred to the value of travel time in the Swedish road freight. The sample was made up of transport companies. The mean value for all transports was found to be 14 SEK per hour and transport (1.54 euros¹²).

With respect to the risk reduction, our figures are lower than those reported by Persson (2003) concerning traffic safety valuation on Sweden. The studies quoted used the CV approach: the

¹¹ There were 405 surveys but they gave rise to 1620 theoretical observations since each respondent had to choose from four alternatives. After eliminating the incomplete answers, 812 observations remained.

¹² According to the exchanges rates on 2004, 18th January.

subjects were asked about their WTP for 50, 25 and 10 per cent reductions respectively. The marginal WTP was found to be a decreasing function of the size of risk reduction, hence the amount the respondents were willing to pay for one percentage point ranges from 3.07 euros to 1.99 euros.

To calculate the aggregated value of both improvements, time savings and accident reduction, we considered different scenarios. For time savings we established a range from 8 to 12 minutes. This is a conservative estimate adjusted exclusively to the new section of 11.5 kilometers. Net savings will probably be closer to 20 or 30 minutes since the new road will bring improved transport fluency within the area under study. Regarding accidents, we assumed the reduction could range from 10% to 25%. We then took into account the transport flows on the A and B roads connecting the Port with the municipalities near the new motorway (Table 5). Multiplying the daily average vehicle intensity on these roads by the monetary value of time savings and the accident reduction assumed, we obtained an estimation of the aggregate value of these improvements. Table 6 summarizes the social benefits corresponding to the different scenarios.

The first columns shown in Table 6 have been obtained by multiplying the last column of Table 5 (annual transport flow) by the monetary value of the time savings (0.24 euros for 8 minutes, 0.30 euros for 10 minutes and 0.36 for 12 minutes). The same applies to the figures related concerning the monetary value of safety gains (the last three columns). The last row summarizes the total benefits by adding the partial benefits of the roads connecting the ceramic industrial district to the Port: 4,144 thousands of euros per year (for 8 minutes saved); 7,401 for 10 minutes and so on. It is worthy to notice that figures concerning accident reduction are higher than those concerning time savings, which may indicate that people value more safety than time savings.

To infer the social benefits yield by the new motorway, several scenarios can be considered. If we supposed, for instance, that the new motorway would save 10 minutes on average with respect to the current spending and that it would reduce the risk of accidents by 15%, then the social benefits would be 29.6 million euros. This amount is the result of adding the value of both time savings (7,401 thousands of euros) and accidents reduction (22,202 thousands of euros). Similarly, the appraisal of the improvements described in profiles 2 and 4 can be obtained (18,945,121 euros and 45,883,456 euros respectively).

Table 5. Transport flows on the A and B roads near the new motorway

Road	DAVI	Annual transport flow
CN-225	9.592	3.501.080
C-01801	16.741	6.110.465
C-18301	4.800	1.752.000
CN-340 (i)	16.173	5.903.145
CN-340 (ii)	20.279	7.401.835

DAVI: daily average vehicle intensity

Source: Own calculations

Table 6. Social benefits yielded by time savings and accidents reduction (thousands of euros per year)

Roads	Time savings			Accident reduction		
	8 min	10 min	12 min	10%	15%	25%
N-225	840	1,050	1,260	2,101	3,151	5,252
C-01801	1,467	1,833	2,200	3,666	5,499	9,166
C-18301	421	526	631	1,051	1,577	2,628
CN-340a	1,417	1,771	2,125	3,542	5,313	8,855
CN-340b	1,776	2,221	2,665	4,441	6,662	11,103
	4,144	7,401	8,881	14,801	22,202	37,003

6. Conclusions

In this paper we have estimated the social benefits derived from the construction of a 11,5 kilometers stretch of motorway. This new road will improve the connections between the ceramic industrial district and the Port in the province of Castellón (Spain). The analysis was carried out from a double perspective. First, we considered the social value the affected population places on the provision of this infrastructure seen as a whole. Second, we appraised the potential improvements the new road could bring in relation to the decrease in the accident rate and the time stakeholders could save in their current journeys within the affected area.

The methodological approaches used were the contingent valuation method and the choice experiment, two direct valuation methods based on individuals' stated preferences. Both are extremely versatile and allow *ex-ante* valuations to be obtained before the provision of the public good takes place, as in the present case.

To carry out the study, 405 citizens living in the town of Castellón were interviewed. The analysis of the first questions in the survey showed that most citizens were unaware of this project, with 62% of the respondents claiming not to have heard about it. Nevertheless, there is a clear social perception of the advantages the construction of ring roads has, since most people consider these infrastructures to be very necessary. In particular, they stated that the new motorway would contribute to making journeys through the Castellón metropolitan area easier and faster.

Our estimation of the social value of this new transport provision gives us a figure of over 37 million euros.

The appraisal of potential improvements in transport by means of the choice experiment resulted in 0.03 euros for one minute of time saved and 0.06 euros for a 1% reduction in the risk of accidents. The figure concerning time value is similar to those obtained by Calfee and Winston (1998) in U.S. metropolitan areas and it is also similar to the amount Bergkvist and Westin (1998) estimated referring the Swedish road freight. With respect to the risk reduction, our figures are lower than those reported by Persson (2003) concerning traffic safety valuation in Sweden.

To infer the social benefits yield by the new motorway, several scenarios can be considered. Thus, if we suppose that the new road will reduce journey time by 12 minutes and the risk of accidents by 25%, its social benefits would amount to 45.8 million euros. When considering

more modest scenarios, the social value of the improvements is lower, at around 19 million euros. In general, the figures concerning accident reduction are higher than those concerning time savings, which may indicate that people value more safety than time savings.

Although the decision of whether or not to build the motorway requires other factors to be taken into account, the information provided in this study will be useful to the professionals in the public sector responsible for managing financial and territorial resources that belong to society as a whole. In particular, the social benefits estimated here can be incorporated into a cost-benefit analysis on the social profitability of this public infrastructure. Cities and their surrounding areas are undergoing continuous evolution and transformation, which poses a constant challenge to public managers who must provide immediate answers to citizens' needs. New investment projects planned, when they affect the potential welfare of thousands of citizens, should incorporate a serious and rigorous assessment of the social benefits they generate. Stated preference methods, despite their limitations, pick the information up directly from citizens and can help to achieve this goal.

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