

Alessia Gaia

*Department of Hydraulic, Transport and Civil Infrastructures,
Turin Polytechnic, Italy
alessia.gaia@polito.it*

How to estimate the social cost of transport? An Italian case study

1 Introduction and objective of the research

In the last decades, several studies have been undertaken to evaluate the total cost of transport, both in the USA and in Europe. Among those studies, we have taken into consideration the one of Litman (1999) and Delucchi (1998) for the USA, the research of Mayeres, Ochelen & Proost (1996), of Quinet (1993) and the EXTERNE study (1996) in Europe and the research of Danielis & Rotaris (2001) in Italy. In the different studies a variety of methodologies to calculate the social cost of transport have been used. The present paper start from a previous research concerning the social cost of transport, carried out in Italy (Pronello, 2003); here the further investigation on the usefulness and the robustness of the methodology already used to evaluate the social cost of transport and also to test two different techniques is carried out. Then, we would like to focus the attention to the results given by the two methods. Are they reliable? Are the results similar and comparable? Or a better understanding of the underlying constructs must be taken into account?

2 Methodologies to calculate the social cost of transport

Since the disaster of the Exxon Valdez in Alaska in 1989, the monetary valuation of “non-marketed” goods has become a very important matter of research. The concept of monetary valuation represents a basis also for the evaluation of the social cost of transport. Individuals manifest their choices, or preferences, through their “Willingness to Pay” (WTP) for the considered good or service. The methodologies used to evaluate people choices can be grouped in two different sets: the “revealed preferences” (RP) techniques and the “stated preferences” (SP) techniques.

The first group of methods determines consumers' preferences from observing their behaviour; these methods identify how the considered good affects the market of other goods, so that the value of the "non-marketed" good is revealed through a "complementary" market. According to Morrison et al. (1996), the "revealed preferences" techniques are: the method of control and prevention costs; the method of travel or transport costs; the method of hedonic prices. The RP methods are based on the observation of people behaviour in a real context of choice. Through these methodologies we can do an economic evaluation of environmental goods referring to the price of other goods, known as "good substitute", whose value is partially determined by environmental characteristics and for which there is a real market.

The Stated Preference (SP) methodology was originally introduced by Arrow in 1953 and it was getting popular in the late 1980's. The SP techniques are now widely used not only in marketing and for economic evaluation but also in other fields of research such as social sciences, transport, medical sciences. Taking into consideration the definition of Ortuzar (1993), SP techniques are based on individuals' response when they are facing a set of hypothetical scenarios or situations. According to Morrison et al. (1996), we can include in the "SP techniques" the following methodologies: the contingent valuation (CV); the contingent rating; the contingent ranking; the paired comparison; the stated choices (SC).

In the last decades more attention has been given to the following two methodologies: the CV and the SC. The method of CV was originally presented by Davis in 1963 and it has been widely used to determine the WTP for environmental goods or benefits that are defined as "non-marketed" ones. In the CV method people are directly asked to state how much they are willing to pay for a particular good or benefit, such as an improving in air quality. In the last years the SC experiments are become the most popular form of SP method in transportation research (Hensher, 1993); the SC method has been suggested as an alternative to the CV because it avoids some of the disadvantages of the CV, such as possible distortions in people preferences declaration (Pronello, 2003) and some possible bias, such as the "hypothetical" and "strategic" bias. Moreover, this category of technique is particular appealing in travel behaviour research because it allows that the environmental goods or benefits under evaluation are assessed relatively to each other and the amount of money is not directly asked to people (Sælensminde, 1999). In SC experiments each scenarios, made up of a combination of attributes, can be considered as an alternative, since it represents a product or a service which may not be observed in the "real" market yet. Taking into account every attribute, people are asked to choose between two scenarios the alternative which suits the best with their preference.

3 Data source

The data analysis is based on a dataset which is the result of a telephone call survey carried out in autumn 2002 in the city of Alessandria, a medium size town in the north west of Italy,

about 100 kilometres far from Turin. The main scope of the project was to understand the mobility of the town and, then, to compare the results obtained to those of the city of Vercelli (Pronello, 2003). Moreover, to have a good understanding of the mobility of the town, how it is perceived by its inhabitants, it was very important to obtain an estimation of the social cost of transport. Concerning this last issue, the research carried out in Vercelli was considered as a starting point for the study in Alessandria because its results showed that there were some notable differences between the values of WTP obtained using the two different techniques to evaluate the social cost of transport (Pronello, 2003).

3.1 Survey and questionnaire design

The city of Alessandria was divided in 23 zones. In order to have a good representativeness of the sample, the town's population was stratified in function of the criteria "zone of residence" and "type of occupation". In order to have an error of 4% with confidence of 95%, a sample of 823 inhabitants was extracted from the Alessandria General Registry Office. The tax of response was of 83%, with an error lower than 5%, so that the people interviewed were 690 persons. The survey was conducted by phone, through a questionnaire and the data were recorded directly by a computer program (CATI).

The questionnaire was presented to the sample divided into three sections.

In the first section all the characteristics of the mobility are investigated: origin, destination, frequency, purpose, transport mode used both for weekly and for week-end trips. According to the mode used for the considered travel, people were also asked to give a vote to some characteristics related to both the trip considered and the mode of transport taken into account (e.g. for the car: congestion, park cost, noise, air pollution, etc.). Then, questions about the evaluation of different characteristics of the city of Alessandria, about people perceptions of mobility, and the way of using transport modes were asked, added to questions about environmental matters and people perceptions and opinions regarding ecological problems.

The second section contained the application of the two different techniques, CV and SC, to evaluate the WTP of the people interviewed for reducing the number of trips in the city centre. The first method presented was the CV; people were asked to state how many times per week and per day they would enter the city centre with their car if it was subjected to a pricing policy and how much they would be willing to pay per access. After the application of the CV, the SC experiments were carried out. In the SC games, six different scenarios were presented to the respondents. Each scenario consisted of two different alternatives, between which people were asked to choose. Every alternative was characterized by relevant attributes for the different scenarios and their levels were defined, on the basis of the literature's review (Sælensminde, 1999) and expert's opinions, as follows: toll cost; parking cost; time in car or in bus; time on foot. The basic approach of the SC experiments was that high costs implied

shorter trip duration and less time spent walking. Other scenarios contemplate two different transport modes: car and bus; in this case the use of the bus implied only the cost of the ticket but the trip duration was almost three times more than the car's one. Table 1 shows one of the scenarios presented to the interviewed. In order to educate the respondents, before the SC experiments, it was described the pricing policy proposed, its aftermaths for the environment in term of level of congestion, air pollution and noise and, for people, in term of costs. People were told to relate the different scenarios to the trip they were referring to in the first section of the questionnaire, with the same purpose.

The third section of the questionnaire was dedicated to obtain socio-economic information of the respondents (such as sex, age, occupation, qualification, income) and of the family (family members, number of vehicles owned, etc.).

Table 1: Example of SC game

Scenario 1			
Alternative A		Alternative B	
Toll cost	2,5 €	Bus ticket	0,90 €
Parking cost	0,80 €/hour	Parking cost	0 €
Time in car	9 min.	Time in bus	18 min.
Time on foot	3 min.	Time on foot	5 min.

4 Main survey results

The majority of respondents were female (56%), representative of the residents' distribution of the city. The greater part of the interviewed was aged between 41 and 60 years (40%). The greater part of the sample was formed by people with a high school degree (56%) and with medium level of income (between € 12,000 and € 35,000). The 57% of the sample is employed, 13% were students and the 29% were retired and housewives. The results of the survey showed a high tax of motorization, about the 90% of the respondents owned at least a car.

The sample showed a high tax of mobility, only a very little percentage of people (10%) did made no trips. The 56% and 15% of the weekly trips had as destination, respectively, work and study locations; the frequency of the 45% of the weekly trips was once a day, that is to and from work or school/university. Regarding the mode used for the weekly trips, the 48% of the sample drove a car; the 18% used the train, while another 19% of the interviewed went on foot.

This feature implies different considerations:

- the mobility of the city is strongly "car-oriented";

- the “internal” mobility of the city is characterized also by a good percentage of trips made on foot (19%) and by bicycle (6%);
- only a limited percentage of people (4%) used the city’s public transport net; this is partly due to a lack of services and partly because Alessandria is not a big city and the most central useful destinations are easily reachable on foot;
- the “external” mobility of the city is characterized by a relatively high percentage (18%) of people who used the train for their trips, mainly commuters; this is confirmed by the percentage of people who used the train in the week-end trips that felt down to only 4%.

In order to understand the inhabitants’ opinion about all the important aspects linked to the transport, the respondents were asked to evaluate with a vote from 0 (the worst) to 10 (the best) a series of characteristics of Alessandria: air quality, availability of green areas, level of noise pollution, availability of cycle-path, level of congestion, availability and condition of foot-path and availability of car parking. It has been observed the almost absolute lack of positive judgements regarding the city’s attributes; in the opinion of the respondents the worst characteristics were the availability of car parking, the availability of cycle-path and the level of congestion. Almost the 80% of the sample considered totally inadequate the present system of car parking, the same percentage deemed that the cycle-path’s net was absolutely inexistent. Concerning the level of congestion of the city, it was ascribed as one of the most important problem of the city, in fact almost the 70% of the sample gave votes between 0 and 3.

Regarding people perceptions on mobility, other topics were investigated about the utility derived from travel and the economic advantage due to time saving. The first topic was investigated through the “teleportation test”, whose question was: “if you could snap your fingers and instantaneously teleport yourself to the desired destination, would you do so?”. The 75% of the sample was receptive to the teleportation test, but one person out of four of the sample gave a negative response: it seemed that in that case the utility for travel derived not only from the activity accomplished at destination but also from the pleasure deriving from travelling. The second topic was studied asking to people if “they would have an economic advantage from a hypothetical travel time saving”; the 77% of the respondents gave a positive answer while the remaining 23% stated that a travel time saving couldn’t be considered as an economic advantage.

5 Evaluation of the WTP in the city of Alessandria

The WTP was determined using two different methods: the CV and the SC. Concerning the CV, in the survey there was a direct question on the respondent’s WTP to enter in the city centre by his own car. This is our WTP_CV value, expressed in €_{access}. The SC games were carried out in order to obtain two different values of WTP: the WTP_SC_ACC (€_{access}) that refers to the value that people is willing to pay per access and it corresponds solely to the toll

cost (not considering the parking cost) of the SC games, that is to have a value comparable to that determined with the CV; the WTP_SC (€/hour) that is representative of the “time value”; really it is the value that people implicitly assign to their time. This WTP has been calculated in eqn (1):

$$WTP_SC = \frac{Toll}{t_{car} + t_{foot}} \cdot 60 + Parking \quad (1)$$

where *Toll* is the cost to enter the city centre by car; *t_{car}* is the time spent in car to reach the destination; *t_{foot}* is the time spent on foot to reach the destination; *Parking* is the cost per hour to park the car.

On the obtained three WTP values was performed the ANOVA, which showed that, the socio-economic variables – age, occupation, income and number of cars – influence all the three values of WTP. Analysing the results deriving from ANOVA, it can be noticed that:

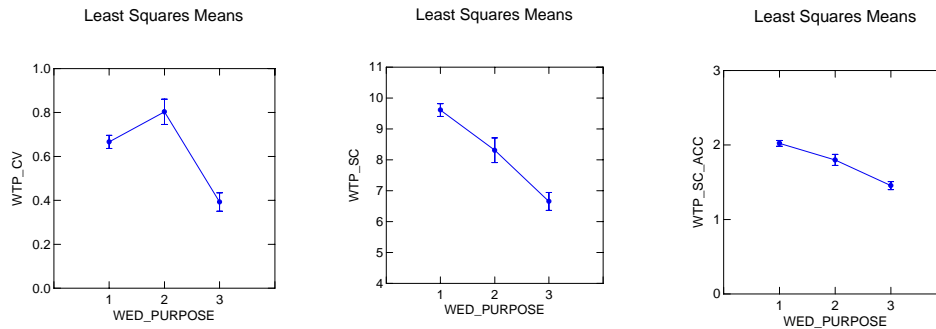
- regarding the “age” variable, we can say that in all the three cases the WTP decreases when the age rises up, so that people aged of over 60 years are less willing to pay than those under 60 years; another important finding related to the “age” variable is that the WTP_CV values are smaller than those related to the SC experiments. The WTP values per access (WTP_CV and WTP_SC_ACC) are comparable, even if not very similar;
- the profession is important because gives an idea about the real possibilities of expense of a person. In all three cases, workers are, obviously, more willing to pay than retired people, housewives and students. Retired and housewives were grouped together because they were characterized by a lower tax of mobility, while the other two groups were workers and students. In all the cases retired people and housewives are less willing to pay than the other two categories;
- about the income we considered three levels: less than 12,000 €, between 12,000 € and 35,000 € and more than 35,000 €. As expected, the willingness to pay increases with the income;
- the number of cars influences the WTP of the respondents; the WTP to enter in the city centre with their own car increases with the number of car per family. Taking into account the results of the t-test performed considering four levels for the variable CAR, we grouped the levels into only two categories: no car and one or more car. In this case, as we could expect, people with no car, essentially retired and housewives, are less willing to pay than people having car; for people with no car the WTP_CV value is 0.20 €, one of the lowest esteem obtained with the CV technique.

Table 2 shows the results of ANOVA for the variable “age”; in the table the mean values are depicted for the two groups of users for each WTP value.

Table 2: ANOVA between the WTP and the AGE variable

	WTP_CV	WTP_SC	WTP_SC_ACC
< 60 years	0,60 €	9,20 €	1,90 €
> 60 years	0,40 €	5,60 €	1,30 €

The ANOVA was performed not only with socio-economic variables but also considering variables linked to people mobility, purpose and mode of transport used for the weekly trip. All the WTP values are influenced by the variable “purpose” of the weekly trips, classified in three categories: work, study and shopping/commission. About the WTP_CV, people travelling for shopping or commissions are willing to pay the least (0,40 €), while people travelling for study seem to be willing to pay the most (0,80 €), more than people who travel for work (0,70 €). In the case of both WTP_SC and WTP_SC_ACC, the WTP presents a downward trend: it reaches its peak for people travelling for work and then it decreases reaching its minimum value for people moving for shopping and commission. Trends and estimated values for the variable weekly purpose in all three cases are depicted in figure 1.

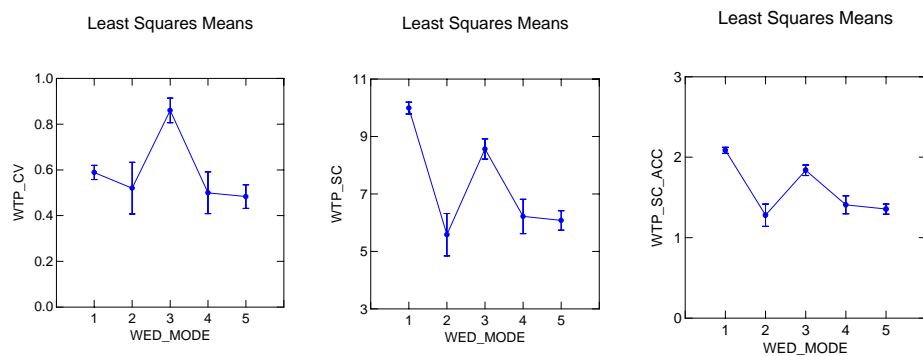


	WTP_CV	WTP_SC	WTP_SC_ACC
Work location	0,70 €	9,60 €	2,00 €
Study location	0,80 €	8,30 €	1,80 €
Shopping/commission	0,40 €	6,60 €	1,40 €

Figure 1: ANOVA analysis between the WTP and the WED_PURPOSE variable

Also the variable mode of transport used for weekly trips seems to influence people WTP, also if not all the respondents used the car for their weekly trips. We considered five classes of modes of transport: car, bus, train, bike and foot. In the case of WTP_CV the maximum WTP is obtained for people who had used the train for their trips, while for the WTP_SC and

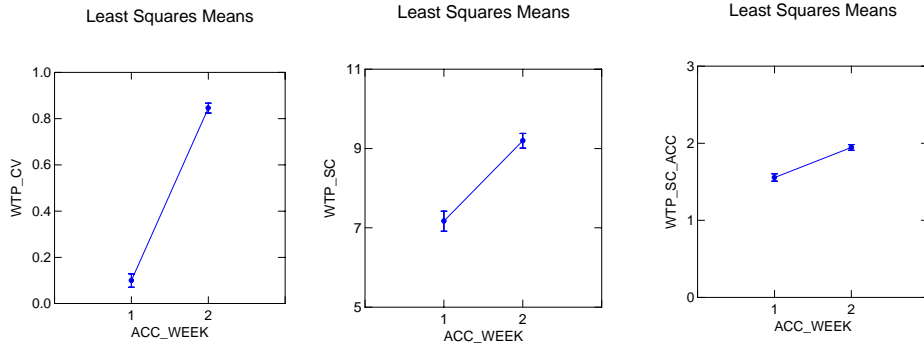
the WTP_SC_ACC the trend is similar, even if the values obtained for the WTP_SC_ACC are smaller than the ones for the WTP_SC. The WTP reaches its peak for people who used the car for their weekly trips, then it decreases steadily for people who used the bus (very few ones); it increases again for people who used the train, after that it presents a downward trend for bikes and on foot trips. As expected, people who went on foot or by bike are willing to pay the least comparing to people who usually uses the car (Figure 2).



	WTP_CV	WTP_SC	WTP_SC_ACC
Car	0,60 €	10,00 €	2,10 €
Bus	0,50 €	5,60 €	1,30 €
Train	0,90 €	8,60 €	1,80 €
Bike	0,50 €	6,20 €	1,40 €
Foot	0,50 €	6,10 €	1,40 €

Figure 2: ANOVA analysis between the WTP and the WED_MODE variable

In the questionnaire people were asked to state how many times per week they would enter by car into the city centre if this was subjected to a toll policy. The ANOVA showed that the variable “number of access” influences the WTP in all the cases. Considering the results of the t-test, we considered the variable “number of access” structured only in two levels: no access to the payment area and one or more access. As expected, people who stated that they would enter the payment area at least once per week are more willing to pay than people who wouldn’t do that. The difference between the two groups is more significant in the case of the WTP_CV than in the other two cases, as it can be seen in figure 3.



	WTP_CV	WTP_SC	WTP_SC_ACC
No access	0,10 €	7,20 €	1,60 €
One or more access	0,90 €	9,20 €	1,90 €

Figure 3: ANOVA analysis between the WTP and the ACC_WEEK variable

The data about people WTP allow to determine the social cost of transport for the city of Alessandria, considering the two techniques: CV and SC. The basic equation to calculate the social cost of transport that we refer to is the eqn (2):

$$CS_{ALESSANDRIA} = CS_{SAMPLE} \cdot \frac{N}{n} \quad (2)$$

where CS_{SAMPLE} is the social cost of the sample of interviewed people; N is the number of inhabitants of Alessandria; and n is the number of units of the sample.

Considering that we have obtained three different values of WTP, also for the social cost we calculate three different estimations both for the social cost of the sample and consequently for the social cost of Alessandria. For the estimation of the sample's social cost we use two different equations according to the fact that the WTP value used is expressed in €access (WTP_CV and WTP_SC_ACC) or in €/hour (WTP_SC). In the first case the equation is the eqn (3):

$$CS_{SAMPLE} = \sum_{i=1}^n WTP_i \cdot ACC_WEEK_i \cdot WED_FREQUENCY_i \quad (3)$$

where WTP_i is people willingness to pay (€access); ACC_WEEK_i is the number of access to the payment area (access/week); $WED_FREQUENCY_i$ is the trip frequency (times/year).

In the second case, for the WTP_SC, the eqn (4) is used:

$$CS_{SAMPLE} = \sum_{i=1}^n \frac{WTP_i}{60} \cdot WED_DURATION_i \cdot WED_FREQUENCY_i \quad (4)$$

where WTP_i is people willingness to pay (€/hour); $WED_DURATION_i$ is the trip duration (minute); $WED_FREQUENCY_i$ is the trip frequency (times/year).

The estimation of the social cost of transport for the city of Alessandria considering the WTP values is showed in Table 3.

Table 3: The social cost of transport in Alessandria

Social cost from: WTP_CV	Social cost from: WTP_SC	Social cost from: WTP_SC_ACC
26.857.253 €	100.146.322 €	63.306.272 €

6 Conclusions and future developments

As it can be seen in the last table presented, the three estimated values for the social cost of transport of the city of Alessandria reveal significant differences: the esteem deriving from the method of the CV is considerably minor than that obtained using the SC technique. Concerning the use of the CV method, the people sometimes have difficulties in quantifying the amount they are willing to pay; people tend to underestimate their WTP if they are directly asked. In addition, in the application of the CV technique possible biases can occur. The two values resulting from the use of the SC present a considerable difference, but the one deriving from the WTP_SC esteem is comparable to the evaluation of the social cost obtained using the aggregate way. These results seem to suggest that the SC method could be considered more robust for the evaluation of the WTP because it limits the possibility of underestimation of people, as they should show their preferences avoiding people interaction and underestimation. These findings, when combined with those of the earlier work on this subject (Pronello, 2003), spur to further understand possible way of interaction between people and SC and CV techniques. Another important issue of the study is the possibility to realize a sort of standardization of the SC application, not only from the theoretical point of view, but also from the applicative one: that is how to design the experiments and how to present them to the participants to the survey. With this study, we hope we provided a direction that will be useful for future endeavours both for further investigation about SC techniques and their pros and cons and for SC experiments design.

References

- Danielis, R., Rotaris, L., Rassegna delle stime dei costi esterni dei trasporti, ISTIEE, Università di Trieste, 2001.
- Delucchi M., The annualized social cost of motor-vehicle use in the U.S., 1990-1991: summary of theory, data, methods and results. Report #1, 1998.
- Hensher, D., Stated preference analysis of travel choices: the state of practice, a special issue of Transportation on The Practice of Stated Preference Analysis, 21 (2), pp.106-134, 1993.
- Litman, T., Transportation cost analysis: techniques, estimates and implications, Report of Victoria Transport Policy Institute, 1999.
- Mayeres, I., Ochelen, S., Proost, S., The marginal external costs of urban transport, Transportation research Part D (2), pp. 111-130, 1996.
- Morrison, M., Blamey, J., Bennett, R., Louvière, J.J., A comparison of stated preference techniques for estimating environmental values, Choice modelling research report, December 1996.
- Nickel, P., Schmid, S., Krewitt, W., Friedrich, R., External costs of transport in EXTERNE, IER Germany, 1996.
- Ortúzar, J., Garrido, R., On the semantic scale problem in stated preference rating experiments, a special issue of Transportation on the Practice of Stated Preference Analysis, 21 (2), pp.185-199, 1993.
- Pronello, C., The methods to evaluate the social cost of urban transport: which are the most reliable?. Urban Transport IX, WIT Press, Southampton, 2003.
- Quinet, E., The social cost of transport: evaluation and links with internalisation policies, in Internalizing the social cost of transport, OECD, ECMT, 1993.
- Sælensminde, K., Stated choice valuation of urban traffic air pollution and noise, Transportation Research Part D, 4, pp. 13-27, 1999.