Analysis of the Willingness to Pay to Reduce Environmental Impacts from Road Transportation: A Case Study from the Spanish Pyrenees

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Resumen:

El transporte por carretera es considerado generalmente como una de las mayores fuentes de externalidades a nivel global. Este artículo, haciendo uso de los resultados de una encuesta ad-hoc a la población residente en núcleos cercanos a las vías pirenaicas de Navarra, España, analiza la disposición a pagar por reducir las dos principales externalidades atribuidas al transporte terrestre: ruido y contaminación del aire. Así, las características de este trabajo son el estudio económico de dichas externalidades, su relación con el nivel físico real de contaminación y la comparación de núcleos rurales y urbanos. Se han usado modelos de probabilidad (Probit y Logit), así como el modelo Spike, observando diferencias significativas entre las valoraciones de ambas externalidades. También se ha detectado una relación entre las medidas realizadas de ruido y aire y la valoración hecha por los residentes.

Abstract:

Road transportation is known to be one of the major sources of externalities worldwide. This paper uses an ad-hoc survey of people living near the roads crossing the Spanish Pyrenees in Navarre, Spain to analyze their the willingness to pay for the reduction of the two main externalities attributed to road transportation: noise and pollution. Thus, the main traits which characterize this paper are the economic study of those externalities (noise and pollution), their relationship to the physical level of real contamination and their applications in rural and urban environments. Probability models (Probit and Logit) and Spike models have been estimated, observing significant differences in valuation among both environmental problems. Close relationships have been also observed between physical pollution and noise with the economic valuation of residents.

Keywords: Air Quality; Contingent Valuation Method; Health; Noise; Road Transportation; Spike Model; Willingness to Pay.
JEL: I18, Q51, Q53, R42

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1. Introduction

Due to its outstanding growth in recent decades, transportation has become a strategic sector of the economy and a major contributor to social and economic progress. Road transportation in particular has increased most significantly, sometimes showing exponential growth patterns. Transport also has negative effects, such as noise, air pollution, and congestion, which have hardly been taken into account in planning strategies. The need to consider these external costs or externalities is nevertheless urgent to ensure simultaneous sustainability of the transport sector and economic growth (Sinha and Labi, 2007) given that the transport sector accounted for more than a quarter of world energy consumption in 2004 (International Energy Agency, 2006). Various studies have tried to quantify the economic impact of these externalities in Europe. According to INFRAS/IWW (2004), external costs from transportation in 2000 reached almost 8.5% and 9.5% of GDP in the European Union and Spain respectively. Road transportation is responsible for nearly 91% of the external costs from transport in Europe (INFRAS/IWW, 2000) and we agree with the view that this activity generates major environmental externalities (Bell *et al.*, 2006, Saz, 2004, Hoyos, 2004 and Matus *et al.*, 2008). Concerns have focused on road transport as the primary mode of freight movement and the largest source of freight-related CO_2 emissions in developed countries (Intergovernmental Panel on Climate Change, 2007).

Nowadays, there is general agreement regarding the need to internalize these negative externalities, by treating them as a priority when formulating infrastructure policy and logistics strategy. The European Union, for example, has developed an infrastructure use taxation system (DIRECTIVES 1999/62/EC and 2006/38/EC, “Eurovignette”) based on the “user and polluter pays” principle (European Commission, 1999, 2006). In some exceptional cases involving infrastructure in mountainous regions, the directives suggest the possibility of adding a mark-up to toll charges. The directive in question emphasizes that “particular attention should be devoted to mountainous regions such as the Alps or the Pyrenees” (European Commission, 2006). Economic valuation of transport related to external impacts is absolutely essential to the success of the normative proposals.

Hence, we can conclude that there are two main traffic related environmental impacts: air pollution effects (Sinha and Labi, 2007) and noise effects (Navrud, 2002). The main purpose of Navrud’s (2002) report is the economic assessment of both these environmental problems (pollution and noise) using contingent valuation in a European area with high levels of contamination. The conjoint analysis of both effects facilitates the design of suitable environmental policies. The aim of this paper is to calculate the willingness to pay (WTP) of residents in an area bordering the Pyrenees in Navarre (Spain), for a reduction in traffic noise and air pollution from transportation. With this goal in mind, we selected the five most important roads crossing the Pyrenees in Navarre, along with the 14 localities through which they pass. Based on that selection, we surveyed 900 adult residents of the localities in question.

One of the main innovative features of our work is the simultaneous analysis of both the externalities described in the previous paragraph. Some authors who have performed similar analyses include Kondo *et al.*, (2003), Wardman and Bristow (2004) and Rehdanz and Maddison (2008). Another feature of this work is the analysis by zones, depending on road transport impact levels. The purpose of these divisions is to compare the economic valuations of the different perceived nuisance levels and the policy actions designed to address them.

Another novel contribution of this paper is its assessment of the relationship between the current levels of noise and air pollution in the study area. The combined use of economic and technical tools in environmental impact valuation studies is not common, due to the difficulties it involves. Previous studies that have used physical measurements include Lambert *et al* (2001), Andersson *et al*. (2009) on noise and Wardman and Bristol (2004) on air pollution and noise. Similarly, Barreiro *et al*. (2005) and Martín *et al*. (2006) taking the available noise maps of their cities, proved a strong relationship between current noise and economic valuations.

Finally, another notable and differentiating aspect of our work is its geographic scope, which is predominantly rural. Hitherto, the research has focused mainly on large cities (Bell *et al*. 2006, Wang *et al*. 2006, Yoo and Chae 2001, Karimzadegan *et al*. 2008 or Marmolejo and Frizzera 2008), and medium-size cities (Barreiro *et al*., 2005; Martín *et al*., 2006, Andersson et al., 2009). In those areas, pollution is a major source of nuisance for the population and its reduction is considered a priority. Our study focuses on small and medium-size localities in the Western Pyrenees where, pollution appears to cause less concern than in big cities. Nevertheless, the fact that the roads under consideration are the natural paths across the Pyrenees, they commonly suffer the effects of road transportation externalities. The Pyrenees also form a natural boundary between Spain and the rest of

Europe, and more than 150,000 vehicles, almost 30% of which are heavy goods vehicles, cross the Pyrenees daily (Observatorio Hispano-Francés de Tráfico en los Pirineos, 2008).

This article is organized into five main sections. Following this introduction (section 1), section 2 describes and justifies the choice of study area. Section 3 explains pollution measurement methods. Section 4 focuses on the methodological aspects of the contingent valuation survey design. Section 5 presents the main results and outcomes of the paper. Finally, the conclusions section describes the paper's limitations and suggests potential avenues for future research.

2. Geographical Scope

The geographical scope of our study is the Pyrenees, which is a natural boundary between Spain and France. It is a region with very high density road transportation, the busiest routes being those located close to the mountains in the regions of Catalonia (La Junquera), the Basque Country and Navarre (Irún-Behovia), which cut through areas of great ecological value. These crossing points suffer a high environmental impact and level of road traffic nuisance. Our study focuses on the main international routes crossing the Pyrenees in Navarre, whose geographic location makes it a strategic region. Thus, five main routes are considered, all of them beginning in Pamplona (the capital of Navarre) and ending in France as shown in Figure 1. These routes, which pass through various towns and villages, vary in characteristics from heavy traffic highways to less busy main national routes.

Following the selection of roads, the next step was to select the localities for the noise and air pollution survey. We began by designating a 400-meter-wide buffer zone or influence area on each side of the road, from which to select affected locations. Localities were then selected according to the following criteria: a) their representativeness as towns/villages that the selected roads transect or pass in close proximity, in order to study different situations, b) number of residents, making a distinction between rural and semi-urban areas and c) other factors, such as village morphology and land uses. The final selection comprised 14 localities distributed almost equally between the five routes, as can be seen in Figure 1.

(INSERT HERE FIGURE 1).

3. Pollution Measurements

Next, we carried out some noise measurements and air pollution estimations in the selected routes and localities using the Decibel Trait and the DISPER 4.0 software (2004) (www.canarina.es) in order to determine the levels of road transportation noise and pollution nuisance suffered across the various zones. Despite the important technical measurement and estimation issues associated to the chosen methodology, it is not our intention to include all the details in this paper. Thus, the most relevant information concerning the measurement and estimation procedures is given in Table 1.

(INSERT HERE TABLE 1)

These measurements and estimations allowed us to obtain two different nuisance zones per locality. Thus, taking the road as the origin, two parallel strips were defined on each side of the road. The inner strip, and therefore that more heavily affected by noise and air pollution, was labeled zone A, and the less affected outer strip was labeled zone B. The main characteristics of both zones are shown in Table 2.

(INSERT HERE TABLE 2)

The final step in this study was to assess the current level of noise and air pollution suffered by each respondent, measured in decibels (dB) and µg/m3 of $NO_{X,}$ respectively. It should be noted that this assessment was performed after the survey, since it required the survey point data thus obtained. Interviewees were located on a GIS (Geographic Information System) based on their postal address, with the aid of a WMS service (Web Map Service offering cadastral data provided by IDENA (2009)) which enabled us to determine the distance of each respondent’s home from the road. By constructing a map of the different roads, including a raster layer and distance data, we were able to perform all the location tasks involved in the study. Thus, by linking noise measurements and distance data, we were able to determine the noise level suffered by each respondent. We used formulas (3.1) and (3.2), given below, to estimate the decibel values affecting each survey point.

$$L_{eq} = L + 10 \cdot \log_{10}\left(d_0 / d\right) \qquad (3.1)$$

$$L_{eq} = L + 20 \cdot \log_{10}\left(d_0 / d\right) \qquad (3.2)$$

where L_{eq} is the continuous level of noise to be estimated, L the level of noise at a specific point (where measurements are taken), d_0 the measurement distance from the road and d the distance from the road to respondent's house. These formulas were developed by Sinha and Labi (2007). Nevertheless, different formulas were used depending on the type of noise being considered. Formula (3.1) was used for villages with traffic flows of less than 3,000 vehicles per day where noise is considered as a point source. When working with villages with traffic flows of more than 3,000 vehicles, we used formula (3.2), where noise is considered as a linear variable.

In the case of air pollution, DISPER 4.0 software enabled us to obtain both dispersion and concentrations data for each point which were then superimposed on the survey points, to obtain the level of air pollution affecting to each respondent.

4. Contingent Valuation Survey Design

As stated in the previous section, the contingent valuation method (CVM) was chosen to measure the impact of road transportation externalities from roads through Pyrenees. The main reason for our choice is that the hedonic pricing method, another well-known procedure for measuring environmental impacts, undervalues some benefits by ignoring, among other variables, the welfare increase of the affected population (Barreiro *et al*, 2005). There is a series of noteworthy papers on air quality measurement using the hedonic price method (Kim *et al*., 1998, Kawamura and Mahajan, 2005, Martin *et al*., 2006, Rehdanz and Maddison, 2008, Andersson et al., 2009), contingent valuation (Alberini and Chiabai, 2007, Delucchi *et al*., 2002, Saz, 2004, Durán and Vázquez., 2008, Dziegielewska and Mendelsohn, 2005, Hammitt and Zhou, 2006, and Wang *et al*., 2006), the Bayesian method due to Vázquez *et al*., (2006) and recently, a combination of the contingent valuation methodologies and choice experiment methodologies (García *et al*., 2008, Tuan and Navrud, 2007). Similar valuation procedures have been used in relation to noise, principally contingent valuation (Barreiro *et al*., 2005, Marmolejo and Frizzera, 2008 and Navrud, 2002), and a combination of contingent valuation and hedonic pricing (Bjørner *et al*., 2003) and other alternative methodologies (Martín *et al*., 2006).

4.1.Questionnaire Analysis

In the design of the survey questionnaire, we followed the recommendations proposed by the NOAA panel by Arrow *et al*. (1993) or Vázquez *et al*. (2006) who indicated that a longer-than-usual questionnaire was required to present the environmental problem to the respondents. This, together with the fact that our survey involved the valuation of two types of improvement, led us to choose the personal interview as the most suitable data collection method.

Hence, the questionnaire, which was designed to obtain a monetary valuation of the reduction of these externalities, was subdivided in three main sections. Responding to Vazquez's (2002) recommendation, it was important to include a relatively extensive introduction to ensure that respondents understood the problem under consideration. Given that we were valuing two different externalities, noise and air pollution, and that one of our aims was to compare the results obtained for each valuation; we opted to describe those externalities to respondents, so that they might appreciate the diverse issues involved. In the first section of the questionnaire, respondents were asked their opinion on the main sources of noise and air pollution in their area (Martín *et al*., 2006), the area's environmental status (Lambert *et al*., 2001; Aprahamian *et al*., 2007), level of nuisance in the last 12 months (ISO/TS 15666, 2003) and health problems affecting respondents or their families arising from these externalities. Some of these introductory questions were of the structure proposed by the ISO/TS 15666 (2003) where respondents have to give ratings on a scale of 1 to 5, make the results comparable with those of other studies.

The second section of the questionnaire described the contingent valuation process. First, we used a dichotomous choice question designed to elicit the willingness to pay (WTP), where respondents were asked whether or not they were willing to pay a given sum. They were furthermore reminded that payment would imply a reduction in their household budget and thus limit other expending (Dziegielewska and Mendelsohn, 2005). An open-ended question was also included to elicit respondents' maximum WTP. This is the format suggested by NOAA panel (Arrow *et al*., 1993) as the most desirable way to elicit WTP because respondents have only to decide for or against that payment, thus mimicking every-day decisions. The open-ended format is sometimes viewed as a difficult task that might increase the number of negative responses. Usually, this type of questionnaires present a non-negligible number of "protest zeros", the term used for zero responses resulting from respondents' objection to the process being used to assign a cost to the measures proposed in a survey.

4.2.Methodological Aspects of the Survey

Therefore, to distinguish protest zeros from real zeros, a close-ended follow-up question was included for respondents who had given a negative response to the dichotomous choice question and had declared a zero value in the open-ended question. Protest responses were identified as those where respondents express opposition to the proposed scenario, that is, they either feel no responsibility for noise and air pollution, find the reduction insufficient or think they already pay enough taxes (Dziegielewska and Mendelsohn, 2005; Ovaskainen and Kniivilä, 2005).

For the noise reduction scenarios, the survey design contemplates one reduction in zone B and two reductions in zone A, thanks to the higher initial level of noise. Reductions are proposed both in terms of the number of decibels abated and in percentage terms. Therefore, only a 20% abatement, from 60 to 50 dB, was suggested in the outer zone and the sample in the inner zone was divided into 20% and 40% reductions, from an initial 70 to 60 and 50 decibels, respectively. Given the well known difficulty of reducing noise levels up to 50 decibels, we established that value as our abatement limit. It was in any case necessary to propose a high enough reduction for respondents to perceive a change from the initial situation.

Thus, we were able to assess the potential impact of WTP on the initial level of noise endured by respondents and the impact of the proposed reduction. One would expect that a higher level of noise and a higher noise reduction impact might lead to higher WTP among the interviewees. A relevant and novel feature of our study was that, before respondents were told the survey scenarios, they were asked to listen to a recorded noise sample based on actual measures, very close to the noise level affecting their dwellings. Once the scenarios were presented, respondents were asked to listen to a second noise sample and an additional track simulating the proposed abatement after application of the intended policy measure. We also proposed two different air pollution reductions based on estimations of initial levels using computer models. Thus, the pollution abatement proposals were for 25% or 50% reductions from their initial values in zones A and B.

Furthermore, aware of the disagreement in the literature concerning the direct effects of air pollutants (Carlsson and Johansson-Stenman, 2000; Dziegielewska and Mendelsohn, 2005), we decided to propose air quality improvement as an increase in public welfare, where the affected population would obtain two different levels of health gain. Kahneman and Knetsch (1992) modeled the health impact as a global problem in order to increase the percentage of positive WTP responses arising from the sense of “moral satisfaction” or “altruistic behavior” respondents get from contributing to the general welfare. Hence, respondents were asked to contribute to reduce, first, the number of people mildly affected by air pollution and then the number severely affected. The mildly affected were described as the population suffering from coughing, irritation of the eyes and respiratory problems that might trigger an allergic response. With about 160,000 people in Navarre considered to be affected by such ailments, according to the Spanish Society of Allergology and Clinical Immunology (2009) a 25% (50%) reduction in air pollution would benefit 40,000 (80,000) people. The severely affected were described as the population suffering from violent coughing or acute respiratory failure that might lead to asthma or pneumonia. According to the Navarre Allergic and Asthmatic Association (2009) around 60,000 people in Navarre show severe symptoms and proposed reductions of around 25% (50%) would benefit 15,000 (30,000) people. Methodologically speaking, this procedure is similar to Dziegielewska and Mendelsohn’s (2005) technique. Thus, the prior expectation was for higher WTP for the 50% reduction in severely affected people, and similar results for the noise study.

Another major issue in WTP questionnaire design is the choice of starting bid, which respondents use as a reference for their replies. The fact that they are valuing non-market goods without being used to it strongly determines the results. This so-called “anchoring effect” has been studied by Aprahamian *et al*. (2007) and Rozan (2004) among others. The starting bid levels were therefore carefully chosen, taking into account the results obtained in similar projects using contingent valuation methods (CVM). These methods are cited in Table 3. Lambert *et al*. (2001) and Wardman and Bristow (2004) propose higher amounts than other authors, possibly influenced by their survey location or elicitation procedure. Taking other studies into consideration, we constructed three equal subsamples with starting bids set at €15, €30 and €45, enabling us to analyze whether a higher bid price reduces the proportion of people willing to pay to reduce the impact of transport externalities. The payment vehicle was a compulsory annual tax for the next five years on the entire Navarre population, such that not only the affected population, but all residents of Navarre would contribute to the abatement.

(INSERT HERE TABLE 3)

To summarize, the alternative scenarios for noise and air pollution reductions, and the different bid prices are shown in Table 4. Twelve different types of questionnaire were finally obtained and randomly tested on the study population, stratified by locality size. The survey of to 900 residents of the mentioned localities situated on or near the border highways was conducted between February and March in 2009 The sampling error was 3.1% and the confidence level 95%.

(INSERT HERE TABLE 4)

To complete the discussion of the methodological aspects, at the end of the questionnaire, respondents were asked whether they had carried out any home alterations and, if so, why, to determine whether their reasons were connected with noise or air pollution (Wardman and Bristow, 2004; Bjørner *et al*., 2003; Barrigón, 2002; Barreiro *et al*., 2006 and Martin et al., 2006). A pro-environmental attitudes question was included using the scale proposed by Castanedo (1995), to allow us to assess respondents' interest in the pollution issue, their views on Government intervention and their attitude towards solving the problem. Finally, socio-economic data on the respondents, including gender, age, level of education, household size including number of members in each group, labor situation and income were also collected. These variables generally reveal the reasons for differences in valuation between groups of respondents by determining their WTP level in the valuation process (Wang *et al*., 2006; Rehdanz and Maddison, 2008; Tuan and Navrud, 2007).

5. Discussion of Results

5.1.General Results

In the valuation of a non-market commodity, individuals who decide to pay for nuisance abatement are considered to form part of the commodity market considered (Casado *et al*., 2004). The most widely used distributions in the contingent valuation of WTP assume that all respondents will give a positive WTP value (Hanemann, 1984). However, zero responses may also arise from the fact that the commodity offers no utility to the respondent. Table 5 shows the number of respondents stating a zero WTP value per valuation and bid level for the whole sample, with high rates of negative answers in all cases.

(INSERT HERE TABLE 5)

These results led us to use a spike model proposed by Kriström (1997) where some of the zero responses are included in the analysis. Other studies faced with the same problem have used a spike model to estimate WTP (Casado *et al.*, 2004; García de la Fuente *et al.*, 2009; Hanley *et al.*, 2009). Based on the classification described in the previous section, protest responses were removed from the analysis and only real zeros were incorporated, where the spike model assigned them a probability different from zero. Two variables need to be defined to apply the spike model (Kriström, 1997). It is necessary, first, to establish whether or not the respondent is part of the commodity market (E_i), and, second, to construct a variable to show whether his/her WTP is higher than the proposed bid (D_i), where A is the bid, as follows:

$$E_i = \begin{cases} 1 & if \ WTP > 0 \\ 0 & otherwise \end{cases} \qquad (5.1)$$

$$D_i = \begin{cases} 1 & if \ WTP > A \\ 0 & otherwise \end{cases} \qquad (5.2)$$

Moreover, the maximum likelihood is defined in (5.3) using the NLOGIT 4.0 econometric software package. Mean WTP (5.4) and the spike value (5.5), respectively, are estimated as follows, where α is the marginal utility of the reduction in pollution and β the marginal utility of the income. The spike is defined as the value where WTP probability is equal to zero.

$$l = \sum_{1}^{N} E_i D_i \ln\left[1 - F_{DAP}(A)\right] + E_i (1 - D_i) \ln\left[F_{DAP}(A) - F_{DAP}(0)\right] + (1 - E_i) \ln\left[F_{DAP}(0)\right] \qquad (5.3)$$

$$mean = \frac{1}{\beta} \ln[1 + e^{\alpha}] \qquad (5.4)$$

$$spike = \frac{1}{1 + e^{\alpha}} \qquad (5.5)$$

Table 6 shows the results when the spike model is applied to the whole sample and, despite the fact that the model tries to exclude the protest zeros, the whole sample is taken in this first analysis for purposes of comparison. The spike value explains the probability of WTP being equal to zero. In our case, that probability is almost 70% for noise and slightly lower (65%) for air pollution, taking into consideration the mildly and severely affected populations. Thus, a zero response is more likely if we have obtained high valuations for noise reductions. These values are very similar to those obtained in Table 5. As expected, the results after protest responses have been removed, show that the probability of WTP being equal to zero decreases and mean WTP increases in all cases. When only positive and real zero responses are taken into account, spike values are 42% for noise abatement and slightly lower (around 38%) for the reduction in the number of people affected by air pollution. Mean WTP suggests a similar interpretation, that is, a reduction in the population affected by air pollution provokes a higher WTP value than noise reductions; and a reduction in the population severely affected by air pollution is more highly valued than a reduction in those mildly affected, as expected previously.

Considering the results without protest zeros, we obtain a mean WTP of €8.22 for noise and €9.31 and €9.56 for a reduction in the mildly and severely affected populations, respectively. Mean WTP for noise is quite similar to that obtained in Martin *et al*. (2006), shown in Table 3, but notably lower than in other studies. For air pollution, the reviewed articles given in Table 3 show payments between €5 and €10 higher. Several reasons could be suggested to explain these differences. The region of Navarre, where the study was conducted, is third last among the Spanish regions in public concern for environmental issues and only the 3.4% of the population has volunteered in environmental activities. Similarly, only 6.6% of Navarre households are affected by noise, versus the Spanish average of 11.7% (Spanish National Statistics Institute, 2009). Another interesting exercise would be to compare environmental impact studies of rural habitats with those of urban habitats, and different valuation methods (Bergmann et al., 2008, Rambolinaza and Dachary-Bernard, 2007, and Sayadi et al., 2009). Such studies might shed some light on the imbalance between environmental studies arising from the rural –urban dichotomy. In our analysis, lower values about people's commitments with environmental issues might be expected because we analyze rural and semi-urban areas.

Mean WTP for noise abatement is at any rate considerably lower than for air quality improvement. With respect to methodological differences, Wardman and Bristow (2005) also show how variations in air quality rank higher than variations in noise. The severely affected population, described as people showing the most severe symptoms, elicits a higher WTP than expected beforehand and comparable to the results reported in Dziegielewska and Mendelsohn (2005), Navrud (2001) or Vázquez (2002), where severe symptoms usually suggest higher payments.

The model parameters α (marginal utility of reductions) and β (marginal utility of income) also show important results (Table 6). For the whole sample, a negative value for α is found in all cases, showing the lack of utility of many extra environmental improvements. It is higher, in absolute terms, for noise reduction, which means that additional noise abatements have less utility for interviewees than reductions in air pollution . After ignoring protest zeros, the α parameter becomes positive, showing that noise and air pollution reductions are highly appreciated and evidencing that protest responses distort the results. In all cases, the marginal utility of income is highly significant and positive, which is a necessary condition for the appropriate definition of mean WTP (Kriström, 1997), revealing the anchoring effect mentioned previously. In all cases, the model is highly significant, with the likelihood ratio tests indicating a probability value of 0.00.

(INSERT HERE TABLE 6)

Cost-benefit analysis is widely used to assess the benefit of a social welfare gain. The current DIRECTIVE 2002/49/EC on Environmental Noise (European Commission, 2002: L189/16) states: “The reduction of harmful effects and the cost-effectiveness ratio shall be the main criteria for the selection of the strategies and measures proposed”. In our study, social benefit is estimated as the transportation which is related to nuisance abatement, where cost is the public investment needed to obtain it, and policy measures are only implemented if the social benefit exceeds the cost. Since there are notable differences between the propagation of noise and that of air pollution, we estimated the social benefits in two different geographical scopes. For noise, we used the set of villages located on or near the roads and highways considered in the study (Saz, 2004). We estimated population density by superimposing the map of population centres in the Geographic Information System (GIS) on to each road with a 300 m. wide buffer zone. This gave an approximate estimate of 15,000 people affected by noise. To assess air pollution effects, and knowing that the propagation of air pollution is greater than that of noise, the whole of the rural population was considered, giving an estimate of around 125,000 (more than 20% of the Navarre population). Table 7 shows an approximation of the social benefits per externality abatement, with the risk of underestimation or overestimation falling within reasonable limits in the zone of interest.

(INSERT HERE TABLE 7)

To conclude our overall findings, another important issue in contingent valuation surveys is strategic behaviour by respondents. Mitchell and Carson (1989) suggest that by a comparing the stated WTP distribution with a normal distribution, it is possible to detect a strategic behaviour. Strategic responses try to influence the mean WTP either increasing or decreasing it. The, if we are facing strategic behaviour, the distribution would follow a bimodal distribution, with most respondents reporting very high or very low WTP values (Saz *et al*., 1999). Figure 2 shows the stated WTP distribution per valuation in our study, after removing protest responses (only real zeros included). As can be seen, we find no strategic behaviour that might lead to a higher mean WTP, because there is no significant number of respondents declaring a price likely to increase it. On the other hand, we find that a large group of respondents declare a zero WTP value, but we consider them all real zeros and not a result of strategic behaviour, because the respondents in question declared themselves either unaffected by pollution or unable to afford to pay for such an externality. This result also corroborates the previously mentioned anchoring effect, reflected in the large clusters around the starting bids. High correlations are also found in valuations of more than 70% and up to 97% for the mildly and the severely affected population.

(INSERT FIGURE 2)

5.2.Impact of Nuisance Level and Proposed Reduction

Our aim in this section is to compare the results obtained not only across the three different valuations but also across respondents exposed to different nuisance levels and across different for noise or air pollution reduction proposals. The prior expectation is that people exposed to higher levels of noise or air pollution will be willing to pay higher sums to reduce such externalities. Similarly, those more strongly in favour of reducing the nuisance should also be willing to pay more.

Table 8 gives the results of the estimated spike models per valuation for zones A and B and the different reductions proposed. Starting with the spike value, we can see how the probability of WTP equal to zero is lower in zone A for all three valuations, although the differences are not very great, (40, 37 and 37% versus 46, 39 and 41%). This suggests that people exposed to higher levels of pollution are more willing to pay to reduce it. Mean WTP behaves in a similar fashion, since it has a smaller value in zone B, where the pollution level is lower, in all three cases. Wardman and Bristow (2004) also find that people are prepared to pay more for a proportionate improvement in noise and air quality when applied to poor or very poor current conditions.

Analysis of the different reductions proposed reveals large differences. As expected, higher abatements are associated with a greater number of people willing to pay and a higher mean WTP value, as found in Dziegielewska and Mendelsohn (2005) and Kondo et al. (2003). Remarkable differences in terms of size are also found across types of reduction and, in relation to noise, the differences between higher and lower reductions are particularly relevant. Mean WTP for the higher reduction is double that for the lower reduction, although this may be due to procedural issues. Before being asked to give their valuations, respondents had listened to a track comparing the noise level before and after the proposed reduction, which may have left them more sensitive to noise abatement than to air quality improvement. It is true, for the case of air pollution, that the differences between the higher and lower measurements are also generally significant, although having less importance than in the noise case.

The marginal utility of pollution reductions is always positive both for zones A and B and higher and lower reductions, meaning that a reduction in the level of noise or in the number of affected people is always positively valued. Of the two zones, this utility is higher in zone A, where exposure is greater (0.3, 0.5 and 0.5 versus 0.1, 0.4 and 0.3). Additionally, reductions in the number of people affected by air pollution seem to offer more utility than noise reductions, since these values are higher, and the differences between zones are slightly smaller. Thus, a general improvement in air quality for the population as a whole is more highly valued than an improvement in a respondent’s personal noise exposure level, confirming the evidence presented by Wardman and Bristow (2005). This result might be interpreted as altruism by respondents, when a social gain suggests a utility increase (Kahneman and Knetsch, 1992). Comparing types of reduction, the utility is higher for higher proposed abatement levels, the differences being greater in the case of noise abatement. In Table 8, differences between reductions in the mildly and severely affected populations are not significant enough to be worth mentioning. The marginal utility of income is always significant showing again how strongly it influences respondents' WTP values. Both the bid parameters and the model parameters are always highly significant.

(INSERT HERE TABLE 8)

Since both zone and level of reduction are significant to explain WTP, by comparing Table 9 and the higher reduction in Table 8, it is possible to verify the most relevant factor. Table 9 shows the spike model for zone A and a lower reduction and the upper rows of Table 8 show the results for zone A and a higher reduction. Therefore, we can compare two different reductions for the same zone. As we can see, there are significant differences among respondents in zone A based on the level of pollution abatement proposed. For example, people living in zone A are willing to pay 2.3 times more (€ 5.504 compared to € 12.781) for a 40% reduction than for a 20% reduction in noise. In the case of air pollution, when a 50% reduction is proposed, people are willing to pay 1.5 times more than for a 25% reduction. We can therefore conclude that respondents' WTP is more influenced by the proposed reduction in the nuisance than by the level of exposure.

(INSERT HERE TABLE 9)

5.3.Real Annoyance Influence Analysis with Logit and Probit

Using computer estimations of noise levels and pollutant concentrations, we constructed Logit and Probit models to evaluate the influence of the current level of pollution. Some authors have already conducted research in this respect. For example, in Barreiro *et al*. (2005) and Martín *et al*. (2006), when real noise levels of surveyed areas are added into the analysis, a strong relationship is found between noise nuisance levels and economic valuations. The chosen variable in the noise case was dB and, although DISPER software enabled us to obtain three different pollutants, only NO_X (measured in $\mu g/m^3$), i.e., the main pollutant produced by road traffic and also the main regulated air pollutant, was used in the air pollution case. Table 10 shows the results of these analyses ignoring zero responses. The dependent variable is a binary variable, where 1 is assigned to respondents who are willing to pay a positive sum and 0 otherwise. For instance, for an interviewee who rejects the € 30 bid but is willing to pay € 10, the variable is assigned a value of 1.

(INSERT TABLE 10)

Table 10 shows a noteworthy result, which is that, when the bid price and the actual nuisance are analyzed together, the bid takes a non-significant value in all cases. For the number of people severely affected by noise, it is negative, as expected, but, for the number mildly affected, it takes a positive value. However, the real variable, both decibel and NO_X, is positive and significant in all three valuations. Despite being very small for the case of air pollution, it shows how the greater the nuisance, the more respondents are willing to pay. The various models are always statistically significant. This shows how the actual level of exposure strongly determines WTP, as highlighted in the aforementioned studies. Our results for noise are consistent with other studies (Barreiro *et al*., 2005; Martín *et al*., 2006). We are unable to make comparisons in relation to air pollution, however, since we have only found one other paper analysing real pollutant measures (Wardman and Bristow, 2004).

Finally, Table 11 shows similar analyses to those described in the above paragraphs. From this table we can see that, in the case of noise, the initial bid parameter is never significant, suggesting that there is no clear relationship between the bid offered and WTP. The decibel parameter also appears non-significant, except for the case where respondents located in zone A are exposed to a higher level of noise, proving that the influence of actual nuisance on valuation is only important when it reaches very high levels. As suggested earlier, listening to the audio track may have heightened respondents’ perception in the case of the noise reduction. Thus, that model is valid only for the case of zone A.

(INSERT HERE TABLE 11)

Air pollution results are very similar for mild and severe exposure levels. Both actual air pollution parameters associated are highly significant for different zones, and their positive sign shows us that the level of air pollution influences respondents’ WTP, with higher levels driving WTP towards positive values. Since interviewees are valuing public improvement, these results suggest us that people under greater exposure to the nuisance are more aware of the problem and thus willing to pay more. The proposed bid parameters are never significant showing the explanation of the WTP is mostly covered by the real variable measuring the air pollution.

6. Conclusions

This paper analyzes the results of a contingent valuation survey, carried out in the West Pyrenean area between Spain and France, in an attempt to calculate the environmental impacts of road transportation in that area. The main contributions of this paper are as follows. Firstly, it performs a joint analysis of noise and air pollution from the road traffic in the area, making comparisons between both externalities. Air pollution is addressed in global terms and the valuation exercise is subdivided by impact levels (mild and severe). Secondly, it analyzes different zones of affection to test for variation. Thirdly, it adds noise level measures and air pollution estimations into the analysis to look for a relationship between physical and economic valuations. Fourthly, the geographical scope of the study can be considered semi-urban/rural areas where traffic flow may be lighter than in urban areas, but the environmental impact is higher because it is concentrated in regions with high environmental quality.

Taking the results as a whole, we find that the number of people stating a zero response is considerably higher than reported in previous studies, forcing us to use the spike model where some of these responses are taken into account. In line with other studies, the results highlight the fact that air pollution abatements are more appreciated than noise reductions. Similarly, WTP is higher for a proposed reduction in the severely affected population than for one in the mildly affected population. When the social benefit is assessed, air pollution abatements are found to generate higher social gains since they are more highly valued by the affected population and exposure can be assumed to be more widespread.

We test whether different zones of affection and different proposed abatement levels are relevant in respondents' willingness to pay . We find both variables relevant in the valuation as a higher nuisance level elicits higher WTP, as do some higher proposed abatement levels. Likewise, survey distributions allow the influence of level of affection and proposed reduction to be measured separately. Thus, interestingly, we find that the nitial level is less important, while the proposed reduction generates sharp differences across the range of potential improvement. This may have major implications for policy decisions. We can therefore conclude that respondents' WTP is more strongly influenced by the proposed reduction than by the level of nuisance suffered.

Moreover, we analyze whether there is any relationship between the current levels of noise and air pollution and the respondents' valuation. The results are consistent with expectations, since the variable measuring the level of noise in decibels and the level of air pollution in $\mu g/m^3$ of NO_X is always highly significant in the estimated model. Additionally, the results show us how only high levels of noise impact on personal evaluation, while independently of the level, air pollution has ever a significant influence on the personal evaluations.

Finally, this paper can be said to have three overall implications. Firstly, the strong relationship between the environmental pressure and the economic valuation shows that the economic valuation method employed is suitable for measuring the associated externalities. Secondly, the difficulty of making simultaneous economic measures of environmental externalities is clearly highlighted by the fact that their effect varies across the population. Thirdly, it is possible to quantify the benefits of addressing environmental impacts, but an aggregate assessment of the different problems would be useful to verify the cost-effectiveness of possible solutions.

In subsequent studies, it would be worth considering non-urban or semi-urban areas to test for variation between these and highly polluted urban areas. Future research should therefore oriented towards finding the reasons for detected differences and generating comparative reports on the effect of environmental externalities in rural and urban areas. A discussion of the influence of different methodological approaches on the comparative results would also enhance future research efforts.

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References

Alberini A, Chiabai A (2007) Urban environmental health and sensitive populations: How much are the Italians willing to pay to reduce their risks? Regional Science and Urban Economics 37:239-258.

Andersson H, Jonsson L, Ögren M (2009) Property prices and exposure to multiple noise sources: Hedonic regression with road and railway noise. Environmental and Resource Economics, DOI 10.1007/s10640-009-9306-4.

Aprahamian F, Chanel O, Luchini S (2007) Modeling starting point bias as unobserved heterogeneity in valuation surveys: an application to air pollution. American Journal of Agricultural Economics 89:533-547.

Arrow K, Solow R, Portney P, Leamer E, Radner R, Schuman H (1993) Report of the National Oceanic and Atmospheric Administration Panel on contingent valuation. Federal Register 58:4602-4614.

Barreiro J, Sánchez M, Viladrich-Grau M (2005) How much are people willing to pay for silence? A contingent valuation study. Applied Economics 37:1233-1246.

Barrigón JM, Vílchez R, Gómez V, Méndez J, Tejeiro C, Bueno L, Vaquero JM (2002) Presentación de una encuesta para la realización de estudios sociales sobre el impacto del ruido urbano. Revista de Acústica, 33: 27-33.

Bell M, Davis D, Gouveia N, Borja-Aburto V, Cifuentes L (2006) The avoidable health effects of air pollution in three Latin American cities: Santiago, Sao Paulo and Mexico City. Environmental Research 100:431-440.

Bergmann A, Colombo S, Hanley N (2008). Rural versus urban preferences for renewable energy developments. Ecological Economics, 65: 616-625.

Bjørner TB, Kronback J, Lundhede T (2003) Valuation of noise reduction - comparing results from hedonic pricing and contingent valuation. SØM publication 51 (research report), AKF Forlaget, Copenhagen.

Carlsson F, Johansson-Stenman O (2000) Willingness to pay for improved air quality in Sweden. Applied Economics 32:661-669.

Casado JM, Barreiro J, Pérez L (2004) Preferencias inciertas y modelo Spike en la valoración del patrimonio natural. Working Paper, EconWPA, Series Microeconomics, number 0403002. http://ideas.repec.org/p/wpa/wuwpmi/0403002.html. Last access in May 2009.

Castanedo C (1995) Escala para la evaluación de actitudes proambientales (EAPA) de alumnos universitarios. Revista Complutense de Educación 6: 253-278.

Delucchi MA, Murphy JJ, McCubbin DR (2002) The health and visibility cost of air pollution: a comparison of estimation methods. Journal of Environmental Management 64:139-152.

DISPER 4.0 Contaminación Atmosférica. Edición Avanzada 2004 (Software). Canarina Algoritmos Numéricos, S.L. Santa Cruz de Tenerife, Canary Islands, Spain.

Durán R, Vázquez MX (2008) Efectos sociales de la contaminación acústica. Una aplicación de valoración contingente al transporte ferroviario. Paper presented at the 3rd Congress of Asociación Hispano-Portuguesa de Economía de los Recursos Naturales y Ambientales (AERNA), Palma de Mallorca, 4-6 June 2008.

Dziegielewska DA, Mendelsohn R (2005) Valuing air quality in Poland. Environmental and Resource Economics, 30:131-163.

European Commission (1999) DIRECTIVE 1999/62/EC of the European Parliament and of the Council of 17 June 1999 on the charging of heavy goods vehicles for the use of certain infrastructures. Official Journal of the European Communities L187:42-50.

European Commission (2002) DIRECTIVE 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise. Official Journal of the European Communities L189:12-25.

European Commission (2006) DIRECTIVE 2006/38/EC of the European Parliament and of the Council of 17 May 2006 amending DIRECTIVE 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures Official Journal of the European Communities L157:8-23.

García D, Hoyos D, Riera P (2008) Allowing for Uncertainty in Choice Experiments. Paper presented at the 3rd Congress of Asociación Hispano-Portuguesa de Economía de los Recursos Naturales y Ambientales (AERNA), Palma de Mallorca, 4-6 June 2008.

García de la Fuente L, Colina A, Colubi A, González-Rodríguez G (2009) Valuation of environmental resources: The case of the brown bear in the north of Spain. Environmental Modelling Assessment (in press). DOI 10.1007/s10666-009-9190-x .

Government of Navarre (2007) Plan de Aforos de las Carreteras de Navarra. Año 2007. Pamplona: Departamento de Obras Públicas, Transportes y Comunicaciones, Government of Navarre.

Hammitt JK, Zhou Y (2006) The economic value of air pollution related health risks in China. A contingent valuation study. Environmental and Resource Economics 33:399-423.

Hanemann WM (1984) Welfare evaluation in contingent valuation experiments with discrete responses. American Journal of Agricultural Economics 66:332-341.

Hanley N, Colombo S, Kriström B, Watson F (2009) Accounting for negative, zero and positive willingness to pay for landscape change in a national park. The Journal of Agricultural Economics 60:1-16.

Hoyos D (2004) La estimación de costes externos del transporte: una aplicación para Euskadi. Ekonomiaz 57:240-273.

IDENA (Infraestructura de Datos Espaciales de Navarra). http://idena.navarra.es/ogc/wms.aspx. Last access in May 2009.

INFRAS/IWW (2000). External Costs of Transport: Accident, Environmental and Congestion Costs of Transport in Western Europe, Study for the International Union of Railways, Paris.

INFRAS/IWW (2004). External Costs of Transport. Update Study. Final report. Zürich/Karlsruhe.

International Energy Agency (2006) World Energy Outlook 2006. International Energy Agency, Paris.

Intergovernmental Panel on Climate Change (2007) Fourth Assessment Report: Climate Change 2007. Mitigation of Climate Change. IPCC, Geneva.

ISO/TS 15666 (2003) Acoustics. Assessment of noise annoyance by means of social and socio-acoustic surveys. International Organization for Standardizaton. http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=28630. Last access in June 2009.

Kahneman D, Knetsch JL (1992) Valuing public goods: the purchase of moral satisfaction. Journal of Environmental Economics and Management 22:57-70.

Karimzadegan H, Rahmatian M, Farhud DD, Yunesian M (2008) Economic valuation of air pollution health impacts in the Tehran area, Iran. Iranian Journal of Public Health 37:20-30.

Kawamura K, Mahajan S (2005) Hedonic analysis of impacts of traffic volumes on property values. Transportation Research Record 1924:69-75.

Kim CW, Phipps TT, Anselin L (1998) Measuring the benefits of air quality improvement: A spatial hedonic approach. Journal of Environmental Economics and Management 45:24-39.

Kondo A, Fujisawa T, Maeda T, Yamamoto A, Enoki Y (2003) Measurement of change of environmental load generated by car traffic on economic value. Advances in Transport 14:535-545.

Kriström B (1997) Spike models in contingent valuation. American Journal of Agricultural Economics 79:1013–1023.

Lambert J, Poisson F, Champelovier P (2001) Valuing benefits of road traffic noise abatement programme: a contingent valuation study. Paper presented at the 17th International Congress on Acoustics (ICA), Rome, 2-7 September 2001.

Marmolejo C, Frizzera A (2008) ¿Cuánto estamos dispuestos a pagar por el silencio? Un análisis contingente para la ciudad de Barcelona. Arquitectura, Ciudad y Entorno 7.

Martín MA, Tarrero A, González J, Machimbarrena M (2006) Exposure-effect relationships between road traffic noise annoyance and noise cost valuations in Valladolid, Spain. Applied Acoustics 67:945-958.

Matus K, Yang T, Paltsev S, Reilly J, Nam KM (2008) Toward integrated assessment of environmental change: air pollution health effects in the USA. Climatic Change 88:59-92

Mitchell RC, Carson RT (1989) Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington, DC.

Navarre Allergic and Asthmatic Association (2009) Information about asthma in Navarra. http://www.cfnavarra.es/salud/anales/textos/vol26/sup2/suple18a.html. Last access in May 2009.

Navrud S (2001) Valuing health impacts from air pollution in Europe. Environmental and Resource Economics 20:305-329.

Navrud S (2002) The state-of-the-art- on Economic Valuation of Noise. European Commission DG Environment. Final Report. April 14th 2002.

Observatorio Hispano-Francés del tráfico en los Pirineos. “Documento nº5. Diciembre 2008”. Ministerio de Fomento, Gobierno de España. Ministère de l'Equipement des Transports du Logement du Tourisme et de la Mer, Gouvernement Française.

Ovaskainen V, Kniivilä M (2005) Consumer versus citizen preferences in contingent valuation: evidence on the role of question framing. Australian Journal of Agricultural and Resource Economics 49:379-394.

Rambolinaza M, Dachary-Bernard J (2007). Land-use planning and public preferences: What can we learn from choice experiment method? Landscape and Urban Planning, 83, 318-326.

Rehdanz K, Maddison D (2008) Local environmental quality and life satisfaction in Germany. Ecological Economics 64:787-797.

Rozan A (2004) Benefit transfer: A comparison of WTP for air quality between France and Germany. Environmental and Resource Economics 29:295-306.

Sayadi S, González-Roa MC, Calatrava J (2009). Public preferences for landscape features: The case of agricultural landscape in mountainous Mediterranean areas. Land Use Policy, 26: 334-344.

Saz S del (2004) Tráfico rodado y efectos externos: valoración económica del ruido. Ekonomiaz 57:46-67.

Saz S del, García L, Palau JM (1999) Los beneficios sociales de la remodelación urbanística de la fachada litoral de Valencia: un estudio de valoración contingente. Biblioteca Cívitas Economía y Empresa. Madrid.

Sinha KC, Labi S (eds) (2007) Transportation Decision Making. Principles of Project Evaluation and Programming. John Wiley & Sons, Inc. Hoboken. New Jersey.

Spanish National Statistics Institute (2009) Encuesta de Hogares y Medio Ambiente 2008. http://www.ine.es/inebmenu/mnu_medioambiente.htm. Last access in September 2009.

Spanish Society of Allergology and Clinical Immunology (2009) Information about respiratory problems and allergy in Spain. http://www.seaic.org. Last access in June 2009.

Tuan TH, Navrud S (2007) Valuing cultural heritage in developing countries: comparing and pooling contingent valuation and choice modelling estimates. Environmental and Resource Economics 38:51-69.

Vázquez MX (2002) Estimación económica de los beneficios para la salud del control de la contaminación del aire. El caso de Vigo. Revista Galega de Economía 11:1-18.

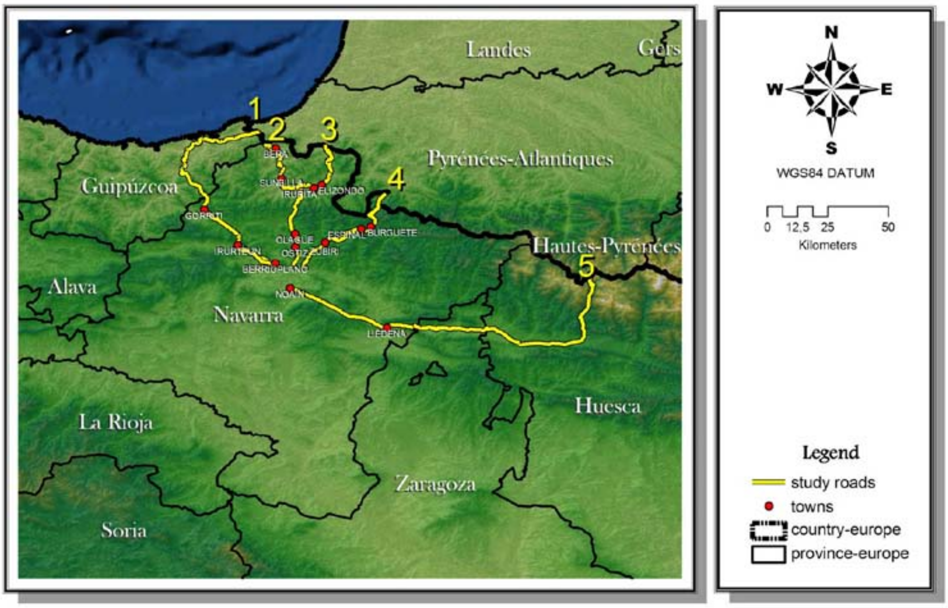
Vázquez MX, Araña JE, León C (2006) Economic evaluation of health effects with preference imprecision. Health Economics 15:403-417.

Wang XJ, Zhang W, Li Y, Yang KZ, Bai M (2006) Air quality improvement estimation and assessment using contingent valuation method, a case study in Beijing. Environmental Monitoring and Assessment 120:153-168.

Wardman M, Bristow A (2004) Traffic related noise and air quality valuations: evidence from stated preference residential choice models. Transportation Research Part D: Transport and Environment 9:1-27.

Yoo SH, Chae KS (2001) Measuring the economic benefits of the ozone control policy in Seoul: Results of a contingent valuation survey. Urban Studies 38(1):49-60.

Figure 1: Geographical scope: roads and villages



(1) AP-15/A-15	(2) N-121a	(3) N-121b	(4) N-135	(5) A-21/N-240
Berrioplano	Ostiz	Irurita	Zubiri	Noáin
Irurtzun	Olagüe	Elizondo	Espinal	Liédena
Gorriti	Sunbilla		Burguete	
	Vera de Bidasoa			

Figure 2. Frequency distribution of stated WTP per valuation

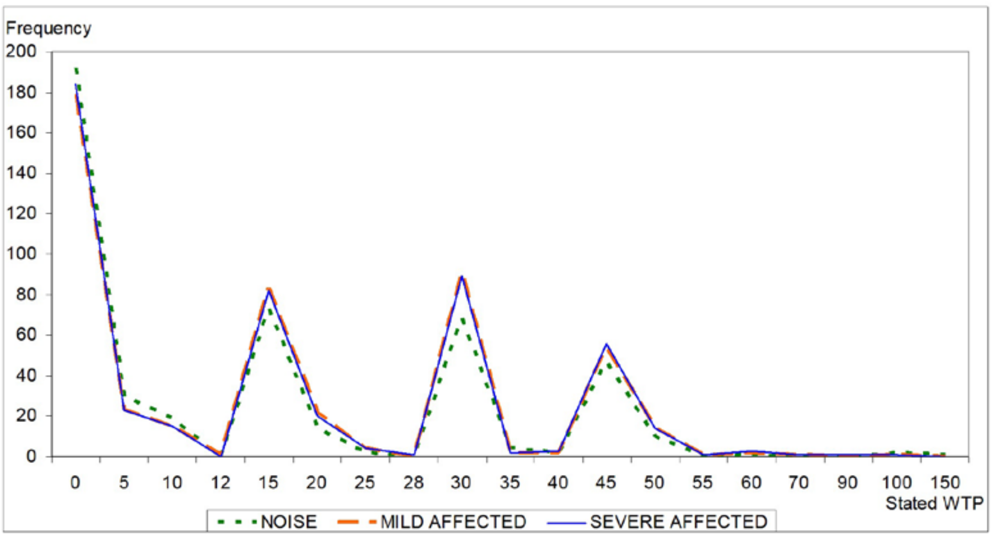


Table 1: Noise measurements and air pollutants estimations data

Noise	Date	January 2009
	Number and duration	2, 3 or 4, depending on villages. 30 minutes per measurement
	Time	Daytime: 10-20 h; Night: From 00h
	Procedure	1.5 meters high, both in front of facade and open areas
	Equipment	Sound level meter. Symphonie bicanal analyzer. Decibel Trait software.
	Results	Equivalent sound levels after external human activities abatement.
Air Pollution	Parameters considered	Traffic density (Government of Navarre, 2007), geographical information, strength and direction of wind, temperature and atmospheric conditions.
	Software	DISPER 4.0
	Estimation model	ISCST (Industrial Source Complex Short Term Model) based on Environmental Protection Agency (EPA), USA
	Results	Concentrations and dispersion for CO, NO_X and C_XH_Y

Table 2: Pollution zones characteristics

	Zone A	Zone B
Distance from highway	From 0 to 80/100 m	From 80/100m to 300m
Approximate Noise levels	Over 65 dB	Under 65 dB
Pollutants concentrations (1)	Until 77 μg/m^3	Under 60 μg/m^3

(1) *Absolutely dependent on placement characteristics (relief, for example) and slightly different between villages. The border limits between zones are not univocally defined because they vary depending on the small towns and villages considered.*

Table 3: Mean WTP in different CVM surveys

Author	Year	Location	Issue	E(WTP) [nom. €]	Scenario
Yoo & Chae	2001	S. Korea	Air	15.50	WTP to improve air quality
Navrud	2001	Sweden	Air	17.90	WTP to avoid one extra day per year of worse health due to air pollution
Lambert *et al.*	2001	France	Noise	73	WTP to implement a program to reduce noise nuisance
Wardman & Bristow	2004	UK	Air	115.20	WTP for a 50% reduction in air pollution
			Noise	106.70	WTP for a 50% reduction in noise level
Dziegielewska & Mendelsohn	2005	Poland	Air	16	25% reduction in the number of people affected by air pollution
				20	Same for a 50% reduction
Barreiro *et al.*	2006	Spain	Noise	26-29	Annual payment to reduce noise annoyance
Vázquez *et al.*	2006	Spain	Air	48	WTP to reduce the number of people affected by diverse symptoms through an improvement in air quality
Wang *et al.*	2006	China	Air	14.30	WTP for a 50% reduction in air contaminants
Martín *et al.*	2006	Spain	Noise	7.20	WTP to reduce noise nuisance

Source: Own elaboration

* Values translated to euros from original currency at exchange rates at time of calculation

Table 4. Different scenarios proposed and number of people surveyed.

Contamination zone	A									B		
Noise reduction	70 - 50			70 - 60						60 - 50		
Pollution reduction	50%			25%			50%			25%		
Initial bid (€)	15	30	45	15	30	45	15	30	45	15	30	45
Type of questionnaire	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Nº of questionnaires	100	100	100	50	50	50	50	50	50	100	100	100

Table 5. Number of respondents who stating zero WTP

WTP = 0		Noise	Air pollution: Mildly affected	Air pollution: Severely affected
Bid [€]	15	203/300 (67%)	192/300 (64%)	192/300 (64%)
	30	205/300 (68%)	190/300 (63%)	190/300 (63%)
	45	218/299 (72%)	201/299 (67%)	201/299 (67%)
Total sample		626/899 (69%)	583/899 (65%)	583/899 (65%)

Table 6. Comparison of estimated spike models for the whole sample and after removal of protest responses.

Valuation		Noise	Air pollution: Mildly affected	Air pollution: Severely affected
WHOLE SAMPLE				
Spike value		0.698	0.652	0.652
Mean WTP		4.14	4.98	5.19
Model	α	-0.841	-0.628	-0.629
	β (bid)	0.086***	0.085***	0.082***
Observations		899	899	899
Log likelihood		669.17	723.42	730.76
Likelihood ratio (prob.)		1338.35 (0.000)	1446.74 (0.000)	1461.52 (0.000)
IGNORING PROTEST RESPONSES				
Spike value		0.424	0.377	0.384
Mean WTP		8.22	9.31	9.56
Model	α	0.305	0.501	0.471
	β (bid)	0.104***	0.104***	0.100***
Observations		465	495	500
Log likelihood		436.63	470.63	483.20
Likelihood ratio (prob.)		873.26 (0.000)	941.26 (0.000)	966.41 (0.000)

Note: ***p<0.01; **p<0.05; *p<0.10

Table 7. Social benefit from a reduction per externality.

	Noise	Air pollution: Mildly affected people	Air pollution: Severely affected people
Spike mean WTP (Table 6)	8.22	9.31	9.56
For 5 years	41.1	46.55	47.8
Considered population	45,000	125,000	125,000
Over age (80%)	36,000	100,000	100,000
SOCIAL BENEFITS [€]	1,479,200	4,655,000	4,780,000

Table 8. Comparison of estimated spike models between pollution zones

	Model		Noise	Air pollution: Mildly affected	Air pollution: Severely affected
PER ZONE					
A	Spike value		0.408	0.370	0.370
	Spike mean		9.096	10.305	10.837
	Spike	α	0.368	0.531	0.528
		β (BID)	0.098***	0.096***	0.091***
	Observations		325	352	352
	Log likelihood		310.52	340.79	346.95
	Likelihood ratio (prob.)		621.04 (0.000)	681.59 (0.000)	693.91 (0.000)
B	Spike value		0.459	0.392	0.412
	Spike mean		6.188	6.886	6.563
	Spike	α	0.162	0.437	0.354
		β (BID)	0.125***	0.135***	0.134***
	Observations		140	143	148
	Log likelihood		123.83	126.32	131.19
	Likelihood ratio (prob.)		247.66 (0.000)	252.65 (0.000)	262.38 (0.000)
PER REDUCTION					
HIGHER [40% Noise; 50% Air]	Spike value		0.324	0.357	0.359
	Spike mean		12.781	11.241	11.941
	Spike	α	0.732	0.587	0.577
		β (BID)	0.088***	0.091***	0.086***
	Observations		156	262	261
	Log likelihood		157.28	256.60	261.51
	Likelihood ratio (prob.)		314.56 (0.000)	513.20 (0.000)	523.03 (0.000)
LOWER [20% Noise; 25% Air]	Spike value		0.473	0.397	0.408
	Spike mean		5.822	7.136	6.948
	Spike	α	0.105	0.414	0.370
		β (BID)	0.128***	0.129***	0.128***
	Observations		309	233	239
	Log likelihood		267.10	208.72	214.13
	Likelihood ratio (prob.)		534.21 (0.000)	417.44 (0.000)	428.26 (0.000)

Note: ***p<0.01; **p<0.05; *p<0.10

Table 9. Estimated spike models ignoring protest responses

	Model		Noise	Air pollution: Mildly affected people	Air pollution: Severely affected people
A zone + Lower reduction	Spike value		0.485	0.406	0.401
	Spike mean		5.504	7.548	7.600
	Spike	α	0.057	0.380	0.398
		β (BID)	1.131***	0.119***	0.119***
	Observations		169	90	91
	Log likelihood		143.11	82.18	82.71
	Likelihood ratio (prob.)		286.22 (0.000)	164.37 (0.000)	165.43 (0.000)

Note: ***p<0.01; **p<0.05; *p<0.10

Table 10. Logit and Probit models for initial bid and actual level of pollution

	Models	Noise	Air pollution: Mildly affected	Air pollution: Severely affected
Logit	α	-1.012	-0.034	-0.015
	β_1 (BID)	-0.0008	0.0001	-0.002
	β_2 (dB)/(NO_X)	0.028**	0.25D-05***	0.27D-05***
	Log likelihood	-312.88	-311.77	-314.95
	Likelihood ratio (prob.)	4.676 (0.096)	24.24 (0.000)	27.96 (0.000)
Probit	α	-0.634	-0.008	0.002
	β_1 (BID)	-0.0004	-0.000	-0.001
	β_2 (dB)/(NO_X)	0.017**	0.15D-05***	0.16D-05***
	Log likelihood	-312.87	-311.61	-314.77
	Likelihood ratio (prob.)	4.69 (0.095)	24.56 (0.000)	28.34 (0.000)
	Observations	465	495	500

Note: ***p<0.01; **p<0.05; *p<0.10

Table 11. Logit and Probit models per zone

		Model	Noise	Air pollution: Mildly affected people	Air pollution: Severely affected people
A	**Logit**	α	-1.200	0.167	0.187
		β_1 (BID)	-0.0003	-0.005	-0.005
		β_2 (dB)/(NO_X)	0.033**	0.21D-05***	0.21D-05***
		Log likelihood	-215.93	-222.12	-222.14
		L. Ratio (prob.)	4.75 (0.092)	13.74 (0.001)	13.71 (0.001)
	Probit	α	-0.749	0.111	0.122
		β_1 (BID)	-0.0001	-0.003	-0.003
		β_2 (dB)/(NO_X)	0.020**	0.13D-05***	0.13D-05***
		Log likelihood	-215.92	-221.96	-221.97
		L. Ratio (prob.)	4.77 (0.091)	14.06 (0.000)	14.04 (0.0008)
		Observations	325	352	352
B	**Logit**	α	-0.248	-0.833	-0.741
		β_1 (BID)	-0.003	0.021	0.0126
		β_2 (dB)/(NO_X)	0.011	0.47D-05***	0.53D-05***
		Log likelihood	-96.21	-86.91	-90.02
		L. Ratio (prob.)	0.25 (0.881)	15.75 (0.000)	18.98 (0.000)
	Probit	α	-0.155	-0.507	-0.447
		β_1 (BID)	-0.002	0.013	0.007
		β_2 (dB)/(NO_X)	0.007	0.28D-05***	0.31D-05***
		Log likelihood	-96.21	-86.84	-89.97
		L. Ratio (prob.)	0.25 (0.881)	15.90 (0.000)	19.09 (0.000)
		Observations	140	143	148

Note: ***p<0.01; **p<0.05; *p<0.10