Comparing Tax and Tax Reallocations Payments in Financing Rail Noise Abatement Programs: Results from a CE valuation study in Italy

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Summary

The paper examines the use of choice experiments (CE) to assess the economic value of alternative rail noise reduction interventions on the so-called Brennero railway, Italy. The novelty of this paper is threefold. To our knowledge, this is the first study on the valuation of noise conducted in Italy and it is the first example of CE applied in the field of rail noise valuation. Second, we consider not only the economic value assessment of noise reduction but also how this reduction is achieved, ranging from policy instruments such as barriers or train technology. Third, the paper provides an original contribution in the valuation literature since we test formally the econometric robustness of the CE estimates under three payment vehicles. In fact, we consider (a) a special regional tax, (b) reallocation of financial resource within the provincial budget on the public transport sector, and (c) reallocation of financial resource of the provincial budget from the administration and entertainment sector. Test results are mixed. Welfare analysis and policy implications of valuing rail noise reduction programs using different payment vehicles are discussed.

Keywords: Choice Experiment, Noise Abatement, Tax, Tax Reallocation, Formal Testing, Welfare Analysis

JEL Classification: C0, R41

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1. Introduction

Since 1998 in Italy rail noise pollution is regulated by an articulated legal act[1] that sets day-time and night-time limits on receptors, depending on their vulnerability and distance from the railway. Residential areas or vulnerable receptors, such as schools and hospitals, have therefore lower limits than less vulnerable ones. Reception limits refer to a precise spatial area along the railway, which include receptors within 250 meters from the railway. Such area is divided into two portions, the so-called "Zone A" and "Zone B", respectively, 100 and 150 meters far from the railroad track, and characterised by different receptions limits.

Almost one decade after the definition of the Italian national noise regulation, the implementation of the required noise abatement measures is still largely incomplete, and only very recently we have assisted to the rise of a national debate on how to proceed in order to abate rail noise below the limits. The Brennero railway, which is located in the north east of Italy in the province of Trento, is the first example in Italy for which noise abatement plans are currently under analysis. For this reason, challenging questions and new opportunities to provide policy makers with relevant insights on the best option to be developed against rail noise. Important issues here concern: how to accelerate the implementation of the noise abatement regulation; how to choose, among the range of possible noise reduction measures, those actions able to provide the highest level of acoustic efficiency at the lowest collective cost (i.e.: with a look at the advantages and disadvantages of each possible action for the whole range of stakeholders involved).

In this context, the present examines the use of a Choice Experiment (CE) methodology to assess the economic value of alternative rail noise reduction policy interventions, and respective instruments. The CE survey has been held in Trento in order to assess the marginal WTP for different attributes including noise reducetion, aesthetics, environmental and technical attributes with respect to alternative railway plans on the so-called Brennero railway. This allows us to study in detail the potential sensitivity of a set of factors that were identified in meeting with experts as influencing rail noise mitigation plans, including the level of abatement and respective type of intervention, landscape aesthetics, and the type of financing proposed.

The paper is organized as follows. Section 2 describes the current situation concerning noise mitigation in the EU political context, identifying the potential in using economic valuation methods in general and choice experiments in particular for assessing the benefits of noise mitigation. Section 3 explores the use of the random utility model formulation so as to study respondent's behavior. In Section 4, we develop survey instrument and describe the in-person interviews conducted on a sample of 511 residents exposed to noise pollution in the province of Trento, Italy. Section 5 links the selected theoretical model to an empirical exercise, using the CE questionnaire and respective economic valuation exercise. Section 6 discusses the range of the economic estimates and evaluates these for different payment scenarios. Section 7 concludes.

2. Background

2.1 Noise mitigation in the EU political context

In the general political intention to shift from more polluting modes of transport to more environmental-friendly ones, generally, rail transport is assumed environmental friendly. In some

[1] In Italy, the overall noise regulation was set in 1995 (LGQ n. 447/1995). The regulation on rail noise is istead more recent as it was set in 1998 (DPR n. 459/1998 "Regolamento recante norme di esecuzione dell'articolo 11 della legge 26 ottobre 1995, in materia di inquinamento acustico ferroviario").

cases, however, railway lines (either old or new) do not get acceptance from the people living close to these infrastructures due to concern about unacceptable noise levels, which are often over the current cut-off limits set by the international and national legislations. The Green Paper Future Noise Policy of November 1996 (Com(96)540) by the European Commission states that the "public's main criticism of rail transport is the excessive noise level". Excessive level of noise can potentially origin both physiological and psychological consequences for people exposed (Miedema and Vos, 1998; Passchier-Vermeer and Passchier, 2000; WHO, 2000). According to a recent report of the European Commission (CEC, 2003), for instance, the 10 percent of the European population is affected by rail noise levels higher that 55 L_{eq} dB(A), which is the standard safety level indicated by the World Health Organization. Moreover, the European Commission "Position Paper on the European Strategies and Priorities for Railways Noise Abatement" (CEC, 2003) underlines that, in order to protect the current population exposed to rail noise pollution, it will be necessary, on average, to reach a noise reduction by 10-15 dB(A).

Therefore, railway noise abatement has acquired an important priority in the European environmental policy agenda. Therefore, there is a high potential for the reduction of railway noise in Europe, because the technical instruments for the abatement of noise are available (CEC, 2003). In the current EU policy panorama, though, the main issue is the economically viable implementation of such expensive noise abatement measures and, therefore, the choice of the most cost-effective type of possible interventions. A crucial question is, therefore, whether the social benefits of reduced noise can justify the high costs of noise mitigation. The implementation of noise abatement measures involves in fact a significant financial cost that is associated either to an investment in the train technology, including wagons and railway tracks, or to an investment in noise barriers (or a combination of both). The effectiveness of the noise abatement will depend on the type of policy intervention adopted, i.e. on the type of noise abatement instrument adopted. Having an economic estimate of social benefits of reduced noise then might allow us to identify the combination of measures providing highest social benefits per euro of costs, i.e. highest benefit-cost ratios. In addition, alternative noise mitigation policies will also have different effects in terms of landscape-aesthetics and cost, which should also be considered to provide an overall evaluation of the goodness of the possible noise abatement alternatives actually available.

Environmental valuation methods can be employed to estimate the economic value of changes in noise levels and, therefore, to provide a decision support for managers and national authorities entitled to plan noise abatement measures. Both Stated Preference (SP) and Revealed Preference (RP) methods have been used to estimate the economic value of reductions and increases in noise levels by mean of the WTP concept. The choice between one of these two approaches need to be motivated depending on a careful consideration of both their pros and cons, and the expected result in terms of theoretical consistency, methodological and estimation robustness, insights for policy. Advantages and disadvantages of RP compared to SP methods are in fact well known and appropriate in their application to noise valuation (for a discussion Navrud, 2002). These will be reviewed in more detail in the following subsection.

2.2 Economic valuation of noise abatement benefits

So far, the literature on noise has been dominated by the use of RP methods and, in particular, Hedonic Price (HP) techniques. The main strength of HP techniques is that they rely on actual behaviour in the housing market, where individual preference for noise and other environmental characteristics can be observed, though indirectly. A major drawback is that results of HP studies are extremely sensitive to modelling specifications and the condition of the local housing markets (see Smith and Huang, 1993; Schipper *et al.* 1996 for meta-analysis of air quality and airport noise, respectively). However, HP techniques are not able to capture non-use values, or non-use welfare impacts, that pertain noise level increases or decreases (e.g., reduced enjoyment of desired leisure activities, discomfort or inconvenience, anxiety, concern and inconvenience to family members and others).[2]

On the other hand, relatively few SP valuation studies on noise are available and most of these have been conducted over the last 5-10 years , following the trend in the methodological valuation literature regarding the increasing use of SP methods for environmental valuation. Navrud (2002), who provides an extensive review of the noise valuation literature, argues that the delay of SP compared to RP methods for noise valuation can be justified by the general methodological difficulty in applying SP methods to noise valuation. In particular, open issues concern the problem of constructing a sound survey for valuing noise level reductions. Major methodological research challenges are related to:

1) the effort to handle within a SP survey the individual perception of noise reduction, which requires, on one side, to describe in a scientifically correct and understandable way the proposed reduction in noise level, and, on the other, the ability to interpret results according to the given noise perception heterogeneity among respondents;
2) the need to employ a realistic and fair payment vehicle that makes respondents accept willingness-to-pay (WTP) questions (in fact, respondents are likely to protest WTP questions since they think it is unfair that they should pay to reduce noise created by others);
3) finally, the difficulty in describing the complexity of possible noise mitigation policies within SP choice scenarios.

The first issue is of pertinent attention in the available SP literature on noise valuation since most existing studies, so far, seem to have given relatively few importance to the formulation of noise perception within the stage survey design (Navrud, 2002). As for other environmental and health disturbances, individual can perceive and react to the same level of noise exposure with different intensity, depending to their sensitivity to noise and starting level of exposure. It is therefore likely that perception and reaction to equal noise reduction vary from person to person. In addiction, even though we assume individuals with identical noise perception, still there is the problem of explaining what a certain noise reduction, say expressed in decibel, would mean to them in terms of actual noise feeling and potential health diseases. In the search for a better way to handle individual noise perception in SP surveys, previous case studies suggests that it is crucial to advance describing noise reductions using, for instance, examples from day-to-day experience and visual or audio aids. Generally speaking, improvements in the description of noise and noise reduction levels might be reached with an effort to make clear to respondents which is the link between objective and subjective ‘measures’ of noise by mean of examples and references to noise experience in daily life.

Among the existing SP studies, the majority refers to noise abatement program described in terms of a percentage reduction in noise levels (typically a 50% reduction). Some authors, including Saelensminde and Hammer (1994), criticize this approach because most of the times there is no

[2] Among RP methods, avoidance costs approach has also been applied to noise, but the applicability of this method is severely reduced because only in certain circumstances the results can be interpreted as a proxy of welfare loss.

additional effort on checking whether respondents actually understand what this reduction in noise would mean to them. More recently, some Contingent Valuation (CV) studies have instead provided respondents with more accurate descriptions of the noise reduction in terms that can be better understood. Some of these are put forward original approaches in the day researchers link the change in noise level to the personal day-to-day noise experience of respondents. Among these, Barreiro *et al.* (2000) describe the noise reduction by referring to the noise levels respondents experience at different times at different weekdays ("day time noise would be reduced from the working day level to that of a Sunday morning"). Vainio (1995, 2001) use a CV scenario of diverting traffic elsewhere or into a tunnel so that "traffic volume can diminish considerably" on the street the respondents had pointed out to cause them the most nuisance. Navrud (2000) and Lambert et al. (2001) both describe the noise reduction explicitly in term of *annoyance*[3]. Lambert et al. (2001) use a five-point Likert scale to capture the respondent level of annoyance, but do not provide details on the way they specify what various levels of annoyance mean to them. Navrud (2000), instead, provides the respondents with a detailed list of avoided impacts in term of discomforts, including sleep disturbance. This approach has the advantage that, if respondents are asked about their current level of noise annoyance, economic estimates per person annoyed per year for different noise annoyance levels can be estimated. Nevertheless, a drawback is that the meaning of lower/higher level of annoyance remains subjective, and researchers have to handle a substantial rate of uncertainty, whenever trying linking annoyance reduction to decibel reduction. Ideally, this problem might be overcome monitoring the actual level of noise exposure at each respondent place and, then, asking the respondents their level of annoyance. In this context, the present study employs the use of a valuation survey that provides respondents with some examples of noise production, and acoustic maps of exposition to rail noise. Finally, in the valuation section, noise abatement is both portrayed in terms decibel reduction and its equivalent measure in terms of the distance for the source – see first row on Table 2.

Second, one needs to look for realistic and fair payment vehicles. This will contribute *inter alia* to the minimize a potential low response rate, as often observed among CV studies on noise, e.g. (Navrud 1997) and Lambert *et al.* (2001). Navrud (2002), however, notes correctly that most appropriate payment vehicle could differ according to different noise sources and different countries with heterogeneous institutional settings, cultures and preferences. For instance, if, on one side, respondents can contribute (as car owner) to the current level of road noise and, therefore, be willing to pay for a reduction in road traffic noise, on the other side, they are more likely to protest payments to reduce, say, aircraft or industrial noise, for which they are not directly responsible. In the present paper we use an innovative payment vehicle based on the trading tax schemes as originally proposed by Bergstrom *et. al* (2004) and Darby and Kontoleon (2004) for the contingent valuation setting. In this context, the present paper explores formal hypothesis testing and highlights welfare implications of valuing and financing public noise abatement programs using both tax and tax reallocation schemes.

Third, it is well known that, in CV surveys researchers have to select only the strictly necessary amount of relevant information to be provided to respondents. This level of simplification, in some

[3] In this context, the term annoyance is more specifically intended to be associated with disturbance of activities, sleep, communication, and to cognitive and emotional response such as anxiety, irritability and nervousness (WHO, 2000). TNO (2000) defines noise annoyance as a feeling of resentment, displeasure, discomfort, dissatisfaction or offence when noise interferes with someone's thoughts, feelings or actual activities. Other, more severe effects, such as hearing loss or physiological stress reactions and manifest disorders (e.g. increased risk of cardiovascular diseases), are nowadays considered less relevant whenever dealing with environmental noise, and, besides, there is still a lack of epidemiological studies able to provide a quantification of the total number of persons affected by such problems.

cases, jeopardizes the possibility both to provide an exhaustive description of possible alternative policies to respondents, and, consequently, to provide a sound analysis of individual preferences. In this context, more and more often, Choice Experiments (CE) methodologies can be used either to complement or to substitute CV surveys, especially whenever the intent is of providing decision makers with insights for the definition of environmental policies and actions. As a matter of fact, CE treat the public policy program, such a noise abatement program, as a bundle of attributes and derives the marginal valuation of each attributes separately. It therefore allows providing substantially more information about the range of possible alternative noise policies as well as reduce the sample size needed compared to CV, and it can reduce the risk of aggregation bias and double counting. Since the purpose of the study is less obvious to respondents, a lower incentive to strategic bias is also expected – for a discussion see Wardman and Bristow (2004). On the other hand, survey design issues with the CE approach are characterized by a higher complexity due to the multiple numbers of attributes that must be presented to respondents and the relative strong demand on the econometric methods used to the analysis of the survey data. This valuation method will be discussed in detail in the next section.

2.3 Features of choice experiment

Choice Experiment (CE) is a non-market valuation method that allows to infer people's preferences for a set of alternatives, described by a set of relevant attributes. This technique has been first developed in market research and has then been widely applied in several other fields with the purpose of analysing choice behaviour, including transportation research, health economics, environmental economics, and the economics of cultural heritage (Louviere *et al*., 2000).

In a typical CE survey, the researcher presents two or more alternatives to the respondents, and asks the respondents to choose the most preferred one. The alternatives are described as bundles of factors, known as 'attributes', which are expected to influence respondents preferences for the proposed alternatives. The alternatives comprised of bundles of attributes are called "profiles". A combination of two or more profile is called "choice set" or "card". This scheme allows us to examine the attributes that influence choices and the relative importance of each attribute, through observation of the choice behaviours of the respondents.

CE, similarly to dichotomous choice contingent valuation methods, which can be considered as a special case of CE, presents some attractive features as a technique for evaluation. First, since choice behaviour is observed in daily life, typically in the form of shopping, the respondents answer the CE questions more easily than other stated preference techniques, such as rating, ranking, and pair-wise techniques, which instead do not involve any choice behaviour in decision-making. Second, we can use the hypothetical goods or polices as alternatives so that the respondents' preferences for those goods and policies can be analysed. In the present case, for instance, we can use different rail noise reduction policies as alternatives. This is a valuable improvement over revealed preference method such as hedonic price approach, where the range of noise reduction is usually not clearly measurable and irrelevant to policy. In addition, we can calculate the WTP for noise decrease based on the preferences of a selected sample, whereas it is the householders' preferences that are usually elicited in the hedonic price approach. Moreover, CE has an attractive advantage over CV. A typical noise abatement policy involves various aspects that can have a significant impact on people well-being. What type of noise is targeted by the policy? What level of noise reduction does the policy grant? When and at which cost will be the policy implemented? CE can separately estimate preferences of individuals for these aspects. On the other hand, CV mainly focuses on the valuation of one aspect or one fixed set of aspect.

Despite these advantages, to our knowledge, CE has not been used so far in the field of the economic valuation of rail noise reduction. We therefore try to explore how the CE can be used in eliciting people's WTP for reductions in train noise pollution, and how it can become an important analytical tool in the field of value measurement and welfare analysis of alternative public noise abatement programs. This exercise will be discussed in detail in Section 4. Before, however, we modelling respondent's behavior, the corner stone for any welfare assessment, will be discussed in detail in the next section.

3. Modeling respondent's behaviour: theoretical framework

3.1 Random utility model

The underlying assumption when assessing the economic valuation of alternative noise abatement programs is that monetary value reflects respondent's behavior. In other words, the economic valuation exercise reflects respondents preferences regarding the choice of alternative noise reduction programs. Let *H* represent the set of alternative noise abatement alternatives, and *S* the set of vectors of measured attributes. The choice for an individual respondent can be defined as a draw from a multinomial distribution with probabilities:

$$\text{Prob}\left(x \mid s, A\right) \quad \forall x \in A \ \text{ with } \ A \subseteq H \tag{1}$$

i.e. the probability of selecting noise reduction program *x*, given the vector of observed attributes *s* and the set of noise pollution abatement practices *A,* for each and every alternative contained in the set *A*. To operationalize the preceding condition, we establish an individual behavior rule, which maps each vector of observed attributes *s* into selected noise abatement program. In other words, we need to set up a respondent's behavior model. In the present analysis, we opt for a model that is anchored in the use of a utility formulation. In this context, let U_{ij} be the utility of the *i*th noise abatement alternative for the *j*th individual respondent. Furthermore, we assume that each utility value can be partitioned into two components: a systematic component, V_{ij}, and a random component, ε_{ij}. Formally we have:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{2}$$

In addition, we assume that respondents will choose the alternative that yields the highest utility. In other words, the individual *j* will choose program *i* if and only if:

$$U_{ij} > U_{hj} \quad \forall i, h \in A \ \text{ with } \ i \neq h \tag{3}$$

Combining equations 2 and 3, we know that a noise abatement program *i* is chosen if and only if

$$\left(V_{ij} + \varepsilon_{ij}\right) > \left(V_{hj} + \varepsilon_{hj}\right), \text{ or } \left(V_{ij} - V_{hj}\right) > \left(\varepsilon_{hj} - \varepsilon_{ij}\right) \tag{4}$$

Since we cannot observe $(\varepsilon_{hj} - \varepsilon_{ij})$, we cannot exactly assess if $(V_{ij} - V_{hj}) > (\varepsilon_{hj} - \varepsilon_{ij})$. Therefore, we only can make statements about a choice up to a certain point. In other words, we need to calculate the probability that $(\varepsilon_{hj} - \varepsilon_{ij})$ will be less than $(V_{ij} - V_{hj})$:

$$\text{Prob}\left(x_{ij} \mid s_j, A\right) = \text{Prob}_{ij} = \text{Prob}\left[\left\{\varepsilon\left(s, x_{hj}\right) - \varepsilon\left(s, x_{ij}\right)\right\} < \left\{V\left(s, x_{ij}\right) - V\left(s, x_{hj}\right)\right\}\right] \forall i, h \in A \quad (5)$$

i.e., the probability that a respondent will choose $x_{i,}$ i noise abatement program, equals the probability that the difference between the random component of the utility function is less than the difference between the systematic component of the utility function, across the two noise abatement programs under consideration. In other words, we set up a random utility model formulation (see McFadden 1974). We do not know the actual distribution of $(\varepsilon_{hj} - \varepsilon_{ij})$ across the population. However, we assume that this unobserved distribution is related to a particular statistical distribution. In order to test the empirical validity of this behavior model formulation, we need to select a particular statistical distribution. This will be discussed in the following sub-section.

3.2 Logit choice model

There are many statistical distributions available, but the one frequently used in random utility modeling is the extreme-type I distribution. This is known as the Weibull distribution. With the help of this family distribution we will able to translate the unobserved random index $(\varepsilon_{hj} - \varepsilon_{ij})$ into a probability expression that will help to the understand respondent's utility (see MacFadden 1984, Hanemann 1984). In order to derive such a model formulation, we start with the definition of the Weibull distribution in terms of ε_hs:

$$\text{Prob}\left(\varepsilon_h \leq \varepsilon\right) = \exp\left(-\exp - \varepsilon\right) = e^{-e^{\varepsilon}} \quad (6)$$

In addition from equation 5, which defines the rule for respondent behavior, we have that:

$$\text{Prob}_{ij} = \text{Prob}\left(\varepsilon_{hj} - \varepsilon_{ij}\right) < \left(V_{ij} - V_{hj}\right) \quad \forall i, h \in A \quad (7)$$

Rearranging equation 7, dropping the subscript j to avoid over-notation and assuming that $U_i \neq U_h$, we get:

$$\text{Prob}_i = \text{Prob}\left(\varepsilon_h < \left(\varepsilon_i + V_i - V_h\right)\right) \quad \forall i, h \in A \quad (8)$$

Combining equation 6 and equation 8 we get:

$$\text{Prob}\left(\varepsilon_h < \left(\varepsilon_i + V_i - V_h\right)\right) = \exp\left(-\exp - \varepsilon\right) = e^{-e^{\varepsilon}} \quad (9)$$

that is, the use of a Weibull distribution together with the random utility model allows us to obtain empirical choice probabilities with respect to alternative noise abatement programs.

Nevertheless, it is the use of a strict economic theoretic foundation that allows us to develop a simple operational model. We refer to the independence from irrelevant alternatives choice axiom. This axiom states that the probability of choosing one clam management practice over another is unaffected by the presence (or absence) of any additional alternatives in the choice set. This implies that the random elements in the utility are independent across choice alternatives and identically distributed. Therefore, and according to Louviere *et al.* (2000) the probability of choosing clam management i can be written as the product of the *H-1* terms, as specified in equation 9, for a given value of ε_i (say b). Formally, we have

$$\text{Prob}_i = \text{Prob}\left(\varepsilon_h < \left(\varepsilon_i + V_i - V_h\right),\ \ \forall i, h \in A\right) = \exp \prod_{h=1}^{H} \exp\left(-\exp-\left[b - V_i - V_h\right]\right) \ =$$

$$= \exp(-b)\exp\left[-\sum_{h=1}^{H}\exp-\left(b - V_i - V_h\right)\right] \qquad (10)$$

This way the probability of choosing a particular noise abatement program i can be assessed by integrating the probability density function, as expressed in equation 10, over all possible values of ε, i.e.

$$\text{Prob}_i = \int_{b=-\infty}^{b=+\infty} \exp(-b)\exp\left[-\sum_{h=1}^{H}\exp-\left(b + V_i - V_h\right)\right]db$$

$$= \int_{b=-\infty}^{b=+\infty} \exp(-b)\exp\left\{-\exp(-b)\left[\sum_{h=1}^{H}\exp\left(V_h - V_i\right)\right]\right\}db \qquad (11)$$

To obtain the final result, we make use of a transformation of variables and replace $\exp(-b)$ with z. Therefore, we can replace db by $-\left(\frac{1}{z}\right)dz$ and rewrite equation 11 in term of z as follows:

$$\text{Prob}_i = \int_{\infty}^{0} z\exp\left[-za\left(-\frac{1}{z}\right)\right]dz = \int_{0}^{\infty}\exp\left[(-za)\right]dz \qquad (12)$$

$$\text{with } a \equiv \sum_{h=1}^{H}\exp\left(V_h - V_i\right)$$

Since $\int \exp(-az) = -\frac{\exp(-az)}{a}$ and that when $z = \infty$, $\exp(-\infty) = 0$ and when $z = 0$, $\exp(0) = 1$ we have that $\text{Prob}_i = -\left[\frac{1}{a}(0-1)\right] = \frac{1}{a}$. Therefore, we can re-write Equation 12 as

$$\text{Prob}_i = \frac{1}{\sum_{h=1}^{H}\exp\left(V_h - V_i\right)} \qquad (13)$$

that defines the basic empirical specification consistent with the random utility model. This is referred to in this article as Multinominal Logit (MNL) model (see Louviere *et al.* 2000 for more details). The task is now to proceed with the estimation of the utility parameters as described in Equation 13. This task will be discussed in the following sub-section.

3.3 Estimation of the parameters of consumer's utility

The first step refers to the specification of a functional form of the utility expression *V(.)*, i.e. specify the relationship between the various attributes and observed respondents choices. In the present analysis, we work with a linear, additive form that maps the multidimensional X attribute vector into a unidimensional overall V utility (rating). Formally we have:

$$V_{ij} \left(= \sum_k \beta_{ik} X_{ikj} \right) \tag{14}$$

Given estimates of the utility parameters, βs, an estimate of V_{ij} is computed by taking the βs and the Xs for individual j and alternative i. Furthermore, according to equation 14 utility parameters may vary across respondents because the levels of attribute contained in each alternative vary across the J individuals.

Finally, we need to select a statistical estimation technique. We use the maximum likelihood estimation method to estimate the utility parameters of the closed-form MNL model. In formal terms we have:

$$\underset{\beta}{Max}\, L = \prod_{j=1}^{J} \prod_{h=1}^{H} \text{Prob}_{hj}^{d_{hj}} \tag{15}$$

with d_{hj} defining a dummy variable such that $d_{hj} = 1$ if alternative h is chosen by individual j and equal zero otherwise. Given, L in equation 15, the log-likelihood function $L*$ can be written as

$$\underset{\beta}{Max}\, L* = \sum_{j=1}^{J} \sum_{h=1}^{H} d_{hj} \log\left(\text{Prob}_{hj}\right) \tag{16}$$

Combining Equations 13-14 and 16 we have,

$$\underset{\beta}{Max}\, L* = \sum_{j=1}^{J} \sum_{h=1}^{H} d_{hj} \log \left(\frac{\sum_k \beta_{ik} X_{ik}}{\sum_{h=1}^{H} \sum_k \beta_{ik} X_{ikh}} \right) \tag{17}$$

Where the βs estimates are interpreted as a magnitude of the weight of the each attribute in the utility expression. With these parameter estimates we are able to assess the economic impact of changing attributes for each and every fish management alternative. This information is crucial in estimating the monetary value of each attribute, and thus in interpreting the decisions on clam fishing and associated welfare changes. Furthermore, this theoretical model allows us to compare expected utility levels across different fish management practices and thus rank them. In fact, from the MNL model formulation the expected utility of a particular alternative i is

$$\log \sum_i e^{V_i} \qquad (18)$$

Bearing equation 18 in mind, one can express the expected value from an initial management condition, denoted by 0, to a new management condition, denoted by 1, as follows,

$$\text{WTP} = -\frac{1}{\lambda}\left[\log \sum_i e^{V_i^0} - \log \sum_i e^{V_i^1}\right] \qquad (19)$$

where WTP (willingness to pay) denotes the economic welfare impact of the management change, or income compensating variation, that makes the individual as well off on the original situation as he will be under the new management situation. λ is the marginal utility expressed in monetary terms, or simply marginal utility of money. In other words, it denotes the change in utility that arises from an infinitesimal increase in individual's income. The marginal utility of money is derived from the MNL linear model as the price coefficient estimate. The price, here interpreted as a noise abatement-related-attribute such as the *una tantum* cost of the program (e.g. regional tax), has a negative coefficient. This reflects that a higher cost of the noise abatement program results in lower utilities. In order to change this into the marginal utility of money we need to multiply this price MNL coefficient estimate by –1.

Now we are in a condition to apply this model to predict consumer choice behavior. We need, however, to identify and measure other noise abatement related attributes that together with the price characterize the utility function of the respondent. This constitutes an important task in our empirical work and it will be discussed in detail in the following section.

4. The CE valuation exercise on rail noise abatement

4.1 Statement of the environmental quality management problem

As mentioned before, the reduction of railway noise reception levels can be achieved by three essential types of measure: on the source, including train vehicles and tracks; in the sound propagation path; or at the receptor. In the past, the latter type of measure was most common. As current practice in Europe, measures such as barriers (with high cost) or sound insulation windows (with limited effect) are mostly chosen instead of more cost-effective source-related measures. The reason for this is articulated and includes several issues. Firstly, the sound propagation measures were normally taken due to noise reception limits which have to be observed locally, whereas vehicles are often of broader origin and beyond the influence of the local authorities. Secondly, vehicle emission limits, which could enforce measures on the rolling stock, exist only in few countries, whereas the application of traditional barriers and sound insulating windows does not need much innovation. In addition, the instruments to evaluate the best solutions from a cost-benefit point of view and to apportion the contributions of vehicles and tracks and the associated responsibilities have been applied only recently in this field.

In Italy, a decree of the Ministry of the Environment (DMA 29/11/2000), which is consistent with what is stated in the more recent "Position Paper on the European Strategies and Priorities for Railways Noise Abatement" (CEC, 2002), indicates that preference should be given to noise measures at the source (i.e.: either on the vehicles and on the tracks) rather than to barriers and buildings insulation systems. Still, local authorities in charge to define noise actions can operate discretionally and need advice to select the strategy that, better than others, can guarantee higher benefits for local communities. Even if some technical guidelines are available, the evaluation of noise measures needs to take into consideration local territorial conditions and, possibly, the preferences of the affected population for alternative policy solutions.

In the context of this study, settled in the province of Trento, two radical positions are debated. On one side, the local Environmental Protection Agency is recommending to intervene along the railroad track gradually, with low noise barriers (perhaps still not sufficient to reduce noise below the limits) to be combined, during a second phase, with some technological innovation in wagons and railroad tracks. This would guarantee, in two steps, the required level of noise reduction, minimizing the drawbacks of noise barriers for people living or working in the vicinity of the railroad, in terms of aesthetics, landscapes and micro-climate changes (such as lower lighting in case of deadening barriers, or green-house effects during summer in case of transparent barriers). On the other hand, the Italian railway company (RFI), is strongly recommending actions with high barriers and no technological advance that would be able to guarantee immediately the required level of noise reduction but with higher collective costs in terms of aesthetic and environmental drawbacks. Time of provision and infrastructure costs are expected to be higher in the former case.

To provide advice to the local authorities on the preferred noise abatement option to maximize social utility, a Choice Experiment approached was designed and a survey was distributed on a representative sample of the local affected population. Overall, 511 householders were randomly selected from the universe of 1400 households exposed to noise level beyond the limits and living within the “Zone A” in seven different sites along the Brennero railway.

4.2 Structure of the questionnaire

The questionnaire consisted of three parts. The first part focused on the respondents’ noise perception. First, we asked respondents their opinion on the current rail noise situation and asked them to talk about their on experience on noise, through a set of eleven questions. First we referred to noise in general terms and used six phrases on noise sensitivity to infer the respondents’ noise profile. Using a six-point Likert scale, responds are asked to say whether they ‘not at all’ or ‘totally’ agree to what stated in each phrase. Second, we asked respondents how many hours they spent home during working days and during week-ends to infer additional information on their level of noise exposure. We then focused on rail noise and ask respondents to say whether rail noise annoyed them, during day and night time, respectively. If yes, respondents were asked to indicate their own level of annoyance using a five-point scale (as recommended by ISO, 2000): ‘not at all’, ‘slightly’, ‘moderately’, ‘very’, extremely’ annoyed). Those ‘moderately’, ‘very’ or ‘extremely’ annoyed were then asked to indicate which type of disturb they suffered, during day and night-time, respectively. A special question were used to understand whether the disturbance was due only to the rail noise emission or it was also related to the vibrations generated during the transit of trains. According to the results of the focus groups held in two of the seven sites surveyed, in fact, vibrations are also perceived as an important source of disturbance generated by the vicinity to the railway. We also asked whether the level of annoyance declared by the respondents (the householders) was either similar to those suffered by the rest of the household components or higher or lower, and which type of disturb they suffered. Finally, we asked whether they had never though to move because of the rail noise, and whether they thought they lived in a noisy or quite neighbourhood.

*** Introduce Figure 1 here ***

The second part introduced the policy choices and prepared the respondents for answering to the choice experiment questions. First we informed the respondent about the current level of noise pollution at which they are exposed and the previsions on the level of noise pollution due to the Brennero railway that will be reach by 2010 according to the local Environmental Protection Agency. For instance, the current noise exposure level is approximately 7 to 9 and 9 to 11 decibels over the limits during day and night, respectively. We also showed the respondent an acoustic map of the site in which he/she lived showing the relation between noise level and distance from the railway (Figure 2), in which he/she could identify his/her own place. We explained that noise would decrease approximately by 8 to 10 and by 11 to 13 decibel if the distance from his/her own place increased, respectively, by 10 and 20 times.

*** Introduce Figure 2 here ***

Second, we informed the respondent that the local administration was about to implement some noise abatement actions to reduce noise below the limits and we described with simple words the main pros and cons of the two alternative types of noise reduction policies that the local administration was considering for implementation. One policy option consisted in noise barriers, the other one in some technological change either in the train or the railway lines, or both. We explained that the maximum noise abatement capacity of noise barriers is approximately 20 decibels and that it increases as its height and deadening power increase, whereas high and sound absorbent barriers can inconvenience residential areas due to aesthetic and environmental drawbacks, such as reduced lightening and air circulation. On the other hand, an improvement in technology is free from aesthetic and environmental impacts and can also grant a reduction of vibrations, but it has a lower noise reduction capacity, up to 5-6 decibels, which would therefore require using also some barriers, though narrower in height. Time of provision would be different in the two cases but we intentionally did not mention this issue to avoid increasing to much the difficulty of the choice exercise. We then showed the respondents several visual simulation of barriers with different height (four and eight meters), either with or without aesthetic improvements with vegetation. The graphical simulation consisted of a succession of images showing a given site (corresponding to the respondent's site) either without or with the barrier, and either without or with vegetation. We also show to the respondents a graph, which we called "noise barometer", with examples of various noise levels that one can experience in day life, and examples of noise reductions moving from one situation to another one. Here noise reduction levels in decibels are also translated in terms of audible noise and explained in terms of increased distance from the noise source and the receptor (Figure 3). The noise barometer was let at the respondent's disposal during the whole CE exercise.

*** Introduce Figure 3 here ***

The third part gathered additional information to have a clear image of the respondents' profile, attitudes, socio-economic conditions, exposure to noise, use values provided by the railway and so forth. Among the others, we asked the respondents: whether their home was provided with thermal and sound insulation systems; whether their home had a garden or a balcony and, if yes, if a noise barrier might spoil their recreational value; rooms' number and exposition on the railway. Questionnaire debriefs closed the survey.

4.3 CE questions

Preliminary to the CE questions, we clearly explained to the respondents that the implementation of the noise reduction policy, which is able to reduce noise below the limits, would have been costly to the local administration (approximately 30 to 80 Euros per household for the year 2006) and that it would have had to find a way to finance it. We therefore explained that the local administration was considering two alternative project financing strategies. Following, Bergstrom et al. (2004), the first one consisted in reallocating the public budget for 2006, and transferring on the noise project the financial resources usually allocated on some other public service, as described in survey stated, without burdening the households with any additional local tax. The second option was to introduce a new local tax *una tantum* for the year 2006, set according to the household income level.

Following the above explanation, the respondents focused on the CE questions. They were instructed to choose their preference between the two survey described profiles. The two survey described profiles correspond to two alternative policies. These fifer in the acoustic efficiency (noise reduction capacity), type, aesthetic (given by the eight of the barrier), the associated price and type of financing. The attributes and the attributes' levels used in the CE are shown in Table 1.

*** Introduce Table 1 here ***

The acoustic efficiency of each profile is described by the level of noise reduction expressed in decibel. Three increasing levels of noise reduction are used. The lower one (minus 9 to 11 decibels) corresponds to the minimum level of noise reduction able to fulfil the limits set by the Italian noise regulation; whereas the higher ones (minus 12 to 14 and minus 14 to 15 decibels) guarantee higher levels of acoustic protection. The sign of the coefficient of this attribute is expected to be positive since the individual utility increases as the noise abatement increases.

Two types of noise reduction measures are involved: barriers and technological investment in the trains and in the railways. Barriers are described providing the respondents with the eight of the barrier, which is expressed in meters and can change on two different levels (either 4 to 6 meters or 6 to 8 meters). Technological change is described in comparison to the current situation and can consist of: 1) an improvement in the train technology, able to reduce aerodynamic noise, traction noise and vibrations; 2) an improvement in the in the railway technology, resulting in a reduction of rolling noise, traction noise and vibrations; 3) a combination of both. To facilitate the respondents in the CE questions, each of such attributes' levels is accompanied with an indication of the related level of noise (and vibration) reduction that explains the overall effectiveness associated to each policy profile.

Price is the financial burden of purchasing the hypothetical good to reduce rail noise, whereas the type of financing is the way in which households will pay for it. The expected sign of this coefficient is negative, since the utility of individuals decreases as the financial burden increases. We prepared all the combinations of the attributes levels, eliminating implausible or inconsistent ones. Choice sets consisted of two alternative profiles. The first one is fixed and corresponds to a benchmark (i.e. a minimum safety standard) policy that guarantees the minimum level of noise reduction able to fulfil the limits (i.e. minus 9 to 11 decibels) using noise barriers (4 to 6 meters high) without any improvement in the railway and train technology, nor the presence of vegetation in the barrier. The second one varies from card to card and corresponds to a policy that provides additional noise reduction levels and a reduction in vibrations too, since it combines the use of noise barriers with improvements of trains' or railway lines' technology. All combinations were asked in roughly equal frequencies. Each respondent was presented with four questions.

5. Modelling and valuation results

5.1 Indirect utility model specifications

In order to operationalize an empirical formulation of the indirect utility function as described by Equation 14, the following six model specifications are examined.[4] Model 1 is the simplest model that we consider to investigate the effect that each attributes under consideration have on the respondents' preferences, and therefore on the choice of the noise policy. Formally we have

Model 1

$$V = \beta_1 PRICE + \beta_2 NOISE2 + \beta_3 NOISE3 + \beta_4 NOISE2 \times HEIGHT$$

In this model formulation, PRICE refers the cost of the policy to the respondents. NOISE2 and NOISE3 denote the variables for the level of noise reduction (minus 12 to 14 and minus 14 to 15, respectively). NOISE2 can be reached in two cases: whenever using a combination of high noise barriers (6-8 meter) and a low technological investment either on trains or rails; or low noise barriers (4-6 meter) and strong technological innovation on both trains and rails. NOISE3, instead, is the highest level of noise reduction that can be provided by the local administration only whenever using the highest level of barriers and strongest effort in technological innovation. The omitted variable is NOISE1 that corresponds to the minimum level of noise reduction able to fulfil regulation limits. It comes from the use of low noise barriers without any technological innovation. The interaction between NOISE2 and HEIGHT controls for the effect of the height of the barrier that we interpret as the most important aesthetic feature of the noise policy. Ceteris paribus, β_4 provides the effect of a unit increment of the barrier's height on the probability to choose a noise policy that reduces noise by 12 to 14 decibel. β_1 can be interpreted as the coefficient of the cost of the noise policy to the respondents regardless of the type of project financing (i.e. payment vehicle).[5]

As we mentioned before, we also want to assess the statistical magnitude of the econometric impact of the different payment vehicles on the consumer's choice and therefore the economic valuation of alternative noise abatement programs. For this reason, we explore the use of Model 2 and Model 3, which can be interpreted as two formal testing of the payment vehicle.

Model 2 considers only the sub-sample with the two tax-reallocation payment vehicle, i.e., all the respondents that receive a questionnaire in which the CE questions is either formulated with the use of a tax reallocation within the public transport budget or a tax reallocation from the administration.

[4] Note that all the indexes for the respondents and alternatives have been omitted.
[5] We also explore other model specifications, however, the effect of vegetation on the barriers has not revealed to be statistically significant.

Model 2

$$V = \beta_1 PRICE + \beta_2 NOISE2 + \beta_3 NOISE3 + \beta_4 NOISE2 \times HEIGHT +$$

$$+ \beta_5 PRICE \times PVADM + \beta_6 PVADM$$

PVADM is a dummy variable for the type of payment vehicle. It takes on value ‘zero’ if the transfer is on the public transport budget and value ‘1’ if on administration budget. β_1 can be interpreted as the coefficient of the cost of the noise policy to the respondent given a transfer on the public transport budget, whereas β_5 is the coefficient of the cost of the noise policy to the respondent given a transfer on the administration budget.

It is therefore interesting to test whether the reported CE responses are influenced by the type of tax reallocation, controlling that all the respondents face one of the two proposed tax reallocation schemes. This can be formalized with the following hypotheses:

Hypothesis 1: Trading taxes effect on reported CE responses

H1a	H1b
$H_0: \ \beta_5 = 0$	$H_0: \ \beta_6 = 0$
$H_a: \ \beta_5 \neq 0$	$H_a: \ \beta_6 \neq 0$

In addition, we explore the use of Model 3 so as to test the empirical significance of the trading taxes vs. paying taxes effect. For this reason, we now consider all the sample of respondents. On one hand we have the sub-sample with all the respondents that receive a questionnaire in which the CE questions is either formulated with the use of a tax reallocation within the public transport budget or a tax reallocation from the administration. On the other hand we have sub-sample with all the respondents that receive a questionnaire in which the CE questions is formulated in terms of a new tax.

Model 3

$$V = \beta_1 PRICE + \beta_2 NOISE2 + \beta_3 NOISE3 + \beta_4 NOISE2 \times HEIGHT +$$
$$+ \beta_5 PRICE \times PVTAX + \beta_6 PVTAX$$

PVTAX is a dummy variable that takes on value ‘1’ if the policy will be financed with a new local tax, ‘zero’ otherwise. β_1 can be interpreted as the cost of the noise policy to the respondent given the tax-reallocation scheme, whereas β_5 is the coefficient of the cost of the noise policy given the introduction of a new local tax

It is therefore interesting to test whether the reported CE responses are influenced by the type of payment schemes, in particular assess whether CE responses confirm contingent valuation data that suggest the WTP with a tax reallocation is higher than the WTP with a special tax. This can be formalized with the following hypotheses:

Hypothesis 2: Trading taxes vs. paying taxes effect on reported CE responses

H2a	**H2b**
$\mathrm{H_0}: \ \beta_5 = 0$	$\mathrm{H_0}: \ \beta_6 = 0$
$\mathrm{H_a}: \ \beta_5 \neq 0$	$\mathrm{H_a}: \ \beta_6 \neq 0$

Finally, we explore Models 4 to 6 so as to investigate the effect of the population characteristics on the marginal WTP uniform utility function. In particular, Model 4 incorporates in the utility function the respondents' level of noise exposure and annoyance. It involves the cross terms of NOISE2 and EXPOSURE, and PRICE and ANNOYANCE. ANNOYANCE is the level of noise annoyance during the day, based on a five-points Likert scale, whereas EXPOSURE is a dummy variable that takes on value '1' if the respondent lives in the first row of buildings directly exposed to the railway, 'zero' otherwise. We can therefore examine the differences in the valuation of one unit of rail noise reduction among different respondents' profiles according to exposure and annoyance level.

Model 4

$$V = \beta_1 PRICE + \beta_2 NOISE2 + \beta_3 NOISE3 + \beta_4 NOISE2 \times HEIGHT + \\ + \beta_5 NOISE2 \times EXPOSURE + \beta_6 PRICE \times ANNOYANCE$$

Model 5 and 6 add income, education level, gender and level of environmental concern in the utility function. INCOME is a continuous variable and provides the household monthly income. EDUCATION is a categorical variable ranging from 'zero' to 'six' (degree or PhD). GENDER is a dummy that takes on value 1 if the respondent is a male, zero otherwise. ENVIRONMENT takes on value 1 if the respondent is concerned about environmental issues, zero otherwise. This allows the examination of the effects of the characteristics of individual respondents on the valuation of the single attributes. From the coefficients of cross terms we can investigate: whether there is a difference in the marginal utility of price due to different annoyance or education levels, and whether there are differences in the marginal utility of NOISE2 given the respondent's income, noise exposure and environmental concern, and of NOISE3 given the gender.

Model 5

$$V = \beta_1 PRICE + \beta_2 NOISE2 + \beta_3 NOISE3 + \beta_4 NOISE2 \times HEIGHT + \\ + \beta_5 NOISE2 \times EXPOSURE + \beta_6 PRICE \times ANNOYANCE + \\ + \beta_7 NOISE2 \times INCOME + \beta_8 PRICE \times EDUCATION$$

Model 6

$$V = \beta_1 PRICE + \beta_2 NOISE2 + \beta_3 NOISE3 + \beta_4 NOISE2 \times HEIGHT +$$
$$+ \beta_5 NOISE2 \times EXPOSURE + \beta_6 PRICE \times ANNOYANCE +$$
$$+ \beta_7 NOISE2 \times INCOME + \beta_8 PRICE \times EDUCATION + \beta_9 NOISE3 \times GENDER +$$
$$+ \beta_{10} NOISE2 \times ENVIRONMENT$$

Now we will present the results of the parameters estimates for each of the models and discuss the welfare implications and the respective repercussions in terms of policy design. Before, however, we will briefly discuss some basic statistics of the questionnaire data.

5.2. Some basic statistics of the questionnaire

The data were collected through in-person home interviews of 511 randomly sampled households affected by rail noise pollution (living in buildings within 100 meter away from the Brennero railway infrastructure), which yielded 482 responses. A trained team of 23 experts from the Statistics office of the Province of Trento were recruited and carefully instructed for the survey. Prior to the survey extensive focus groups and pretest to check the validity of survey instruments was carried out in February 2005 for other 50 households. The responses to the focus groups and the pretest greatly helped to improve phrases in the questionnaire and develop a more understandable explanation of the good evaluated. In particular, information requirements, comprehension of noise reduction levels, visual aids, payment vehicle and monetary bids were discussed during the focus groups.

Descriptive statistics on the socio-demographic characteristics of the respondents are summarized in Table 2. The sample significantly represents the universe of households affected by rail noise in the province of Trento. We selected samples evenly from households living in buildings directly or indirectly exposed toward the railway (i.e. first or second row of building from the railway). The average respondent is a 56 years old householder living in the vicinity of the railway since more than 20 years. Her/his household consists of about 2 persons, with one component younger than twelve in the 16 percent of the cases. The average household income (1,742 Euro per month) is little lower than that of Trento population, which is estimated to be around 2,400 euro per month. In the 72 percent of cases respondents own the place where they live, which usually has a garden or a terrace that is exposed to rail noise. Overall the sample is highly sensitive to health and environmental issues and fairly informed on the rail noise issue. In addition, survey results indicates that respondents scarcely use the Brennero railway.

*** Introduce Table 2 here ***

The survey also contained a set of questions to have a better understanding on: 1) how respondents perceived rail noise in comparison to other environmental issues; 2) how much sensitive they were to noise in general, and how much they were annoyed by rail noise; 3) whether they were also annoyed by vibrations; 4) which type of disturb they suffered; 5) which was their level of noise exposure (given distance, orientation, insulation capacity of the building and hours spent home). All these factors are expected to affect preferences for noise level reductions. Table 3 shows the descriptive statistics of noise perception, sensitivity, annoyance and exposure questions.

*** Introduce Table 3 here ***

5.3 CE estimation results

Estimation results for Models 1 to 6 are shown in Table 4. In Model 1 all variables are highly statistically significant. As expected the sign of PRICE is negative and that of the level of noise reduction is positive. Significant coefficients of the level of NOISE2 and NOISE3 show that the valuation of noise reduction varies according to the relative level of provision. Respondents displayed the highest preferences for the measures that provide an additional level of noise reduction equal to NOISE2 rather than NOISE3, in respect to the minimum granted by the so-called benchmark policy (i.e. NOISE1). As shown in Table 5, WTP to NOISE2, a policy noise abatement strategy that relies in an investment both on train or tracks together with a noise barrier set at a minimum level (at most 6 meters) is highly appreciated by the respondents showing a WTP of about 230 Euro per household for 2006. However, if one portrays a maximum decibel abatement increasing barriers up to 8 meters, then the WTP decreases to a range of 31 Euro per household. Confronting this estimate with the coefficient of the interaction between NOISE2 and HEIGHT, which is negative and statistically significant, we can understand that that respondents have a strong preference for a policy that provides a certain noise abatement thanks to an increase of trains or rails technology rather than increasing the height of noise barriers. These results suggest that, as expected, the height of the barrier is perceived as a major drawback of the noise policy. We can interpret this result as signalling a strong disutility from the powerful negative aesthetic impact of such a construction.

Model 2 provides a test of the effect of different payment vehicles on individual preferences. According to Model 2 estimates, the cross term of, PRICE_PVAMD is positive. This signals that *ceteris paribus* the payment of the noise abatement program with the reallocation of taxpayers money from the administrative budget, rather than with the reallocation of taxpayers money within the transport budget, has a positive in the respondent’s utility and therefore in choosing the protection program. Nevertheless, the respective statistical magnitude does not differ from zero. For this reason we can not reject the null for **H1a**. In Model 2 we also consider a direct effect of the payment vehicle on the indirect utility, captured by PVAMD. This is positive. This signals that *ceteris paribus* if one proposes the financing of the program via reallocation of taxpayers money from the administrative budget has positive effect in the indirect utility, independently of the amount of payment. Therefore, it capture a sort of psychological objection towards the reallocation of taxpayers money within the transport budget towards the noise abatement (or alternatively a psychological content towards the reallocation of taxpayers money from the administrative budget towards *per se*. As before, the respective statistical magnitude does not differ from zero. For this reason we can not reject the null for **H1b**. Therefore, we can conclude that CE data does not show that the two tax reallocation schemes under consideration provide different incentives on consumer’s choice behaviour and thus on choosing a noise protection program.

On the contract, estimation results for Model 3 show that the cross term between PRICE and PVTAX is negative and highly statistically significant. This suggests the existence of a negative relationship between the introduction of a new local tax and the selection of a noise protection program. For this reason we can not reject the null for **H2a**. This in turn is reflected in the monetary valuation of the program. In fact, respondents are more inclined to pay for a noise policy that is financed reallocating a quota of the resources normally destined to other public services than for one financed with a new local tax – see Table 5. This is an important result that confirms and extends to CE the results presented by Bergstrom *et al.* (2004) in the case of a CV study to assess ground water protection policy in Georgia and Maine.

In Model 4, both the effect of the cross terms with EXPOSURE and ANNOYANCE are positive and highly statistically significant, meaning that individual utility is sensitive to the individual level of noise exposure and annoyance in the expected way. The higher the respondents' baseline level of noise exposure and annoyance, the higher is their WTP for noise abatement.

Finally, in Model 5, N2_INCOME is positive and significant though the coefficient is narrow in absolute value. This suggests the existence of a positive relationship between the choice of a noise protection program, and income, as expected. Similarly, P_EDUCATION is positive and significant. In Model 6, GENDER_N3 and ENVIRONMENT_N2 are both positive but not statistically significant.

6. Welfare analysis and policy discussions

Standard economic theory suggests that the WTP should be positively associated with the magnitude of risk reduction. Even though this study is not directly concerned with risk, we can expect that, similarly, the WTP should increase as the level of provision of noise abatement increases. Results from Model 1 and 2 tell us that an additional level of noise reduction, higher than NOISE1, is welcomed by respondents as coefficients of NOISE2 and NOISE3 are both positive and statistically significant. However, if we calculate the WTP associated to NOISE2 and NOISE3, we see that the marginal utility of moving from a noise abatement by -10 to -12 decibels is higher that the marginal utility of moving from -10 to -14 decibels – see Table 5. Apparently this is a misleading result. We tentatively understand that this is due to the disutility associated to an increase in the height of the barrier, which for NOISE3 is at its maximum level. HEIGHT_N2 is negative and statistically significant showing that the utility attached to NOISE2 and NOISE3 is related to the corresponding level of technological innovation rather than to the barrier. HEIGHT is perceived as a severe source of aesthetic impoverishment, which is central to debates over the type of rail noise abatement measures to be preferred in Italy and Europe. All the rest fixed, the effect of a unit increment of the barrier's height on the probability to choose a policy is negative and priced at a range of minus 30 Euro per household for 2006.

Results from Model 3 provide an original contribution for improving the acceptance and realism of the payment vehicle. Model 3 tells us that the acceptance of a payment vehicle based on an indirect payment in the form of a tax-reallocation scheme is higher than that for a conventional tax scheme. The coefficient of PVTAX_P is in fact negative and statistically significant, resulting in a lower evaluation of those noise policies financed via the introduction of a new local tax by 37 percent – see Table 5. As in Bergstrom et al. (2004) in the field of ground water protection policies, the empirical results of our case study indicate that people in our sample were willing to pay more for noise reduction using a tax reallocation financing mechanism as compared to a special tax financing mechanism. In addition to Bergstrom *et al.* (2004), whose CV study does not specify the bundle of public services to be traded off for environmental goods, in our survey we used caution to describe them to the respondents and referred to two types of public services: public administration and public transport. The former and the latter one being perceived by the residents of the Province of Trento, respectively, as relatively important and very much important.

The coefficient for EXPOSURE_N2 and ANNOYANCE_P in Model 4 suggest that the individual pattern of noise perception is likely to influence the WTP for noise abatement in a predictable way. Individuals with a stronger perception of noise, which can derive from exposition to higher decibel levels or higher sensitivity to noise (resulting in higher annoyance) are more prone to pay to purchase noise abatement. This is an appealing result that confirms the importance of knowing as accurately as possible the respondents' profile according to noise perception, and of improving the methods for gathering such information.

7. Conclusions

We developed a framework for the valuation of several relevant features of rail noise policies using a CE approach. This approach allows us to understand the preferences of people exposed to rail noise for alternative noise abatement measures, which are expected to differ according to their acoustic efficiency, aesthetic, level of technical innovation and type of project financing.

The signs of major estimated coefficients are statistically significant and consistent with the theoretical predictions, including that respondents evaluate price increase negatively, while evaluating noise abatement positively. In addition, estimation results show that respondents strongly prefer a noise policy that relies on technological innovation rather than barriers. In particular the height of the noise barrier is perceived as a cost priced at about 30 Euro per household per unit increase.

In addition, we explore forma hypothesis testing so as to infer if and how the type of financing mechanism explains different level of willingness to pay for alternative noise reduction policies. In our sample people were willing to pay more for noise reduction using a tax reallocation financing mechanism rather than a special tax financing mechanism. Moreover, our empirical results suggest that the bundle of public services to be traded off for environmental goods needs to be specified as WTP varies according to it. We found that respondents were more willing to pay for noise policies financed by drawing resources from the budget normally used for public administration as compared to policies financed using a quota of resources usually allocated on public transport. Furthermore, we proceed with the econometric analysis of the population characteristics on the reported CE responses and thus on the valuation of the noise abatement program. Estimated results suggest that it is good practice to check for the valuation transmission mechanism caused by the individual noise exposure and annoyance.

Finally, and to conclude, estimation results show that if no policy action is undertaken so as to make additional investments in the train or railroad, and thus able to reduce aerodynamic noise, traction noise and vibrations, a significant welfare loss may result. An estimate of the total welfare loss ranges from 218,400 to 322,000 Euro. This value is obtained by: (1) assuming that the respondents that participated in the survey are representative for the entire population that live in the 100 meters strip along the Brennero railway; and (2) multiplying the sum of the noise abatement benefits, which is derived from the CE model and ranges from 156€ to 230€ by the total number of residents in that same strip line in the Brennero region, estimated at 1,400. However, the probability that a noise abatement project would be welfare improving for the community according to CBA or potential Pareto improvement criterion will depend positively on the premise that (a) the project was financed by a reallocation in public budget, (b) project would involve strong investment in the train and railway technology, and (c) respondents present a high sensitivity to noise exposure and annoyance.

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Table 1. List of the attributes used in the CE value application

1. Reduction of noise level and disturbance [decibel]:
    - Minus 9-11 decibel
      [As if the distance between your place and the railway would increase 10 times (e.g. from 100 meter to 1 kilometre)]
    - Minus 12-14 decibel
      [As if the distance between your place and the railway would increase 20 times (e.g. from 100 meter to 2 kilometre)]
    - Minus 14-15 decibel
      [As if the distance between your place and the railway would increase 30 times (e.g. from 100 meter to 3 kilometre)]

2. Height of noise barrier:
    - 4 to 6 meters
    - 6 to 8 meters

3. Height of noise barrier:
    - 4 to 6 meters
    - 6 to 8 meters

4. Barrier:
    - With vegetation
    - Without vegetation

5. Price of the program (Euro/household/$year_{2006}$):
    - 35 euro
    - 37.5 euro
    - 45 euro
    - 55 euro
    - 60 euro
    - 65 and 70 euro

6. Type of financing:
    - Reduction of 2006 provincial budget on public transport, without any additional tax
    - Reduction of 2006 provincial budget on administration and entertainment expenses, without any additional tax.
    - New provincial tax una tantum for the year 2006, without any reduction of provincial budget.

Table 2: Descriptive statistics for socio-demographic characteristics.

	Mean or percentage
Age	56.3
Over sixty-five	31%
Female	49%
Household size	2.39
Has child below 12 years of age	16%
Years of schooling (>13)	51%
Since when lives in the vicinity of the railway (years)	23.00
Owns the place where she/he lives	72%
Has garden or terrace	84%
Cares about health issues	98%
Cares about environmental issues	94%
Fairly, very much or extremely informed on rail noise before the survey	77%
Uses the Brennero railway for work	7%
Uses the Brennero railway for tourism or other than work	38%
Household monthly income (Euro)	1742.5

Table 3: Descriptive statistics of noise sensitivity scores, noise perception annoyance and exposure questions.

	Mean or percentage
▪ *Noise sensitivity*	
If I should buy or rent a house, I would avoid the proximity to busy streets, nightclubs or restaurants	5.48
Some times noise makes me nervous	4.12
If noisy while studying or working I shut the door or move in another room	4.70
▪ *Rail noise perception*	
Rail noise is 'more' or 'equally' important than traffic noise	72%
Rail noise is 'more' or 'equally' important than air pollution	47%
Rail noise is 'more' or 'equally' important than biodiversity depletion	71%
Rail noise is 'more' or 'equally' important that electromagnetic pollution	65%
▪ *Rail noise annoyance*	
Annoyed by noise during the day	85%
'Very much' or 'extremely' annoyed during the day	42%
Annoyed by noise during the night	74%
'Very much' or 'extremely' annoyed during the night	50%
Did think to move because of rail noise	25%
Disturbed by rail noise when using garden or terrace	65%
Can not rest quietly during the day	15%
Weak up easily during the night	39%
Gets nervous	14%
Can talk with relatives or listen to radio and TVs	56%
▪ *Noise and vibrations*	
Only noise disturbs me	25%
Only vibrations disturb me	1%
Noise and vibrations disturbs me equally	29%
Both noise and vibrations disturb me, but more noise than vibrations	31%
Both noise and vibrations disturb me, but more vibrations than noise	14%
▪ *Noise exposure*	
Building with direct exposition on the railway	53%
Hours spent home during the week	6.7
Hours spent home during the week-end	8.2
Thermal or sound insulation systems installed	93%

Table 4: Estimated coefficients (Model 1 - Model 6).

	Model 1	*Model 2*[a]	*Model 3*	*Model 4*	*Model 5*	*Model 6*
PRICE	-0.016*** (0.006)	-0.013* (0.008)	-0.012*** (0.006)	-0.082*** (0.011)	-0.136*** (0.015)	-0.135*** (0.015)
NOISE2	2.493*** (0.383)	3.043*** (0.515)	2.674*** (0.388)	2.140*** (0.429)	1.524*** (0.454)	1.432*** (0.541)
NOISE3	0.521*** (0.196)	0.404* (0.243)	0.536*** (0.197)	0.750*** (0.222)	0.755*** (0.230)	0.655*** (0.258)
N2_HEIGHT	-0.314*** (0.057)	-0.398*** (0.074)	-0.337*** (0.058)	-0.281*** (0.064)	-0.278*** (0.066)	-0.282*** (0.066)
P_PVADM		0.0004 (0.012)				
PVADM		0.134 (0.626)				
P_PVTAX			-0.007*** (0.002)			
N2_EXPOSURE				0.344*** (0.119)	0.212* (0.122)	0.216* (0.123)
P_ANNOYANCE				0.020*** (0.003)	0.020*** (0.003)	0.020*** (0.003)
N2_INCOME					0.0004*** (0.737^{-04})	0.0004*** (0.738^{-04})
P_EDUCATION					0.014*** (0.002)	0.014*** (0.002)
N3_GENDER						0.164 (0.244)
N2_ENVIRONMENT						0.114 (0.312)
SAMPLE	1905	1432	1905	1615	1614	1610

Notes: Significance is indicated by ***, ** and * for the 1, 5, and 10 per cent level, respectively, with standard error in parentheses.
[a] Model 2 considers the sample of questions with a tax-reallocation payment vehicle, either on public transport or administration budget.
EXPOSURE_N2, INCOME_N2, ENVIRONMENT_N2 are cross terms with NOISE2. GENDER_N3, PVADM_P, PVTAX_P, EDUCATION_P are cross terms with NOISE3 and PRICE, respectively.

Table 5: Willingness to pay estimates (Model 1- Model 3).

WTP	*Model 1* *(pooled)*	*Model 2*[a] *Administration*	*Model 2*[b] *Public transport*	*Model 3*[c] *Tax*
NOISE2	156	230	223	139
NOISE3	33	31	30	28
HEIGHT_N2	-20	-30	-29	-18

Notes: Willingness-to-pay is expressed in Euro per household for the year 2006.
[a] WTP estimates from Model 2 given a tax reallocation on the budget for administration and entertainment expenses.
[b] WTP estimates from Model 2 given a tax reallocation on the budget for public transport.
[c] WTP estimates from Model 3 given the introduction of a new local tax.

	Do you ear the train?	*Does the rail noise disturb you?*
	Yes ☐	Not at all ☐
	No ☐	Slightly ☐
		Moderately ☐
		Very much ☐
		Extremely ☐

Figure 1: Question on the level of noise annoyance

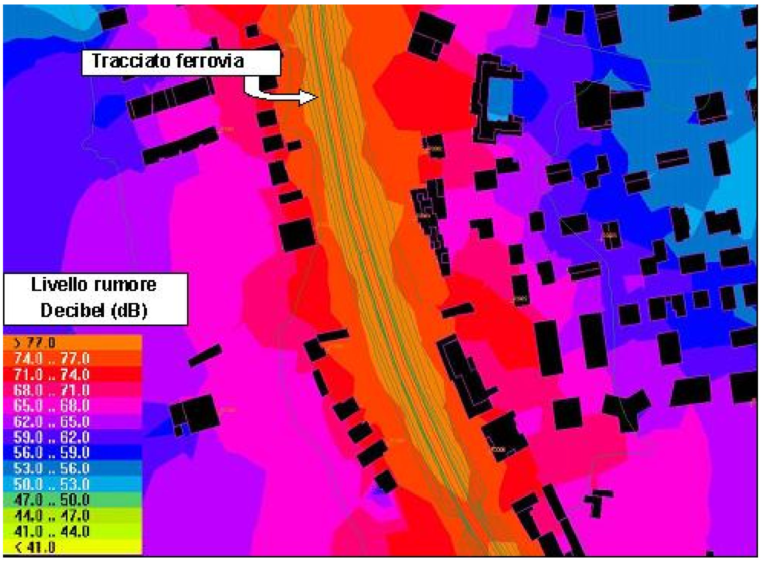

Figure 2: Acoustic map showing the relation between noise level and distance from the railway

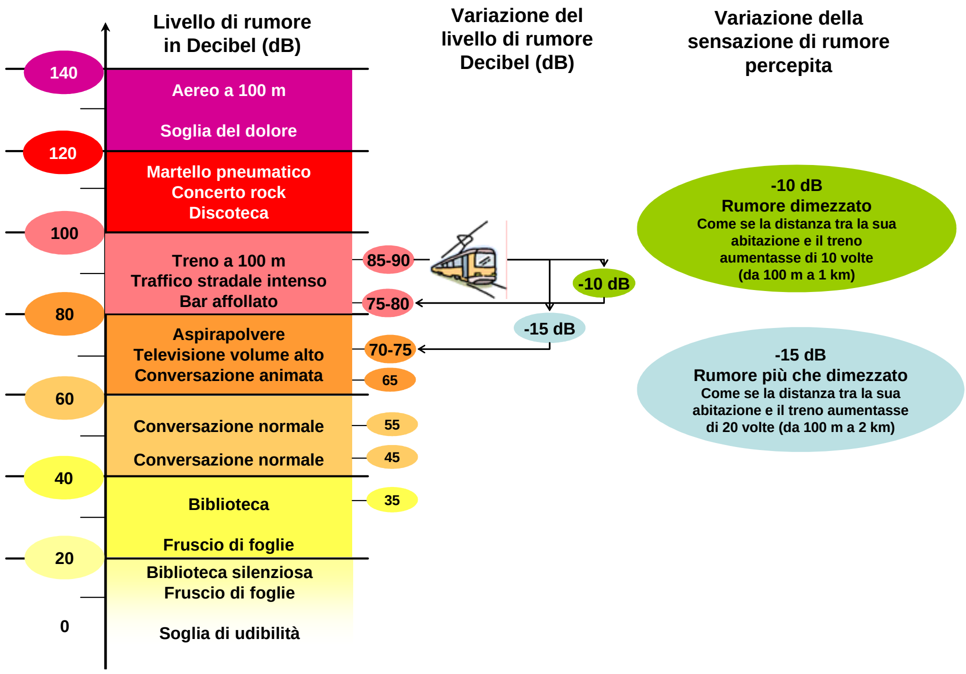

Figure 3: Noise barometer with examples of noise levels pertaining to different day life situations and examples of various noise reduction levels.

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