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Sub-priority 6.1.3.2.5: Socio-economic tools and concepts for energy strategy.

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</tr>
<tr>
<td>RE Restricted to a group specified by the consortium (including the Commission Services)</td>
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<tr>
<td>CO Confidential, only for members of the consortium (including the Commission Services)</td>
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Summary

The overall objective of this work package (WP) is to obtain a more reliable and credible number for the value of a life year (VOLY) lost by air pollution mortality, one of the most important parameters of ExternE and until now one of the most uncertain. The new value is the consensus of a team of European experts for this question, based on the results of a new contingent valuation (CV) questionnaire that has been applied in 9 countries: France, Spain, UK, Denmark, Germany, Switzerland, Czech Republic, Hungary, and Poland. The total sample size is 1463. A procedure for transferring the results to other countries has also been developed and tested.

The approach is innovative because it is based directly on the change of life expectancy (LE), by contrast to previous valuations of air pollution mortality that were based either on accidental deaths or on a small change in the probability of dying. There are several reasons for basing the valuation on loss of LE rather than a number of premature deaths, as recognized by ExternE since 1998 and explained in detail by Rabl [2003 and 2006]. Furthermore our experience with the questionnaire of Krupnick et al during the New Ext [2003] project had demonstrated that people have too much trouble understanding small probability variations, whereas a change in life expectancy is well understood, as shown by the work of Chilton et al [DEFRA 2004] and by tests in France during the NewExt project. The new questionnaire was developed specifically for this WP, with extensive testing by focus groups, debriefing and verbal protocols.
Based on the results of this questionnaire, our recommended VLY estimates are (“EU16” being EU15 + Switzerland)

for “EU16”: 41,000 €
for New Member Countries (NMC): 33,000 €

However, for cost-benefit analyses of EU directives and policies we would recommend using the same value for EU25 (“EU26”, including Switzerland), based on the VLY value from the pooled sample. However, this estimate should be adjusted to correct for the difference in the proportion of “EU16” and NMC observations in our sample and the actual populations

for EU25: 40,000 €

These values are somewhat lower than the 50,000€ used by ExternE since the NewExt project.

To render the CV result more credible, two complementary sources of information were examined:

• values implied by current medical practice (the value of a QALY).
• an upper bound implied by the relation between LE and GDP/capita.

A survey of the literature of health economics showed that the study of the cost-effectiveness of medical interventions (i.e. the ranking of interventions according to their cost per QALY) is a very active field; however, until now no government in Europe has recommended official guidelines, even in the UK where the establishment of guidelines has advanced the furthest. Nonetheless an informal consensus seems to be emerging that interventions costing less than roughly 50,000€ per QALY should be recommended and those that cost more than 100,000€ per QALY should be rejected (for comparison with VLY we make the reasonable assumption that the monetary value of a QALY should be equal to VLY). The relation between LE and GDP/capita implies an upper bound for VLY in the range of 100,000 to 300,000€.

Of course, significant uncertainties remain since the potential errors of CV are known to be large. We note therefore that the values determined by the CV are sufficiently compatible both with the previous value of ExternE, with DEFRA [2004] and with these complementary sources. Furthermore, it is of interest to consider the relation between VLY and the value of a prevented fatality (VPF) since the ratio VPF/VLY should be in the range of 20 to 40 (if VPF is to equal the discounted sum of annual VLYs). In 2000 the DG Environment of the European Commission [EC 2000] recommended that a value of a prevented fatality (VPF) of 1 million € be used for environmental cost benefit analysis. In view of these considerations the VLY of 40,000 € for EU25 appears very reasonable and can thus be recommended for future application by ExternE. As for confidence intervals, we argue that VLY is at least 25,000€ and at most 100,000€.

Finally the QALY scale used by health economists is combined with the new VLY to obtain an implied cost for morbidity endpoints, in particular chronic bronchitis, the end point making the second largest contribution after mortality (about 25%) to the total damage cost of PM, NO2 and SO2. Until now the cost of chronic bronchitis assumed by ExternE has remained quite uncertain because it has been based on only two CV studies in the USA (that use essentially the same questionnaire), dating from 1990 and 1991, and the application of those studies poses some problems. The result of the QALY approach turns out to be so close to the 200,000€ currently used for chronic bronchitis by ExternE, that no change is recommended.
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1. Introduction

The overall objective of this work package (WP6 of the NEEDS project) is to obtain a more reliable and credible number for the value of a life year (VOLY) lost by air pollution mortality, one of the most important parameters of ExternE and until now one of the most uncertain. The new value is the consensus of a team of European experts for this question, based on the results of a new contingent valuation (CV) questionnaire that has been applied in 9 countries: France, Spain, UK, Denmark, Germany, Switzerland, Czech Republic, Hungary, and Poland. The total sample size is 1463. A procedure for transferring the results to other countries has also been developed and tested.

The approach is innovative because it is based directly on the change of life expectancy (LE), by contrast to previous valuations of air pollution mortality that were based either on accidental deaths or on a small change in the probability of dying. There are several reasons for basing the valuation on loss of LE rather than a number of premature deaths, as recognized by ExternE since 1998 and explained in detail by Rabl [2003 and 2006]. Furthermore our experience with the questionnaire of Krupnick et al during the New Ext [2003] project had demonstrated that people have too much trouble understanding small probability variations, whereas a change in life expectancy is well understood, as shown by the work of Chilton et al [DEFRA 2004] and by tests in France during the NewExt project. The new questionnaire was developed specifically for this WP, with extensive testing by focus groups, debriefing and verbal protocols.

To render the CV result more credible, two complementary sources of information were examined:
- values implied by current medical practice (the value of a QALY).
- an upper bound implied by the relation between life expectancy and GDP/capita.

Finally the QALY scale used by health economists is combined with the new VOLY to obtain an implied cost for morbidity endpoints, in particular chronic bronchitis, the end point making the second largest contribution after mortality (about 25%) to the total damage cost of PM, NO₂ and SO₂. Until now the cost of chronic bronchitis assumed by ExternE has been based on only two CV studies in the USA (that use essentially the same questionnaire), dating from 1990 and 1991, and the application of those studies poses some problems.

2. State-of-the-Art

Until about 1996, and in the USA until now, all studies of air pollution damage costs estimated a number of premature deaths and multiplied it by VSL (value of statistical life). For the latter the ExternE project series has taken approximately 3 M€ (with adjustments for inflation). In the USA higher values, around $ 6 million, have been used for environmental assessments, although it is interesting to note that the US Dept. of Transportation uses about $ 3 million [Mrozek & Taylor 2002]. These numbers for VSL are based on accidental deaths where the loss of LE is typically in the range of 30 to 40 years. Recognizing that such an approach is not appropriate for air pollution, the ExternE project series has been using a valuation in terms of LE loss since 1996. As no empirical data for the value of a life year (VOLY) were available, the latter was calculated on theoretical grounds by assuming that VSL is the sum of discounted annual VOLY weighted by the survival probabilities. With the
central value of the discount rate (3%) the resulting VOLY for total mortality is approximately 100,000 €.

By contrast to the numerous studies on VSL, the contingent valuation of a life year has received very little attention until recently. The first survey that asked explicitly about the valuation of an LE gain is the one of Johannesson & Johansson [1997], administered by telephone (in 1995, concerning 2824 individuals), whose valuation question is "The chance for a man/woman of your age to become at least 75 years old is x percent. On average, a 75-year old lives for another 10 years. Assume that if you survive to the age of 75 years you are given the possibility to undergo a medical treatment. The treatment is expected to increase your expected remaining length of life to 11 years. Would you choose to buy this treatment if it costs y and has to be paid for this year?" The resulting VOLY values are very low, in the range of $700 to $1,300. However, as mentioned by the authors, there are many factors that could explain such low values, specially the expected quality of life at an old age which was asked explicitly. Half of the sample had a willingness-to-pay (WTP) of zero. The average of positive WTPs is about $2,700, which is still a very low amount.

In the Morris and Hammitt study [2001], the CV question was based on WTP for a hypothetical pneumonia vaccine. Half of the sample (n = 332) received a version in which the benefit was expressed as a LE gain and the other half (n = 349) the benefit was expressed as a reduction of the risk of dying. Each sample was then split in two, the first group being asked about their WTP for a vaccine received at the age of 60 (LE = 11 months), the second group for a vaccine received at the age of 70 (LE = 5 months). Interviews were made by phone after respondents received a mailed packet of material. The mean age of the sample is 40 years. 30% of the sample would not take the vaccine, essentially because the benefits are too small or uncertain. The results show that if benefits are expressed in terms of LE gain, the median WTP is 52% higher than for the risk reduction for a vaccine at 60 (but equal for a vaccine at 70). The authors reach the conclusion that LE is more readily understandable and enhances the validity of economic valuation, a conclusion confirmed in our study, even if the LE gains are different (11 months in Morris & Hammit, 40 days on average for the French sample).

Soguel & van Griethuysen [2000] determined a VOLY related to air pollution. A representative sample of the city of Lausanne (n = 199) were asked to value (in a face-to-face questionnaire) to value a bundle of health damages caused, each year, by an incinerator: 6000 days of life lost, 1200 cases of restricted activity days and 500 new cases of chronic bronchitis and asthma. Expressed as average loss per person, this is 1 hour of life per year, a 1% chance to have a restricted activity day, and 0.5 % chance to suffer of chronic bronchitis. The ranking enabled the authors to apportion the WTPs among the different health outcomes and to extract an implicit VOLY. They obtained a VOLY of 53,000 Swiss Francs (34,000 €) based on a Box-Cox regression.

In the late 90’s Krupnick and his colleagues at Resources for the Future developed a self administered and computerized CV questionnaire to value specifically the benefits of air pollution reduction even if this cause is not mentioned. It was applied in Canada [Krupnick et al. 2002] and the USA [Alberini et al., 2001]. The persons are asked to value a 1/1000 and a 5/1000 risk reduction in their risk of dying during the next 10 years and at the age of 70. The payment vehicle is a medication or medical treatment to be taken during 10 years. The sample is composed of persons from 40 to 75 years old. For Canada the authors derive a VSL of $0.96 million for a 5/1000 risk reduction, and of $3.04 million for a 1/1000 risk reduction, but they do not provide a VOLY.
The latest study [DEFRA 2004] was conducted in England between November 2002 and January 2003. Like the Swiss study people had to value a bundle of damages related to a reduction in air pollution. 665 persons were asked to value one (or three, or six) months of LE gain in normal health (and in poor health), as well as avoiding hospital admission, and avoiding breathing discomfort. The value of a person year in normal health is 27,639 £ (42,000 €) for the one month sample, 9,430 £ (15,000 €) for the 3 months sample and 6,040 £ (10,000 €) for the 6 month sample. A Voly in poor health is much lower (more than half of the sample gave a zero valuation), ranging between 7280£ for the one month subsample, to 1290 £ for the 6 month subsample.

Between 2001 and 2003 the NewExt [2003] phase of the ExternE series included a contingent valuation to obtain a better estimate of Voly. To minimize the cost, the team in charge of this valuation decided not to develop a new questionnaire but to apply the one of Krupnick et al. [2002] in the UK, Italy and France. With the results the team recommended a Voly of 50,000€. By contrast to the application in other countries the one in France involved several additional features: an open question was added after each set of bids and at the end of the questionnaire the WTP values were recalled to give the respondents the opportunity to correct their values; five variants were tested on samples of about 50 each, including variants phrased in terms of LE gain; and each questionnaire was followed by detailed written debriefing, and verbal debriefing for some of the variants, to learn how the respondents interpreted the questions. Based on the experience of NewExt, the decision was made to develop a new questionnaire for the NEEDS project of ExternE.

3. The Questionnaire

3.1. Nature of the Study

Following the aims and objectives of the study as outlined in the Introduction to this report, this Chapter focuses on the methodological development and description of the contingent valuation survey underpinning the empirical study. The aim of the survey was to investigate how much people in the different EU countries in question are willing to pay for reductions in the health risks associated with air pollution. The survey was administered in eight different countries - UK, France, Poland, Czech Republic, Hungary, Switzerland, Spain and Denmark - with a view to pooling the data to estimate a common Voly from air pollution reduction for use across the EU. As such, the study focuses on gains in life expectancy in normal health (chronic effects).

The questionnaire was designed to obtain within sample estimates of three and six month gains in life expectancy. A substantial period of time was spent developing the questionnaire using cognitive testing and pilot studies.

The main survey was conducted in between November 2005 and January 2006 in the various countries and the aim was to question a representative sample of the population in one major city in each country – Newcastle upon Tyne (UK), Paris (France), Warsaw (Poland), Prague (Czech Republic), Budapest (Hungary), Neuchatel (Switzerland), Barcelona (Spain) and Copenhagen (Denmark). The total number of completed interviews was 1,463.
Interviews were carried out on a one-to-one basis by members of the national research teams or interviewers trained by them. Interviews lasted on average 35 minutes. The final questionnaire is shown in Annex ?.

In the next sub-section the main developments from the piloting phases are highlighted, followed by an in-depth description of the questionnaire used in the main study.

### 3.2. Questionnaire approach

#### 3.2.1. Development of questionnaire

In the inaugural workpackage meeting in Prague, the main issue discussed in relation to the study was that of how to communicate a risk reduction of premature death due to air pollution. It was decided to try to present the good to be valued as a small increase in life expectancy customized as much as possible to the individual person. This would be qualitatively described to respondents as small risk reductions throughout their life in an attempt to avoid giving the impression that the gain was a certain increase of x months at the end of life.

A protocol was subsequently drawn up by the UK team and presented in Paris in January 2005 with a view to translation and administration in the other countries (February-March 2005) to tests its feasibility, tractability and generalisability.

After implementing the protocol in the other countries it was concluded that while some aspects worked and merited incorporation into a subsequent questionnaire e.g. the cost of living payment vehicle and the willingness to pay for an average gain other aspects were cognitively too difficult. In addition, altruism, consideration of co-benefits (e.g. environment) and quality of life entered peoples’ considerations more so than in the UK as did lack of trust in government, particularly in the transition states. Accordingly, a new, shorter individual-interview based questionnaire was drawn up based on a format proposed by the French team but which included the more successful aspects described above. Initial protocols suggested that, people generally found it difficult to separate morbidity from mortality. Further refining and testing took place in an attempt to mitigate this problem. This questionnaire was piloted in the various countries (UK n=50, Poland n=31, Czech Republic n=16, Hungary n=20, France n=20, Switzerland n=8 and Spain). The results were reported in Budapest in August 2005.

The main conclusions were that, subject to a few further final amendments to the questionnaire, we could proceed to the main study. In particular, the survival curve (explained in the next section) worked well but generally needed augmentation and detailed description. Altruism, quality of life and the environment were present to some degree in many peoples’ answers, particularly in the case of the transition states. It was decided to build in continued reminders into the main study to try and consider only oneself and that the type of air pollution that would be reduced would not be that which affected greenhouse gas emissions. There was a widespread view that gains of 2 or 5 months were too small to be worth considering. Because of this, gains of three and six months would be substituted into the main study, successfully implemented previously in the UK [DEFRA 2004].
3.2.2. The final questionnaire

This section provides an outline of the general approach taken in the questionnaire to eliciting willingness to pay values for the gains in life expectancy.

The initial stage of the questionnaire provided respondents with general information about the background to the project and its rationale.

The first stage in the questionnaire (Questions 1-3) asked respondents to consider the effect of pollution on their health and whether it was of general concern to them. The aim of these early questions was to provide initial context for the subsequent valuation questions and to allow respondents to begin to consider explicitly the effects of air pollution on health. Questions 4-9 developed this aspect further, concentrating on their knowledge of the effects of air pollution on health, air pollution-related illnesses in their family, their general health and lifestyle, specifically exercise and smoking.

In the second stage of the questionnaire (Part II) the respondent was given information on average life expectancy in the various countries and how air pollution affects life expectancy. Attention was also drawn to their own life expectancy, given how old they were at the time of interview and factors which affect individual life expectancy such as genetic, behavioural and environmental conditions.

Two potential policies that could reduce air pollution and hence generate gains in life expectancy were outlined in the third stage of the questionnaire (Part III) i.e.:

**Policy I**, will impose a 3% reduction per year in the emission of air pollutants for 20 years:
(which means a total reduction of 60% by 2025)
Afterwards the emission of air pollutants will be maintained at this lower level whatever the economic growth

The benefit in terms of life expectancy would be an average increase of:

**6 months**

**Policy II**, will impose a 1.5% reduction per year in the emission of air pollutants for 20 years:
(which means a total reduction of 30% by 2025)
Afterwards the emission of air pollutants will be maintained at this lower level whatever the economic growth

The benefit in terms of life expectancy would be an average increase of:

**3 months**
The remaining information focused on presentation of a schematic graph developed and pioneered specifically for this project. Fig.1 (with appropriate modifications for different age groups) is used in the questionnaire to illustrate the notion of a survival curve whereby a person’s chance of surviving to the next year, conditional on them reaching the current age, falls as we age until at some point i.e. death that person has no chance of further survival. The crucial point here is that each person has a survival curve associated with current levels of air pollution. Were the level of air pollution to change, the survival curve will shift up or down depending on whether air pollution is reduced or increased respectively. Using this approach, we were able to explain to respondents the actual process by which gains in life expectancy arise i.e. as small increases in the probability of survival throughout their lives due to a slowing down of the ageing process which results in an upward shift of their survival curve such that life expectancy is increased by three or six months depending on the amount of air pollution reduction, as opposed to an additional three or six months at the end of a person’s life. It was also emphasized that while most of the risk reduction (or increased chance of survival) occurs towards the end of a person’s life, conditional on them reaching this stage, some benefit accrues immediately the risk reduction is implemented.

Fig.1. Gain of life expectancy (LE) when air pollution is reduced
(example of someone who has age 50 now)

In the fourth stage of the questionnaire (Part IV) the interviewer explained that the cost of any measures to reduce air pollution would increase prices and hence their cost of living. Each respondent was asked first of all whether they would in principle be willing to pay something in the form of higher prices to gain an increase in their life expectancy (and, in addition, for any other benefits from improved air quality).

If they responded ‘no’ to this question then the reasons for this were explored further and noted down. This was in order to identify ‘protest votes’ from those who legitimately did not value the health benefit. For those who said ‘yes’ the respondent would be reminded at this stage of their budget constraint. The respondent was then asked their maximum WTP for the six month gain average life expectancy followed by the three month gain. To help the participant with this task, each was then given a set of payment cards and template. They were
asked to shuffle the cards and then take one card at random and decide if they were willing to pay that amount per month for the rest of their lives, if yes they were told to place it on the template in the box marked “definitely would pay”, if no, they were told to place it in the box marked “definitely would not pay”, or if they were not sure place it in the “unsure” box. The participant repeated this exercise for all of the different payment cards. The interviewer recorded the highest value placed in the “definitely would pay” box onto the questionnaire booklet along with the lowest value placed in the “definitely would not pay” box. The interviewer then proceeded to ask the participant what is the maximum amount they would be willing to pay for the given increase in life expectancy i.e.:

- **What is the maximum amount you are willing to pay in the form of higher expenses to gain an average of 6 months in your life expectancy?** It may be one of these figures or something in between.

*The largest amount of your “Yes, I would pay” cards:*

- _____ per month (for the rest of my life)
- _____ per year (for the rest of my life)

### 4. Descriptive statistics

Whilst the sample surveyed cannot claim to be representative of the countries populations it is interesting to compare the survey population data with the national data and to compare the individual countries’ survey data. The tables immediately below present the results from a number of questions in the survey that gather information on the context in which the questionnaire respondent finds him/herself. A full summary of responses to all questions in the questionnaire can be found in the Annex to this report.

Table 1 presents background data for the survey sample whilst Table 2 presents – as far as possible – equivalent data for the country populations. Apart from Hungary and France, which are a little high, the gender balance between the sample and national populations is very similar. Income levels are also generally comparable though it is interesting to note that the incomes in the sample populations are significantly higher in the new member countries than in their national populations. One might expect the percentages in tertiary education to reflect this different though this appears not to be the case. The age statistics are not directly comparable in the two tables. However, it seems likely that the mean age of the sample populations are not dissimilar to their national equivalents.

#### Table 1. Survey sample statistics on aspects of demography and socio-economics

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Table 2. National statistics on aspects of demography and socio-economics

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<td>Hungary</td>
<td>10.2</td>
<td>68.8</td>
<td>14.6</td>
<td>5,057</td>
<td>52.3</td>
</tr>
<tr>
<td>Poland</td>
<td>38.6</td>
<td>69.4</td>
<td>12.4</td>
<td>4,369</td>
<td>51.4</td>
</tr>
<tr>
<td>UK</td>
<td>59.2</td>
<td>65.6</td>
<td>16.1</td>
<td>24,388</td>
<td>50.8</td>
</tr>
</tbody>
</table>

Table 3 and Table 4 together give an impression as to how well the issue of air pollution and its health effects was understood by the survey populations in each country. The samples from Switzerland and Denmark were least bothered by air pollution and, correspondingly, were least concerned about the effects of air pollution on their health. The converse was true for the Czech Republic and Poland who had a relatively high degree of bother from air pollution and associated concern. One anomaly was the UK sample which was relatively untroubled by air pollution but was the most concerned of the country samples.

Table 3. Responses to Q1: Does air pollution in your city (physically) bother you? (%)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Very often</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>Never</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>5.6</td>
<td>28.5</td>
<td>34.6</td>
<td>31.3</td>
<td>0</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>30.1</td>
<td>44.5</td>
<td>17.9</td>
<td>6.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Germany</td>
<td>9.3</td>
<td>28.7</td>
<td>32.7</td>
<td>29.3</td>
<td>0</td>
</tr>
<tr>
<td>Denmark</td>
<td>17.3</td>
<td>14</td>
<td>27.9</td>
<td>50.7</td>
<td>0</td>
</tr>
<tr>
<td>Spain</td>
<td>28</td>
<td>40</td>
<td>14</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>France</td>
<td>20.8</td>
<td>50.5</td>
<td>14.8</td>
<td>12.9</td>
<td>1</td>
</tr>
<tr>
<td>Hungary</td>
<td>17.8</td>
<td>44.1</td>
<td>33</td>
<td>5.1</td>
<td>0</td>
</tr>
<tr>
<td>Poland</td>
<td>40</td>
<td>33.3</td>
<td>19.3</td>
<td>7.3</td>
<td>0</td>
</tr>
<tr>
<td>UK</td>
<td>11.3</td>
<td>40.7</td>
<td>24</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td><strong>Pooled data</strong></td>
<td><strong>18.0</strong></td>
<td><strong>35.0</strong></td>
<td><strong>25.4</strong></td>
<td><strong>21.3</strong></td>
<td><strong>0.2</strong></td>
</tr>
</tbody>
</table>

Table 4. Responses to Q2: Are you concerned with the effects of air pollution on your health? (%)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Very much</th>
<th>Somewhat</th>
<th>Not so much</th>
<th>Not at all</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>8.4</td>
<td>41.3</td>
<td>39.7</td>
<td>10.6</td>
<td>0</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>27.5</td>
<td>35.4</td>
<td>28.8</td>
<td>17.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Germany</td>
<td>19.7</td>
<td>46.7</td>
<td>19.3</td>
<td>14.3</td>
<td>0</td>
</tr>
<tr>
<td>Denmark</td>
<td>14.7</td>
<td>44.8</td>
<td>29.4</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Spain</td>
<td>18</td>
<td>51</td>
<td>26</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>France</td>
<td>23.8</td>
<td>33.7</td>
<td>33.7</td>
<td>6.9</td>
<td>2</td>
</tr>
<tr>
<td>Hungary</td>
<td>27.1</td>
<td>28</td>
<td>32.2</td>
<td>11.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Poland</td>
<td>30</td>
<td>44</td>
<td>21.3</td>
<td>4.7</td>
<td>0</td>
</tr>
<tr>
<td>UK</td>
<td>30</td>
<td>44</td>
<td>20.7</td>
<td>8.7</td>
<td>0</td>
</tr>
<tr>
<td><strong>Pooled data</strong></td>
<td><strong>21.6</strong></td>
<td><strong>41.4</strong></td>
<td><strong>27.1</strong></td>
<td><strong>9.6</strong></td>
<td><strong>0.27</strong></td>
</tr>
</tbody>
</table>
Table 5 shows that across the sample there is a high degree of awareness that respondents’ own actions contribute to the air pollution problem. Only the Spanish sample appears not to be well-versed in the linkage.

Table 5. Responses to Q3: Are you aware that your consumption and lifestyle contribute to air pollution?

<table>
<thead>
<tr>
<th>Samples</th>
<th>No</th>
<th>Yes</th>
<th>I know but don’t think about it</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>1.7</td>
<td>86.6</td>
<td>11.7</td>
<td>0</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>8.7</td>
<td>69.9</td>
<td>20.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Germany</td>
<td>6.0</td>
<td>79.7</td>
<td>14.3</td>
<td>0</td>
</tr>
<tr>
<td>Denmark</td>
<td>9.6</td>
<td>90.4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spain</td>
<td>41</td>
<td>52</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>France</td>
<td>4</td>
<td>78.2</td>
<td>17.8</td>
<td>0</td>
</tr>
<tr>
<td>Hungary</td>
<td>7.6</td>
<td>89.8</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>Poland</td>
<td>13.3</td>
<td>84</td>
<td>2.7</td>
<td>0</td>
</tr>
<tr>
<td>UK</td>
<td>13.3</td>
<td>96.7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pooled data</td>
<td>9.1</td>
<td>81.0</td>
<td>9.5</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Question 10 in the survey asks: Are you willing to accept a higher cost of living, therefore an increase in your daily expenses, to gain an increase in your life expectancy? The survey gives a range of possible reasons for answering “no” in order to try to tease out the motives of the respondent. The range of answers offered include:

1. yes
2. no, refuses scenario (link of pollution and LE, payment vehicle, don’t trust institution)
3. no, budget constraint (can’t pay for anything extra, no purchasing power)
4. no, not interested in living longer (to old to benefit, not concerned with LE)
5. no, someone/something else should pay (industries, companies, etc…)
6. no, 3/6 months is too short
7. no, only interested in pollution reduction
8. no, not specified reason (cz)

The responses to this question are summarized in Table 6. In each country, the majority of responses are positive; the respondent is willing to pay something for a gain in life expectancy as a result of a reduction in air pollution. The range of positive answers is from 50% in Spain to 95.6% in Denmark and the mean across the sample is 76.1%. It is worth noting that the Spanish percentage is considerably lower than the other countries. Of the reasons for the zero WTP, the budget constraint is the most significant (6.5%), whilst refusing the scenario is also important (5.8%). The answers are interpreted so as to identify protest bids i.e. responses where respondents state zero even if they have a positive WTP. We judge that answers 2 and 5 signify protest bids and we use this classification in the subsequent analysis of WTP. These responses are highlighted in Table 6 and show that, in sum, 9.6% of the total sample are protest bids.
Table 6. Motivations for zero WTP for gain in life expectancy: Summary results (%)

<table>
<thead>
<tr>
<th>Samples</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>69.8</td>
<td>8</td>
<td>5</td>
<td>3.3</td>
<td>6.7</td>
<td>5</td>
<td>1.7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>79.9</td>
<td>6.5</td>
<td>4.4</td>
<td>1.3</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0.4</td>
<td>2.2</td>
</tr>
<tr>
<td>Germany</td>
<td>74.3</td>
<td>11.0</td>
<td>6.3</td>
<td>2.7</td>
<td>2.7</td>
<td>3.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Denmark</td>
<td>95.6</td>
<td>0</td>
<td>2.9</td>
<td>0.7</td>
<td>0</td>
<td>0.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spain</td>
<td>50</td>
<td>7</td>
<td>10</td>
<td>11</td>
<td>15</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>France</td>
<td>77.2</td>
<td>5.9</td>
<td>7.9</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hungary</td>
<td>71.2</td>
<td>5.9</td>
<td>13.6</td>
<td>2.5</td>
<td>5.1</td>
<td>1.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Poland</td>
<td>62.7</td>
<td>11.3</td>
<td>12.7</td>
<td>4.7</td>
<td>3.3</td>
<td>1.3</td>
<td>3.3</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>UK</td>
<td>93.3</td>
<td>0</td>
<td>0</td>
<td>0.7</td>
<td>1.3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>Pooled data</td>
<td>75.7</td>
<td>6.8</td>
<td>6.5</td>
<td>3.0</td>
<td>3.5</td>
<td>3.1</td>
<td>0.5</td>
<td>0.1</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Table 7 gives a further analysis of the zero responses to Question 10 in the survey. It shows that there is a large variation between the percentage of zero bids in the total sample between countries, around a mean of 26% across the whole sample. Whilst Denmark and UK have very low percentages (4 and 7 respectively), Spain has the highest (53%). The whole sample mean is typical of what one might expect from a CV survey whilst the low values for Denmark and UK are rather unusual and not easy to explain. Whilst most countries show about 40% of their zero bids to be protests, Denmark and UK have 0% and 18% respectively, from their low number of total zeros.

Table 7. Protest responses analysis (using the responses to 3 months life expectancy gain)

<table>
<thead>
<tr>
<th>Countries</th>
<th>Total sample (N)</th>
<th>WTP=0 (% of total sample)</th>
<th>Protest (% of WTP=0)</th>
<th>WTP=0 (% of total sample, protest removed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>179</td>
<td>31</td>
<td>49</td>
<td>18</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>229</td>
<td>19</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td>Germany</td>
<td>300</td>
<td>29</td>
<td>48</td>
<td>17</td>
</tr>
<tr>
<td>Denmark</td>
<td>136</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Spain</td>
<td>100</td>
<td>53</td>
<td>42</td>
<td>40</td>
</tr>
<tr>
<td>France</td>
<td>101</td>
<td>35</td>
<td>29</td>
<td>27</td>
</tr>
<tr>
<td>Hungary</td>
<td>118</td>
<td>31</td>
<td>35</td>
<td>23</td>
</tr>
<tr>
<td>Poland</td>
<td>150</td>
<td>38</td>
<td>39</td>
<td>27</td>
</tr>
<tr>
<td>UK</td>
<td>150</td>
<td>7</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>Pooled data</td>
<td>1,463</td>
<td>26</td>
<td>39</td>
<td>18</td>
</tr>
</tbody>
</table>

5. WTP Results

5.1. Analysis

Using the payment card mechanism described in Section 3 the survey asked in Question 11:

What is the maximum amount you are willing to pay in the form of higher expenses to gain an average of 6 months in your life expectancy, per month for the rest of your life?

The question was repeated for a gain of 3 months in life expectancy.

The resulting WTP data collected were analyzed, excluding the protest bids outlined in Section 3 above. Due to variations between countries in the common structure of the WTP
questions we were unable to impose a distribution on the data in parametric analysis. Consequently, the values reported are derived from simple non-parametric treatments of the datasets.

Table 8 shows the WTP data relating to the 3 month question. The higher mean values than median values reflect the right-skewed distribution of the observations – a common pattern in these kinds of valuation experiments reflecting a number of high-end outliers. The mean values for the different countries are generally clustered, with a pooled average of just under €22. Most of the country variation may be explained by differences in income level, though the mean value of €42 for Denmark is markedly different.

Table 8. Monthly WTP for 3 months life expectancy gain, excluding protest responses (€2005, PPP-adjusted)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Obs</th>
<th>Median</th>
<th>Mean</th>
<th>Std. err</th>
<th>95% confidence interval (mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland (a)</td>
<td>148</td>
<td>12.57</td>
<td>27.55</td>
<td>3.3</td>
<td>21.0</td>
</tr>
<tr>
<td>Czech Republic (a)</td>
<td>213</td>
<td>8.92</td>
<td>27.63</td>
<td>3.4</td>
<td>20.9</td>
</tr>
<tr>
<td>Germany</td>
<td>254</td>
<td>20.81</td>
<td>36.75</td>
<td>3.6</td>
<td>29.6</td>
</tr>
<tr>
<td>Denmark</td>
<td>134</td>
<td>22.81</td>
<td>42.21</td>
<td>3.8</td>
<td>34.6</td>
</tr>
<tr>
<td>Spain</td>
<td>78</td>
<td>11.04</td>
<td>25.26</td>
<td>4.3</td>
<td>16.6</td>
</tr>
<tr>
<td>France</td>
<td>91</td>
<td>9.36</td>
<td>22.47</td>
<td>3.1</td>
<td>16.2</td>
</tr>
<tr>
<td>Hungary</td>
<td>105</td>
<td>3.35</td>
<td>14.07</td>
<td>2.6</td>
<td>9.0</td>
</tr>
<tr>
<td>Poland (a)</td>
<td>128</td>
<td>8.20</td>
<td>17.72</td>
<td>3.6</td>
<td>10.5</td>
</tr>
<tr>
<td>UK</td>
<td>148</td>
<td>10.77</td>
<td>21.25</td>
<td>2.6</td>
<td>16.2</td>
</tr>
<tr>
<td><strong>Pooled data</strong></td>
<td>1299</td>
<td>11.56</td>
<td>27.60</td>
<td>1.2</td>
<td>25.2</td>
</tr>
</tbody>
</table>

Note: For those countries marked with (a) values correspond to the mid-point interval between the highest bid value that respondents agreed to pay and the following bid value. For all other countries values correspond to the maximum WTP value obtained in an open question that followed the bid game.

Table 9 shows the results of both the 3-month and 6-month WTP questions also including the introduction of a further data cleaning protocol. This protocol aimed at removing outliers simply removed those observations that were “yes” responses to the highest payment card bid, on the basis that these were unlikely to be realistic payments given a budget constraint. The table shows, as expected, that the removal of these bids lowers the bids fractionally.

The table also disaggregates the WTP mean totals by region, highlighting the fact that the values for the original “EU16” countries are between 10% and 85% higher than those for the new member countries.

As with many of the previous studies that value premature mortality changes, the WTP values are not in proportion to the length of the life extension gain. Thus, whilst we might expect the 6 month: 3 month ratio to be close to 2, for the pooled sample the figure is 1.28. Also, there is little difference in this ratio between “EU16” and the new member countries: 1.25 and 1.32, respectively. Analysis of the answers to a subsequent question in the survey, Q17, showed that there was significant variation between countries of the dominant reason given, but overall the main reason was that respondents were able not able to see much difference between 3 and 6 months as a life extension.

---

1 For Switzerland, Czech Republic and Poland we assumed maximum WTP equal to the mid-point of the interval between the maximum bid value accepted (and informed) and the following bid value.
Table 9. Comparison of WTP 3 and 6 month Mean WTP (PPP-adjusted € per month) with data cleaning protocols

<table>
<thead>
<tr>
<th>Country</th>
<th>For 6months LE gain</th>
<th>For 3months LE gain</th>
<th>Ratio 6M/3M</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protesters deleted</td>
<td>Protesters and outliers deleted</td>
<td>Protesters deleted</td>
</tr>
<tr>
<td>Switzerland</td>
<td>32.61</td>
<td>29.26</td>
<td>27.22</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>35.76</td>
<td>35.76</td>
<td>37.86</td>
</tr>
<tr>
<td>Germany</td>
<td>50.01</td>
<td>39.33</td>
<td>41.86</td>
</tr>
<tr>
<td>Denmark</td>
<td>46.52</td>
<td>37.81</td>
<td>25.39</td>
</tr>
<tr>
<td>Spain</td>
<td>32.39</td>
<td>27.4</td>
<td>22.49</td>
</tr>
<tr>
<td>France</td>
<td>33.99</td>
<td>33.99</td>
<td>14.18</td>
</tr>
<tr>
<td>Hungary</td>
<td>19.30</td>
<td>19.30</td>
<td>18.48</td>
</tr>
<tr>
<td>Poland</td>
<td>25.78</td>
<td>25.78</td>
<td>21.53</td>
</tr>
<tr>
<td>“EU16”</td>
<td>39.60</td>
<td>33.65</td>
<td>31.03</td>
</tr>
<tr>
<td>NMC</td>
<td>29.02</td>
<td>29.02</td>
<td>21.93</td>
</tr>
<tr>
<td>Pooled data</td>
<td>35.99</td>
<td>32.04</td>
<td>27.91</td>
</tr>
</tbody>
</table>

The following three tables reflect responses to questions asked subsequent to the WTP questions and shed more light on the reliability of, and rationale for, the WTP results. Question 24 asks: What expenses did you think about that you would forgo when you were thinking of an amount for your willingness to pay? The options given are:

1. reduce insignificant expenditures (sweets, alcohol, cigarettes, cinema, magazines, etc.)
2. reduce savings
3. reduce significant expenditures (food, restaurants, clothes, car energy bills, luxuries, etc.)
4. amount that does not disturb present expenditures, savings
5. Did not think about it (CZ)
6. Others (CZ)

Responses to this question are given in Table 10. The table shows that all countries apart from Czech Republic and Denmark, respondents said that the payment for the gain in life expectancy would be at the expense of expenditures on “insignificant”, or trivial, items such as cinema tickets. The majority of respondents from Denmark thought that that the expenditure would be afforded through savings. The results from the Czech Republic are not directly comparable to those for other countries since that country survey included two additional options, indicated. Interestingly, here the majority of respondents admitted not to have thought how the expenditures would be afforded.
Table 10. Responses to Q24 relating to foregone expenses (%)

<table>
<thead>
<tr>
<th>Samples</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>37.4</td>
<td>11.2</td>
<td>21.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30.2</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>14.4</td>
<td>0.9</td>
<td>14</td>
<td>11.3</td>
<td>41.5</td>
<td>0.9</td>
<td>17</td>
</tr>
<tr>
<td>Germany</td>
<td>9.7</td>
<td>0.3</td>
<td>14.3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>74.7</td>
</tr>
<tr>
<td>Denmark</td>
<td>20.6</td>
<td>4.4</td>
<td>7.3</td>
<td>22.8</td>
<td>0</td>
<td>0</td>
<td>44.8</td>
</tr>
<tr>
<td>Spain</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>98</td>
</tr>
<tr>
<td>France</td>
<td>28</td>
<td>2</td>
<td>19</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>48.5</td>
</tr>
<tr>
<td>Hungary</td>
<td>24.6</td>
<td>7.6</td>
<td>18.6</td>
<td>2.5</td>
<td>10.2</td>
<td>0</td>
<td>36.4</td>
</tr>
<tr>
<td>Poland</td>
<td>29.3</td>
<td>10</td>
<td>8</td>
<td>15.3</td>
<td>0</td>
<td>0</td>
<td>37.3</td>
</tr>
<tr>
<td>UK</td>
<td>47.3</td>
<td>11.3</td>
<td>10</td>
<td>24.7</td>
<td>0</td>
<td>0</td>
<td>6.7</td>
</tr>
<tr>
<td><strong>Pooled data</strong></td>
<td>22.5</td>
<td>5.1</td>
<td>13.1</td>
<td>8.6</td>
<td>7.3</td>
<td>0.1</td>
<td>33.3</td>
</tr>
</tbody>
</table>

Question 18 asked: Are you confident of the amount you stated you were willing to pay to increase your life expectancy an average of 6(3) months? The majority of respondents are confident of their WTP bids, lending some support to the belief that these can be interpreted as their true WTP. However, the use of these statistics is, in part, limited by the numbers of missing responses in a number of countries, most noticeably Spain where 50% of the responses are missing.

Table 11. Responses to Q18: Are you confident in your WTP answer?

<table>
<thead>
<tr>
<th>Samples</th>
<th>No</th>
<th>Yes</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>9 (5%)</td>
<td>115 (64.2%)</td>
<td>55 (30.7%)</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>17 (7.4%)</td>
<td>191 (83.4%)</td>
<td>21 (9.2%)</td>
</tr>
<tr>
<td>Germany</td>
<td>44 (14.7%)</td>
<td>179 (59.7%)</td>
<td>77 (25.7%)</td>
</tr>
<tr>
<td>Denmark</td>
<td>23 (16.9%)</td>
<td>112 (82.3%)</td>
<td>1 (0.7%)</td>
</tr>
<tr>
<td>Spain</td>
<td>49 (49%)</td>
<td>1 (1%)</td>
<td>50 (50%)</td>
</tr>
<tr>
<td>France</td>
<td>35 (34.6%)</td>
<td>66 (65.3%)</td>
<td>0</td>
</tr>
<tr>
<td>Hungary</td>
<td>0</td>
<td>85 (72%)</td>
<td>33 (28%)</td>
</tr>
<tr>
<td>Poland</td>
<td>9 (6%)</td>
<td>85 (56.7%)</td>
<td>56 (37.3%)</td>
</tr>
<tr>
<td>UK</td>
<td>21 (14%)</td>
<td>119 (79.3%)</td>
<td>10 (6.7%)</td>
</tr>
<tr>
<td><strong>Pooled data</strong></td>
<td>207 (14.1%)</td>
<td>953 (65.1%)</td>
<td>303 (20.7%)</td>
</tr>
</tbody>
</table>

A further potentially important question in helping to explain the WTP bids was Question 20 that asked: When you picked an amount, what did you think about the most? The options offered were:

1. only about your life expectancy
2. cleaner air and its overall benefits on health (I will breathe better, will be in better health)
3. a bit of both
4. other

The responses to this question are summarized in Table 12. Whilst, overall, the most frequent explanation was that respondents were thinking of cleaner air as well as all the health benefits (27% of the pooled sample) there was a diverse pattern of responses across countries. Thus, whilst the most popular answer in Spain was “only life expectancy”, in France and Switzerland it was “cleaner air and its overall benefits on health”, in Hungary it was “a bit of both” and in the Czech Republic it was “other”. Only 12% of the total sample population valued the life expectancy extension alone. However, even if this result indicates that the stated WTP is an overestimate for increased life expectancy, we cannot rule out that this
question in itself made the respondents uncertain about what they were actually asked to value and lead them to state that they considered not only the life expectancy even if they actually had done so.

Table 12: Responses to Q20: What did you think about most in answering WTP?

<table>
<thead>
<tr>
<th>Samples</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>5.6</td>
<td>40.8</td>
<td>23.5</td>
<td>0</td>
<td>30.2</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>18.8</td>
<td>22.7</td>
<td>9.2</td>
<td>44</td>
<td>5.2</td>
</tr>
<tr>
<td>Germany</td>
<td>7</td>
<td>21.3</td>
<td>34.3</td>
<td>11.7</td>
<td>25.7</td>
</tr>
<tr>
<td>Denmark</td>
<td>3.7</td>
<td>29.4</td>
<td>12.5</td>
<td>8.1</td>
<td>46.3</td>
</tr>
<tr>
<td>Spain</td>
<td>61</td>
<td>0</td>
<td>26</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
<td>51.5</td>
<td>21.08</td>
<td>2</td>
<td>24.6</td>
</tr>
<tr>
<td>Hungary</td>
<td>3.4</td>
<td>20.3</td>
<td>44.1</td>
<td>4.2</td>
<td>28</td>
</tr>
<tr>
<td>Poland</td>
<td>3.3</td>
<td>24.7</td>
<td>28.7</td>
<td>6</td>
<td>37.3</td>
</tr>
<tr>
<td>UK</td>
<td>8</td>
<td>24.7</td>
<td>29.3</td>
<td>31.3</td>
<td>6.7</td>
</tr>
<tr>
<td><strong>Pooled data</strong></td>
<td><strong>11</strong></td>
<td><strong>25.9</strong></td>
<td><strong>25.3</strong></td>
<td><strong>15.1</strong></td>
<td><strong>22.7</strong></td>
</tr>
</tbody>
</table>

5.2. Validity test

We tested the construct validity of our survey by regressing the stated WTP of the pooled sample on income (which is the only variable from economic theory we expect to influence WTP) and other characteristics of the respondents. Income had a significant positive effect on WTP, as expected (the income variable used was either personal or household income, depending on which of these two the respondent stated he/she used when stating their WTP). If respondents stated concern about health effects of air pollution, they also have significantly higher WTP than those that did not. Those that were sure about their stated WTP also gave significantly higher WTP than those that were not. WTP was also significantly higher for male respondents, and those with the highest education. Age, however, had no significant effect.

We used regression analysis to perform validity testing on the WTP estimates, in order to identify the individual characteristics that explain respondents’ WTP. We used a simple model defined as:

\[ WTP = \alpha + x_\cdot \beta + \varepsilon \]

where (\varepsilon) is the error term, (x) is a 1 x k vector of individual characteristics and (\beta) is a k x 1 vector of unknown parameters.

The results are presented in Table 13. For both the 3 and 6 months life expectancy gain income is a positive significant explanatory variable at 1% level, as one might expect. Other positive significant variables at 1% or 5% for both 3 and 6 month gains include: respondents’ confidence in their WTP answers; male gender, and; education. This result suggests that men with university degree tend to express higher WTP for an increase in their life expectancy. Concern with the health effects of air pollution is statistically significant at 1% for the 6 month LE gain and 10% for the 1 month LE gain. Age is positive but not significant at 10%, at least. Overall the regressions have low explanatory power (and highest for the 3 months LE gain), but not lower than found in most CV studies. Thus, we conclude that the survey has provided valid responses.
### Table 13: Validity test of WTP – Pooled data – protesters and outliers deleted

<table>
<thead>
<tr>
<th>Covariates</th>
<th>6months LE gain</th>
<th>3months LE gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>Robust standard error</td>
</tr>
<tr>
<td>Constant</td>
<td>-16.53</td>
<td>16.28</td>
</tr>
<tr>
<td>Q1 - Air pollution physically bothers you?</td>
<td>1.83</td>
<td>1.58</td>
</tr>
<tr>
<td>Q2 - Concerned with health effects of air pollution?</td>
<td>3.57 (**)</td>
<td>1.46</td>
</tr>
<tr>
<td>Q3 - Aware that lifestyle contributes to air pollution?</td>
<td>-0.84</td>
<td>2.66</td>
</tr>
<tr>
<td>Q3a - Knows that air pollution is harmful to health?</td>
<td>3.26</td>
<td>3.05</td>
</tr>
<tr>
<td>Q6 - Subjective health status of respondent (1=good; 2=average; 3=poor health)</td>
<td>-0.37</td>
<td>2.58</td>
</tr>
<tr>
<td>Respondent has bronchitis and/or asthma</td>
<td>-3.59</td>
<td>3.84</td>
</tr>
<tr>
<td>Respondent has emphysema, cancer, cardiovascular or other serious diseases</td>
<td>4.04</td>
<td>4.72</td>
</tr>
<tr>
<td>Smoker</td>
<td>4.57 (*)</td>
<td>2.71</td>
</tr>
<tr>
<td>Q18 - Sure about stated WTP figures</td>
<td>8.30 (***)</td>
<td>2.93</td>
</tr>
<tr>
<td>Q25 - Private health insurance</td>
<td>3.72</td>
<td>2.73</td>
</tr>
<tr>
<td>Male</td>
<td>6.79 (***)</td>
<td>2.76</td>
</tr>
<tr>
<td>Superior education level</td>
<td>6.67 (***)</td>
<td>3.26</td>
</tr>
<tr>
<td>Age</td>
<td>0.66</td>
<td>0.68</td>
</tr>
<tr>
<td>Age square</td>
<td>-0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Income (used to express WTP – individual or household income)</td>
<td>0.004 (***)</td>
<td>0.001</td>
</tr>
<tr>
<td>N</td>
<td>992</td>
<td>986</td>
</tr>
<tr>
<td>R-square</td>
<td>0.0634</td>
<td>0.0653</td>
</tr>
</tbody>
</table>

Note: (*) Significant at 10%; (**) significant at 5%; (***) Significant at 1%

### 5.3. Income elasticity

The WTP income elasticity was estimated using a simple double-log (in WTP and income) model while controlling for the significant individual characteristics observed in the WTP validity tests (variables Q2, Q18, and dummies ‘male’ and ‘superior education’). That is, the general model used to estimate income-elasticity of WTP is as follows:

$$\text{log}(WTP) = \alpha + \beta \text{log}(\text{income}) + x.\delta + \varepsilon,$$

where ($\beta$) corresponds to the income-elasticity of WTP, ($\varepsilon$) is the error term, ($x$) is the 1 x k vector of individual characteristics, and ($\delta$) is a k x 1 vector of unknown parameters. The sub-sample used did not include protesters and outliers. A number of variants to this model were estimated:

- **Model 1**: \(\text{log}(WTP) = \alpha + \beta \text{log}(\text{individual income}) + x.\delta + \varepsilon,\) all respondents;
- **Model 2**: \(\text{log}(WTP) = \alpha + \beta \text{log}(\text{individual income}) + x.\delta + \varepsilon,\) only those who thought about individual income when stating WTP;
- **Model 3**: \(\text{log}(WTP) = \alpha + \beta \text{log}(\text{household income}) + x.\delta + \varepsilon,\) all respondents;
- **Model 4**: \(\text{log}(WTP) = \alpha + \beta \text{log}(\text{household income}) + x.\delta + \varepsilon,\) only those who thought about household income when stating WTP;
Model 5: \[ \log(WTP) = \alpha + \beta \log(\text{relevant income}) + x_i \delta + \epsilon, \] all respondents, using the income thought when stating WTP.

The results are presented in Tables 14 and 15 for 6 months and 3 months gains in life expectancy, respectively. The range for the pooled sample – on which we would put the most weight – is between 0.38 and 0.69, conforming well to existing estimates in the literature. Regarding model 5, where WTP income elasticity is estimated using the income considered by respondents when eliciting their WTP, WTP is shown to be inelastic in most countries (< 1), which means that the percentage variation in WTP is lower that a percentage variation in income. The exceptions are Switzerland and Hungary for the 3 months life expectancy increase. Values for 6 month gains are slightly less than for 3 months gains. The values are lower for the “EU16” country group than the new member countries, perhaps reflecting a luxury good aspect to life expectancy gains (but note that there is no unique link between income elasticity of WTP and income elasticity of demand used to define a luxury good).

### Table 14. WTP INCOME ELASTICITIES – For 6 months LE gain

<table>
<thead>
<tr>
<th>Country</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.779</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.541</td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td></td>
<td>0.188</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.432</td>
</tr>
<tr>
<td>Spain</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.136</td>
</tr>
<tr>
<td>France</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.779</td>
</tr>
<tr>
<td>Hungary</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.960</td>
</tr>
<tr>
<td>Poland</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.264</td>
</tr>
<tr>
<td>UK</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.290</td>
</tr>
<tr>
<td>“EU16”</td>
<td>0.080</td>
<td>0.012</td>
<td>0.176</td>
<td>0.594</td>
<td>0.156</td>
</tr>
<tr>
<td>NMC</td>
<td>0.527</td>
<td>0.596</td>
<td>0.708</td>
<td>0.565</td>
<td>0.557</td>
</tr>
<tr>
<td>Pooled data</td>
<td>0.338</td>
<td>0.345</td>
<td>0.455</td>
<td>0.586</td>
<td>0.374</td>
</tr>
</tbody>
</table>

### Table 15. WTP INCOME ELASTICITIES – For 3 months LE gain

<table>
<thead>
<tr>
<th>Country</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1.815</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.505</td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td></td>
<td>0.129</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.326</td>
</tr>
<tr>
<td>Spain</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.434</td>
</tr>
<tr>
<td>France</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.980</td>
</tr>
<tr>
<td>Hungary</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1.026</td>
</tr>
<tr>
<td>Poland</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.304</td>
</tr>
<tr>
<td>UK</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.508</td>
</tr>
<tr>
<td>“EU16”</td>
<td>0.110</td>
<td>0.069</td>
<td>0.192</td>
<td>0.591</td>
<td>0.222</td>
</tr>
<tr>
<td>NMC</td>
<td>0.512</td>
<td>0.552</td>
<td>0.694</td>
<td>0.575</td>
<td>0.548</td>
</tr>
<tr>
<td>Pooled data</td>
<td>0.368</td>
<td>0.376</td>
<td>0.478</td>
<td>0.607</td>
<td>0.419</td>
</tr>
</tbody>
</table>
6. VLOY calculation and discussion

6.1. Calculation of VLOY

We used the non-parametric WTP figures shown in Table 9 to estimate the value of a life year according to two slightly different equations. The first uses the life expectancy \( \text{LE}_k \) and average age of the same in each country \( k \)

\[
\text{VLOY}_k = (\text{WTP}_{3,k} \times 12) \times 4 \times (\text{LE}_k - \text{average age of sample}_k)
\]

(1)

\[
\text{VLOY}_k = (\text{WTP}_{6,k} \times 12) \times 2 \times (\text{LE}_k - \text{average age of sample}_k)
\]

for the average 3 and 6 month WTPs in country \( k \), respectively. The results are shown in Table 16, using the mean WTP.

<table>
<thead>
<tr>
<th>Country</th>
<th>For 6months LE gain</th>
<th>For 3months LE gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protesters deleted</td>
<td>Protesters and outliers deleted</td>
</tr>
<tr>
<td>Switzerland</td>
<td>25,592</td>
<td>22,963</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>28,236</td>
<td>28,236</td>
</tr>
<tr>
<td>Germany</td>
<td>45,489</td>
<td>35,775</td>
</tr>
<tr>
<td>Denmark</td>
<td>30,592</td>
<td>24,864</td>
</tr>
<tr>
<td>Spain</td>
<td>23,243</td>
<td>19,662</td>
</tr>
<tr>
<td>France</td>
<td>25,452</td>
<td>25,452</td>
</tr>
<tr>
<td>Hungary</td>
<td>7,874</td>
<td>7,874</td>
</tr>
<tr>
<td>Poland</td>
<td>18,314</td>
<td>18,314</td>
</tr>
<tr>
<td>UK</td>
<td>26,045</td>
<td>24,534</td>
</tr>
<tr>
<td>“EU16”</td>
<td>30,318</td>
<td>25,762</td>
</tr>
<tr>
<td>NMC</td>
<td>19,339</td>
<td>19,339</td>
</tr>
<tr>
<td>Pooled data</td>
<td>26,258</td>
<td>23,376</td>
</tr>
</tbody>
</table>

Alternatively, we used the remaining life expectancy \( \Delta \text{LE}_{k,i} \) of each individual \( i \) (calculated by means of the life tables of each country \( k \) according to the gender and age of respondent \( i \))

\[
\text{VLOY}_k = \frac{1}{n_k} \sum_{i=1}^{n_k} (\text{WTP}_{3,k,i} \times 12) \times 4 \times \Delta \text{LE}_{k,i}
\]

(2)

\[
\text{VLOY}_k = \frac{1}{n_k} \sum_{i=1}^{n_k} (\text{WTP}_{6,k,i} \times 12) \times 2 \times \Delta \text{LE}_{k,i}
\]

where \( n_k \) = number of respondents in country \( k \). Table 17 shows the resulting mean and median VLOYS for the sub-samples where protesters and outliers were excluded.
Table 17. INDIVIDUAL VOLY (PPP-adjusted €)

<table>
<thead>
<tr>
<th>Country</th>
<th>For 6months LE gain</th>
<th>For 3months LE gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protesters and outliers deleted</td>
<td>Protesters and outliers deleted</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
</tr>
<tr>
<td>Switzerland</td>
<td>24,307</td>
<td>11,487</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>32,334</td>
<td>11,520</td>
</tr>
<tr>
<td>Germany</td>
<td>35,034</td>
<td>21,690</td>
</tr>
<tr>
<td>Denmark</td>
<td>27,945</td>
<td>16,254</td>
</tr>
<tr>
<td>Spain</td>
<td>22,371</td>
<td>12,663</td>
</tr>
<tr>
<td>France</td>
<td>27,351</td>
<td>15,183</td>
</tr>
<tr>
<td>Hungary</td>
<td>11,759</td>
<td>3,243</td>
</tr>
<tr>
<td>Poland</td>
<td>25,220</td>
<td>9,983</td>
</tr>
<tr>
<td>UK</td>
<td>30,139</td>
<td>19,317</td>
</tr>
<tr>
<td>“EU16”</td>
<td>27,863</td>
<td>16,778</td>
</tr>
<tr>
<td>NMC</td>
<td>24,525</td>
<td>8,105</td>
</tr>
<tr>
<td>Pooled data</td>
<td>27,642</td>
<td>14,115</td>
</tr>
</tbody>
</table>

In order to account for differences in population sizes among the 9 countries in our sample we re-estimated the pooled countries VOLY weighted by the populations in the new member countries (NMC) and the EU15 countries. In mathematical form:

$$VOLY_{POOLED \text{- WEIGHTED}} = \frac{(VOLYNMC \times POP_{NMC}) + (VOLYEU_{16} \times POP_{EU_{16}})}{POP_{NMC} + POP_{EU_{16}}}$$

(3)

The results can be seen in Table 18.

Table 18. POPULATION-WEIGHTED VOLY (PPP-adjusted €) – Protesters and outliers deleted, comparison of Eq.(1) and Eq.(2) and population weighting with Eq.(3).

<table>
<thead>
<tr>
<th>VOLY estimates</th>
<th>“EU16”</th>
<th>NMC</th>
<th>Population-weighted pooled, Eq.(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>For 6months LE gain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean as in (1)</td>
<td>25,762</td>
<td>19,339</td>
<td>24733</td>
</tr>
<tr>
<td>Mean as in (2)</td>
<td>27,863</td>
<td>24,525</td>
<td>27328</td>
</tr>
<tr>
<td>Median as in (1)</td>
<td>16,989</td>
<td>5,984</td>
<td>15226</td>
</tr>
<tr>
<td>Median as in (2)</td>
<td>16,778</td>
<td>8,105</td>
<td>15389</td>
</tr>
<tr>
<td>For 3months LE gain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean as in (1)</td>
<td>40,133</td>
<td>29,228</td>
<td>38386</td>
</tr>
<tr>
<td>Mean as in (2)</td>
<td>42,548</td>
<td>37,309</td>
<td>41709</td>
</tr>
<tr>
<td>Mean, averaged over (1) and (2)</td>
<td>41,341</td>
<td>33,269</td>
<td>40048</td>
</tr>
<tr>
<td>Median as in (1)</td>
<td>20,886</td>
<td>11,409</td>
<td>19368</td>
</tr>
<tr>
<td>Median as in (2)</td>
<td>22,921</td>
<td>11,174</td>
<td>21039</td>
</tr>
<tr>
<td>Population (million)</td>
<td>388 (EU15)</td>
<td>74 (EU25-EU15)</td>
<td>462 (EU25)</td>
</tr>
</tbody>
</table>

6.2. Mean versus median

As usual in CV surveys, the mean WTP is much higher than the median. Some authors prefer using the median because it is less sensitive to high outliers that are not considered
representative or realistic. However, there is another consideration for the present study which is supposed to determine an appropriate VOLY for environmental policy decisions: the median is in effect a voting system where the WTP of each individual is counted only as being above or below a reference value, i.e. the median. By contrast, the mean takes the strength of the vote into account: an individual A whose WTP is twice that of an individual B carries twice as much weight in the determination of the result. Choosing the median is thus closer in spirit to typical yes/no choices in democratic elections. However, one could also argue that the strength of a vote should be taken into account for issues that clearly involve a matter of degree. Determining a VOLY for environmental policy is a matter of degree, not a simple yes/no, and thus it seems more appropriate to take the strength of each vote into account.

There is also the question “who pays?”. The cost of pollution control per person tends to increase with income and consumption (the detailed attribution of costs depending of course on many factors, for instance the way the environmental policies are formulated). To the extent that WTP also increases with income, it seems fair that individuals with high WTP end up paying more. For these reasons we believe that the means are more appropriate and we base our recommended VOLY on the mean WTP.

In a recent paper, Baker et al (2007), have examined the question of who pays and who benefits in detail and provide a theoretical foundation that justifies the application of a “common” VSL for the prevention of a statistical fatality by any particular cause within a given society, irrespective of the of the per capita income level of the sub-group in society to which the safety improvement will actually apply. The model that is utilised, starts from the premise that a society will seek to maximize a weighted-additive utilitarian welfare function. A constraint is then added to structure this welfare function so that everyone’s gain (or loss) in survival probability is treated equally, i.e. ensuring that everyone’s life is treated equally by society.

This paper draws two important conclusions: under the assumptions of the model a common VSL should be applied, even if the individuals in society who pay for the safety improvement do not benefit from it; and in societies that have a general tax structure that is similar to the one found in either the USA or UK, using the arithmetic mean of a sample of the population’s willingness to pay for the safety improvement will result in a statistically valid estimator of the “true” willingness to pay.

### 6.3. Discussion

The main results of the Value of a Life Year (VOLY) calculations, based on the willingness-to-pay (WTP) questions for a 6 and 3 months gain in life expectancy (LE), are:

(i) Mean WTP is more than twice as high as the median WTP. Mean WTP is the theoretically correct measure (based on welfare economics).

(ii) For the pooled sample for all 9 countries, 39 % of those that stated zero WTP are classified as protest zeros, i.e. they have a positive WTP but state zero because they protest one or more aspects of the CV scenario. These protest zero answers should be deleted when calculating mean and median WTP.
(iii) The outliers (here defined as those that accepted the highest bid on the payment card in each country) were only 15 and 13 for 3 and 6 months LE gain, respectively. Thus, they constitute less than 1.5% of the sample, but deleting them reduces the mean VOLY by 11-13%. The highest bid on the payment card implies a monthly WTP of about 250 €, and an annual WTP of 3,000 €, for almost everyone unrealistic high compared to disposable income. Even though we cannot exclude the possibility that a small part of European population has such a high WTP, this portion is probably overestimated in our sample. In order not to overestimate VOLY, we recommend using the estimates where these outliers are excluded.

(iv) The sample size for each country is too small to provide reliable country estimates of VOLY. However, the pooled sample from all 9 countries, and the estimates for “EU16” (i.e. EU15 + Switzerland, the EU15 represented here by Denmark, Spain, France, Germany and the UK,) and NMC (New Member Countries, represented here by the Czech Republic, Hungary and Poland) are large enough to produce representative estimates of VOLY.

(v) VOLY estimates based on WTP for a 3-months LE gain are significantly higher than those based on WTP for 6-months LE., since mean WTP for a 6 months LE gain is much less than twice the WTP for a 3 months LE gain; for the pooled sample the ratio is 1.29. Because individuals’ budget constraint will kick in for the 6-months LE, we recommend using the mean VOLY estimate based on the WTP for a 3-months LE gain.

(vi) VOLY is calculated as the stated mean WTP/month/individual multiplied by 12 to get annual WTP. Since this is the annual WTP for a 3 or 6 months LE gain, this number is multiplied by 4 and 2, respectively, to get WTP for a year gained. To get the WTP over their remaining lifetime2, we calculate VOLY as the present value (assuming a zero discount rate) over their remaining life length (defined as their life expectancy (based on country average for each age class) minus their age). We have used both the sample average age and the actual age of the individuals. The last procedure, which we consider to be theoretically more correct, produce somewhat higher VOLYs. Here we take the average of these two procedures (Eq.1 and Eq.2).

Based on these considerations and the numbers in Table 18, our recommended VOLY estimates are (Mean values based on 3 months LE gain with protesters and outliers deleted and individual remaining LE)

\[
\begin{align*}
\text{"EU16":} & \quad 41,000 \text{ € (rounded from 41,341),} \\
\text{NMC:} & \quad 33,000 \text{ € (rounded from 33,269).}
\end{align*}
\]

However, for cost-benefit analyses of EU directives and policies we would recommend using the same value for the entire EU25 (“EU26”, including Switzerland), based on the VOLY

\footnote{An alternative would be to multiply by the life expectancy. This perpetuity argument is as follows: Respondents focus primarily on the periodic payment, and do not think of a benefit being worth some lump-sum amount and then adjust their periodic payment in the light of their remaining life expectancy. One way of interpreting/using such responses is as follows: Suppose government is contemplating some package of measures to bring about/sustain some reduction in pollution to a degree that is expected to give people a month more life expectancy (in normal health) than would be the case if the package of measures were not implemented. Suppose also that it is estimated that this package of measures, to be implemented and sustained for the indefinite future, would effectively impose costs of £25 per year (at current prices) for every member of the population. If we track a typical cohort of individual from birth to death, this would mean that during their earlier years when they are financially dependent on parents/guardians, the £25 for each of them is borne by those p/g's; when they become financially independent, they bear the cost themselves; and if they in turn come to have dependants, they bear the costs on behalf of those dependants; and there may even be a final phase when they once again become dependent in their old age, so that whoever is then responsible for them bears the cost. If we want to know whether society is willing to pay the price of a package of measures that has this implication, one way to answer that is to take a representative cross-section of the current population, embodying people at all of the above stages of life, and find out if this group would be willing to pay amounts that would cover the £25-per-head cost. We have, however, conservatively assumed that respondents thought about their remaining LE when stating their WTP.}
value from the pooled sample, with population-weighting according to Eq.4 to get the correct proportion of the NMC in the population of the EU25. The result is EU25: 40,000 € (rounded from 40,048).

7. Benefit Transfer

Transfer errors and validity of transfers were tested by using the pooled sample except one country, transferring the mean and median WTP estimates to this country, and comparing the transferred estimate with original primary WTP estimate. Since the explanatory power of the WTP function was found to be low, we performed unit value transfers rather than benefit function transfers. Simple unit value transfers (in Purchase Power Parity (PPP)-euros), and unit transfer with income adjustments (assuming both income elasticity of WTP equal to 1, and the income elasticity calculated from the sample): The income elasticity of WTP was found to be less than 1 in all models and countries, and typically in the range 0.4-0.6 for the pooled sample based on the income respondents used when stating their WTP (i.e. model 5 in Section 5). Income elasticity was typically higher in NMC than “EU16”, showing that WTP for a LE gain increases more with income in low-income countries.

The transfer errors for mean WTP, however, seems to be the lowest for the simple unit value transfer, with an average of 21-24% for the pooled sample. Unit transfers with income adjustments (and income elasticity equal to 1) do worse (41-42% transfer error), and the transfer error is even higher when we apply the estimated income elasticities (i.e. 72-73% transfer error). Tests of the validity of these benefit transfers (using an equivalency test where the null hypothesis is that the transferred and original mean WTP are different, and accepting a transfer error of ±20%) show that in 7 of 8 countries the transfer is valid for simple unit value transfer, and 5 out of 8 both for unit value transfer with income adjusts assuming a income elasticity of 1 and less than 1 (calculated from the sample). To conclude, simple unit value transfers (based on PPP-adjusted euros) are valid when we accept a transfer error of ±20%. In most applications of cost-benefit analysis this would be an acceptable transfer error. Only in those cases where benefit and costs are very close, would a higher level of accuracy in transfers be needed [Navrud 2004 and Ready & Navrud 2006].

8. Other sources of valuation: QALY, GDP

8.1. Motivation

In view of the large uncertainties of a determination of VOLY by means of contingent valuation, it is desirable to look at other sources of information for estimating what an appropriate VOLY should be. One such source, discussed in Section 8.2, is to analyze decisions about public health and medical interventions in order to infer the implicit valuation by society. Since a life year lost due to air pollution involves health impacts such as cardiopulmonary disease and lung cancer, the valuation of air pollution deaths should be consistent with the practice of medical decisions. Especially important are guidelines for threshold values, a lower threshold below which an intervention should certainly be performed and an upper threshold beyond which they are certainly not considered cost-effective. Such threshold values provide bounds for VOLY. For this purpose one can draw on an extensive literature by health economists who have tried to determine the monetary value of a QALY (quality adjusted life year).
Another source of information is the relationship between life expectancy (LE) and wealth because it implies an upper bound for VOLY; that is discussed in Section 8.3.

8.2. Value of a life year (VOLY) implicit in current medical practice

8.2.1. The work performed for this WP

In recent years many reports and papers have been published with the goal of establishing guidelines for medical decisions, in order to render the practice more consistent. Here we summarize the results of a survey of the published literature regarding cost-effectiveness analyses of medical interventions in a number of European countries: England, Wales, Ireland, Norway, Sweden, Finland, France, Switzerland, Italy, Spain, Greece, the Czech Republic, Hungary, Poland, Slovakia and the Baltic States. An Internet search for documents and databases was performed and several health experts were contacted in order to obtain information about cost per QALY estimates and thresholds values. The available results by country are described in the final report for Task 6.4 of this WP. Of particular interest are the UK and Sweden: in the UK the study of cost-effectiveness and the attempt to establish guidelines have advanced the furthest, and very detailed and comprehensive data are also available for Sweden.

8.2.2. The situation in the UK

In the UK an organization with the name of NICE was created in 1999 as a decision-making body of the UK National Health System (NHS); it regularly commissions studies for the Health Technology Assessment (HTA) Programme aiming to obtain high quality research information on the costs, effectiveness and broader impact of medical interventions in the UK. In addition, NICE is the organization with responsibility for evaluating and providing guidance on the effectiveness and cost-effectiveness of new health technologies in England and Wales, based on the HTA studies.

Devlin and Parkin [2003] and Towse et al. [2002] provided a list of medical interventions that were accepted or rejected by NICE up to 2002. We updated the analysis to include data for the period 2002 – 2005 using the information available at the NICE website (www.nice.org.uk) regarding the institution’s guidelines about the medical interventions and their cost effectiveness, and the HTA studies available at the NHS HTA programme’s database (www.hat.nhsweb.nhs.uk). The original cost-per-QALY estimates were corrected to 2005 British pounds (£) using the Consumer Price Index (CPI all items – www.statistics.gov.uk). The estimates were converted to Euros using the exchange rate observed in 01/07/2005 equal to 1.481 (http://www.x-rates.com). The results indicate that the cost per QALY estimates can vary significantly in the UK, from few Euros per QALY to approximately 400,000€. In addition, it seems that there is no relation between the cost per QALY and NICE’s decision on recommending or not a specific medical intervention. For example, some interventions not recommended for use in England and Wales presented smaller cost per QALY than others that were recommended.

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3 No purchase power parity adjustments were undertaken.
NICE does not formally adopt a cost per QALY threshold in its evaluations, although some authors suggest that there might exist an implicit threshold that can be observed from NICE’s decisions. For example, Towse and Pritchard [2002] and Devlin and Parkin [2003] suggest that NICE adopts a threshold value ranging between £20,000 (29,620€) and £30,000 (44,430€) per QALY, and that technologies with incremental cost-effectiveness ratios above the upper level of this range are likely to be rejected. Rawlins and Culyer [2004] argue that NICE rejects the use of an absolute threshold for judging the level of acceptability of a technology in the NHS but agree that a cost-effectiveness ratio close to £30,000 could be considered as an upper-bound value: “NICE would be unlikely to reject a technology with a (ICER) ratio in the range of £5,000-£15,000/QALY solely on the grounds of cost ineffectiveness but would need special reasons for accepting technologies with ratios over £25,000-£35,000 (37,025-51,835€)/QALY as cost effective” [Rawlins and Culyer, 2004].

In another attempt to estimate potential cost per QALY threshold values for England and Wales, Devlin and Parkin [2003] develop a binary choice model of NICE’s decision making on accepting/rejecting new medical interventions in England and Wales in order to explore NICE’s cost-effectiveness threshold(s) and other possible factors influencing its decisions. The authors use data from the NICE Guidance and Technology Appraisals available at May 2002 to estimate a Logit regression that enables them to estimate the probability of acceptance or rejection for each cost-effectiveness ratio. The probability-based cost-effectiveness ratio (threshold) could be estimated at the point where the probability of acceptance (or rejection) was 0.5. The results suggest a threshold ranging between £40,216 (59,560€) and £57,216 (84,737€).

8.2.3. The situation in Sweden

Ramsberg and Sjoberg [1997] published a study of the cost-effectiveness of lifesaving interventions in Sweden, following the example of an earlier study by Tengs et al [1996] of such interventions in the USA. Both of these studies covered all sectors for which data could be obtained, not just medical interventions. Ramsberg and Sjoberg analyzed 165 interventions in nine sectors of the economy.

In their Table I Ramsberg and Sjoberg summarize the cost per life year for each of nine categories of life saving interventions. There is a wide range of values and little consistency between sectors. The mean cost per life saved (i.e. the value of a prevented fatality) is $34 million for all interventions. For the cost per life year saved Ramsberg and Sjoberg find a mean of $863,000 and a median of $19,500, but if they drop the most extreme outlier of almost $5000 million their mean costs are reduced to $5.1 million per life and $122,000 per life year saved.

In their Table II Ramsberg and Sjoberg list the cost per life year for each of the 165 interventions they examined, indicating whether the intervention has only been proposed or also implemented; most of the ones in the health sector are implemented, but for a few the authors have not been able to determine this aspect. We adjusted their estimates their numbers for medical interventions to cost per QALY values by using the disability weight factors
proposed by WHO for different quality of life states, in an attempt to make the Swedish values comparable to the cost per QALY of NICE. The weight factors reflect the severity of the disease on a scale from 0 (perfect health) to 1 (death). The disability weights used correspond to the WHO European region (EUR A), mainly west and northern Europe region, and to an intermediate level of severity of the disease. For example, the disability weights relative to neoplasms (cancer) are given for different stages of the disease: diagnosis/therapy, waiting, metastasis and terminal. We used the weights relative to the ‘waiting’ stage, assuming that this is an intermediate stage of the disease and the correspondent medical intervention is still applicable at that stage.

Borgstrom et al. [2004] claim that there are no available guidelines on cost per QALY threshold in Sweden. However, the authors argue that Swedish analysts use either estimates provided by the National Road Administration (€56,000) or adjusted international (the US and the UK) estimates (€62,000) in their analysis of the results of cost-effectiveness of medical interventions. This information is confirmed in Kolbet et al. [2004]: “Recent studies used the threshold value for saving lives used by the Swedish road authority in investment decisions and estimated the value of a QALY at €60,000”. Kolbet et al. also argue that similar amounts, although marginally lower (€35,000 – €55,000), can be deduced from recent reimbursement decisions for health technologies in Sweden.

Johannesson and Meltzer [1998] used an alternative approach to estimate the willingness to pay (WTP) per QALY by using estimates of the value of a statistical life in Sweden available in the literature. The authors divided the WTP per statistical life saved by the discounted QALYs gained for a saved life. The VSL used by the Swedish Road Administration (US$1.4 million), the average number of life-years lost at a traffic death in Sweden (30.5 years) and rough QALY weights of the Swedish population, discounted at 3% per year, produced a WTP per QALY equal to US$90,000.

8.2.4. Implications for VOLY

To the best of our knowledge, until now no government has explicitly defined a maximal admissible value over which a treatment is not to be provided or reimbursement by public health insurance is to be refused. Nonetheless a certain consensus seems to be emerging in the international literature, namely that interventions having a cost per QALY of less than 30,000€ are generally recommended whereas those whose costs exceed 100,000$ per QALY are in many cases rejected. These values are applicable in the “EU16”. In the new member states less information is available but the need for lower values is recognized, with a threshold around 10,000 to 15,000 €/QALY for interventions that should be applied. The value of a QALY varies according to age and context; it may also vary according to the cost-of-living and wealth of the countries, as well as reflect different societal choices.

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5 The term reimbursement can apply for (i) individuals having their medical expenses reimbursed by the health insurance company or government, and (ii) the pharmaceutical companies having their costs of development of a new technology reimbursed by the health authority.
In view of this situation it seems reasonable to recommend a VOLY between 30,000 and 100,000 € for policy makers in the “EU16”, although values for the New Member States could be significantly lower in the short run.

8.3. Upper Limit for VOLY implied by relation between life expectancy and GDP/capita.

8.3.1. The argument

Numerous studies have found a relationship between mortality or life expectancy (LE) and wealth: LE is higher in richer countries, and within a given country the richer tend to live longer than the poor [see e.g. Preston 1975, and Wise 2001. The causality of such a correlation is very plausible in view of many links, both at the level of an individual and at the level of an entire country: for example the rich can afford better doctors, can eat healthier food, and can live in healthier environments. Rich countries tend to have better public health systems, more and better trained doctors per population, higher standards for sanitation systems, and stricter safety regulations. Education is also correlated with income and plays a crucial role for health and longevity.

The details of the links between such factors and LE are very complex, and they can be very different between different countries (and different studies do not always find the same explanatory variables). They can also change over time. An effect that has become especially important in recent decades is medical progress [Deaton and Paxson 2001]. Understanding such detailed links is important for guiding public policy by identifying which policy measures might be most effective in increasing the LE. For the present paper they are, however, not relevant because only the overall correlation between the input (money) and the output (LE) matters: if the government impoverishes the country by wasting money, the LE decreases. Specifically, if the coefficient of a regression of LE with respect to GDP/capita is $\alpha$, a GDP loss of $\Delta x$ induces on average an LE loss of

$$\Delta LE = \alpha \Delta x.$$ 

The coefficient $\alpha$ is the combined result of all effects, of both public and private spending, from changes in nutrition to changes in medical progress due to funding of medical research.

This observation implies an upper limit $\text{VOLY}_{\text{max}}$ for the value of a life year (VOLY) that the government should use in evaluating policies that increase the life expectancy, for instance regulations for the emission of air pollutants. Consider a policy that costs $x_p$ each year and whose only benefit is to increase the average life expectancy of the population by $LE_p$ years; its annual cost per life year saved is $x_p/LE_p$. But this benefit does not account for the LE loss induced by the expenditure. The net benefit is only $LE_p - \alpha x_p$, and the policy is justified only if the net benefit is positive. If the policy does not satisfy the condition

$$\text{annual cost per life year saved} = x_p/LE_p < 1/\alpha,$$

it would save less than simply leaving the money in the general economy, to be spent according to the average spending pattern.

Arguing along such lines, but in terms of number of deaths rather than LE loss, Keeney [1995] estimated that at the level of the population of the USA a loss of $5$ to 12 million induces an extra fatality. The value of a prevented fatality (VPF) used for policy analysis should therefore not exceed this range.
8.3.2. Upper Limit for VOLY

To derive the upper limit on VOLY, we have to convert a stream of annual costs into an equivalent present value. The details are described in the Final Report for Task 6.5 of this WP. As result one obtains the upper limit

\[ \text{VOLY}_{\text{max}} = f_{P/A}(r_d, N)/\alpha \]

where \( f_{P/A}(r_d, N) \) in the range from 30 to 80, \( \alpha \) is the ratio of an incremental LE gain and the corresponding increase in GDP/capita, and

\[ f_{P/A}(r_d, N) = \frac{1 - (1 + r_d)^{-N}}{r_d} \]

with \( N = \text{number of years of annual costs} = \text{LE} = 80 \text{ years} \) and \( r_d = \text{discount rate}, \text{in the range of 0 to 3\%} \).

To estimate \( \alpha \) we use two methods. The first is based on the relation between LE and GDP for the different countries of the world, based on data of http://www.cia.gov/cia/publications/factbook. Fig. 2 shows this relation for countries with GDP/capita between $10,000 and $40,000 only because this range is appropriate for applications in the EU. The line is a logarithmic fit of the data.

![Fig. 2. Relation between LE and GDP/capita.](image)

The GDP/capita of the EU25 was approximately 22000 €/yr in 2003, according to Eurostat [http://epp.eurostat.ec.europa.eu], implying a \( \text{VOLY}_{\text{max}} \) of 92,000 € per life year if we choose a discount rate of 3\%; at 0\% discount rate it would be approximately 250,000 € per life year.

As a second method we use the correlation between individual income and mortality in the USA, as found by Deaton and Paxson [2001]. For the per capita GDP of the EU25 of 22000 €/yr we thus obtain a \( \text{VOLY}_{\text{max}} \) of 122,000 € for \( r_d = 3\% \) and 326,000 € for \( r_d = 0\% \).

8.3.3. Conclusion about upper limit for VOLY

The results are summarized in Table 16. Our approach and the results are quite similar to a paper by Heck [2004]. However, by contrast to Heck we argue that the result is only an upper bound for VOLY, not a value that could be used as such.
Table 16. Summary of results for VOLY\textsubscript{max}, for two methods of estimating the relation between GDP/capita and LE.

<table>
<thead>
<tr>
<th>Method</th>
<th>r\textsubscript{d}</th>
<th>0%</th>
<th>3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>All countries between 10000 and 40000€/person</td>
<td>92,000 €</td>
<td>250,000 €</td>
<td></td>
</tr>
<tr>
<td>Individuals in USA</td>
<td>122,000 €</td>
<td>326,000 €</td>
<td></td>
</tr>
</tbody>
</table>

Admittedly this approach for estimating an upper bound for VOLY is not perfect and many questions could be raised. For example the efficiency with which an income increase is used for increasing LE can vary greatly between different countries, just as it varies greatly between individuals. The LE – GDP/capita correlation for countries includes the effects of both public and private spending whereas the correlation for individuals in the USA includes only private spending. The relation may be different in the future, e.g. due to changes in medical progress and nutrition (junk food or more health conscious diet). And the result varies strongly with the discount rate. Nonetheless we believe that our results indicate an upper bound that can be valuable for avoiding the risk of choosing a VOLY that is too high.

9. A QALY based alternative to the conventional monetary valuation of morbidity impacts.

9.1. Motivation for Such an Approach

The monetary valuation of some of the morbidity end points has been problematic, especially for chronic bronchitis (CB). It is therefore interesting to look at the QALY scores of the medical economics literature to obtain complementary information for the valuation of such end points, by setting the monetary value of a QALY equal to the VOLY that has been determined in this work package (even though there is as yet no official consensus on the monetary value of a QALY, the equality of VOLY and QALY is the most reasonable choice).

According to the current valuation used by ExternE (200,000 €/case), CB contributes by far the largest of the morbidity costs and about a quarter of the total health costs of PM, NO\textsubscript{2} and SO\textsubscript{2}. However, there are doubts about the about the unit cost assumed because it is based on only two monetary valuation studies [Viscusi, Magat & Huber 1991 and Krupnick & Cropper 1992], both using more or less the same questionnaire and only Krupnick & Cropper applied it to individuals familiar with CB. The valuation of chronic bronchitis was reviewed as part of the ExternE-Pol phase of ExternE [Rabl et al 2004] and the value of 200,000 €/case was recommended. Since the uncertainty remained very large, it is desirable to have additional information to improve the monetary valuation of this end point.

9.2. QALY for Chronic Bronchitis

Probably the most complete listing of QALY weights is the “Catalog of Preference Scores”, formerly at the Center for Risk Analysis of Harvard University, now at the Cost Effectiveness Analysis (CEA) Registry of Tufts-New England Medical Center [http://www.tufts-nemc.org/cearegistry/index.html]. It shows several QALY scores for various conditions of
CB; they range from 0.68 to 0.79. Assuming that the monetary value of a QALY is identical to a VOLY, the forgone value of a year live with CB, compared with a life year in normal health, is in the range of 0.21 to 0.32 VOLY. Of course, the uncertainties of QALY scores are very large, see for instance the review by Arnesen and Trommald [2004]. That range is also consistent with values reported by Tengs and Wallace [2000]. For a further source of information we look at DALY scores as reported by Mathers et al [2002]. For chronic obstructive pulmonary disease (COPD) the DALY score is listed as 0.266. COPD comprises several severe respiratory conditions, but mostly CB. A DALY is very roughly equivalent to 1 – QALY, although their precise definitions involve differences such as discounting (for DALY but not QALY). In view of these numbers we assume that on average a year lived with CB corresponds to the loss of 0.26 VOLY.

To obtain the total cost of a case of CB the annual cost is to be multiplied by the discounted duration. The onset of CB is typically around the age of fifty, and the condition is difficult or impossible to cure, especially if it is advanced [see e.g. Priez and Jeanrenaud 1999]. Symptoms can be alleviated but the prognosis is poor. We have not been able to find sufficient data for a firm estimate, to say nothing about the large differences in severity between different cases. However, it seems reasonable to assume a discounted duration of about 20 years. That implies a monetary value of 5.2 VOLY for CB. With the VOLY = 35,000€ as determined in this WP, the monetary value of chronic bronchitis would therefore be 182000 €. This is so close to the 200,000€ for a case of chronic bronchitis currently used by ExternE, that no change is recommended.

10. Conclusion

Based on the CV carried out for this WP, including the tests of validity, and considering the consistency with other relevant sources of information, our recommended VOLY estimates are

<table>
<thead>
<tr>
<th></th>
<th>VOLY estimate (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU 16:</td>
<td>41,000</td>
</tr>
<tr>
<td>NMC:</td>
<td>33,000</td>
</tr>
</tbody>
</table>

However, for cost-benefit analyses of EU directives and policies we would recommend using the same value for EU25 (EU26, including Switzerland), based on the VOLY value from the pooled sample. With adjustments to correct for the difference in the proportion of “EU16” and NMC observations in our sample and the actual populations this leads to

| EU25:         | 40,000            |

For a case of chronic bronchitis the value of 200,000€ is recommended (no change from current value).

Acknowledgment

Funding for the German survey was provided by EDF.

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6 Note that the hypothesis of the monetary value of a QALY being identical to a VOLY is somewhat problematic. The VOLY is the value of a year life of an average person (with the average health state of the population, that is with average health problems, not a person in perfect health) whereas the QALY is the utility a person in perfect health (not an average person).
References


Annex: The Questionnaire

The study is funded by the European Union and is concerned with the health consequences that result from air pollution. It is important to take public opinion into account.

One of the main health benefits we can attribute to a reduction in air pollution is an increase in the life expectancy of individuals. The objective of this questionnaire is to find out how much you value an increase in your life expectancy if air pollution is reduced.

*The same questionnaire is being applied in 8 EU countries.*

*Answers will remain anonymous.*
*There are no right or wrong answers.*
*Just think about yourself.*

Gender: __________
Age: __________

What is your profession? Or if you are not employed, what does your spouse do?
_________________________________________________________________________

I. THE EFFECTS OF AIR POLLUTION ON HEALTH

Q1 Does air pollution in your city (physically) bother you?

□ very often
□ sometimes
□ rarely
□ never

When? Please describe (*very often or sometimes*)
_________________________________________________________________________

Q2 Are you concerned with the effects of air pollution on your health?

□ very much
□ somewhat
□ not so much
□ not at all

**Interviewer:** *please take note of any comments made here by respondent*
In your city air pollution can mainly be attributed to:
1. public and private transportation (cars, trucks, buses, etc)
2. heating systems
3. household waste incinerators,
4. power plants and industry.

(show overhead “Air pollution aggression”)

In other words, through our lifestyle, transportation needs and the goods and services that we consume we are all responsible for creating air pollution.

Q3 Are you aware that your consumption and lifestyle contribute to air pollution?
☐ Yes
☐ No

Interviewer: please take note of any comments made by respondent

Breathing pollutants such as fine particulates and sulphur dioxide, is harmful to our health; it is known to worsen respiratory and cardiovascular problems. It increases the risk of heart disease and strokes.

It also causes eye irritation and increases the number and intensity of chronic bronchitis, asthma attacks and emphysema.

Did you know this?

Interviewer: Take note of the individual’s level of knowledge on the subject

In order for to put this information in an everyday life context understand that the level of air pollution in a big European city like Paris is like smoking 4 cigarettes a day.

Also, scientists have estimated that some lung cancers (perhaps ten percent of all lung cancers) are due to air pollution.
Your health status and the health status of your close family

Q4 To become familiar with your health status and the health status of your family, could you tell us if the following individuals have ever had or have:

<table>
<thead>
<tr>
<th></th>
<th>You</th>
<th>Spouse</th>
<th>Children</th>
<th>Father</th>
<th>Mother</th>
<th>Brothers/Sisters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye irritation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Headaches/migraines</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Allergies</td>
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<tr>
<td>Sinus problems</td>
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<tr>
<td>Chronic bronchitis</td>
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<tr>
<td>Asthma</td>
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<tr>
<td>Cardio-vascular disease</td>
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<tr>
<td>Emphysema</td>
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<tr>
<td>Cancer</td>
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<tr>
<td>Other serious chronic disease</td>
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</tbody>
</table>

Q5 Age of father: ____ □ if deceased at what age ?
Age of mother: ____ □ if deceased at what age ?

Q6 Do you think you are in:
□ good health for your age
□ average health for your age
□ poor health for your age

Q7 Do you practice any (sports) physical activity?
□ several times a week
□ once a week
□ less than once a week
□ never

Q8 Are you?
□ a smoker
□ an occasional smoker
□ a non-smoker
Q9 Do you live with a smoker?

☐ yes
☐ no

II. THE EFFECTS OF AIR POLLUTION ON LIFE EXPECTANCY

Reducing life expectancy is another major effect of air pollution on health and this is the one that we will concentrate on for the remainder of the questionnaire.

Life expectancy is the number of years you can expect to live, depending on how old you are now. For example a baby girl born today has a life expectancy of 83 years, and a baby boy has a life expectancy of 76 years. Of course it is an average calculated for the whole population.

For a man

![For a man](image1)

For a woman

![For a woman](image2)

YOUR REMAINING LIFE EXPECTANCY
(BASED ON AN AVERAGE OF THE POPULATION OF YOUR AGE)

<table>
<thead>
<tr>
<th>Age</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>75</td>
<td>80</td>
</tr>
<tr>
<td>20</td>
<td>55</td>
<td>60</td>
</tr>
<tr>
<td>30</td>
<td>45</td>
<td>50</td>
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<tr>
<td>40</td>
<td>36</td>
<td>41</td>
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<tr>
<td>50</td>
<td>27</td>
<td>31</td>
</tr>
<tr>
<td>60</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>70</td>
<td>12</td>
<td>15</td>
</tr>
</tbody>
</table>

For someone of your age, you can expect to live another ........ years
Your life expectancy actually depends on several factors, which are:

1. biological (genetic)
2. social (if you live in a city, in the mountains, your lifestyle, your standard of living)
3. behavioural factors (you are a smoker, a non-smoker, you exercise, you eat healthy)
4. medical (you have high blood pressure, diabetes, kidney failure)
5. environmental (you live in a highly polluted neighbourhood or not very polluted neighbourhood)

We will only focus on environmental factors, but remember the other factors also play a role on your life expectancy.

There have been significant scientific advances in the past ten years and today we can better estimate the effects of air pollution on the health status of individuals.

**What are the effects of air pollution on your life expectancy?**

The daily inhalation of air pollutants gradually damages the body and accelerates the aging process.

Individuals (of all ages) who are already more vulnerable because they suffer from respiratory or cardiovascular illnesses are more sensitive to air pollution because it aggravates their symptoms.

An improvement in air quality would lead to an increase in the life expectancy of the general population.

To obtain this benefit all sectors of the economy will have to respect new reduced pollutant emission levels.
III. POLICIES TO DECREASE AIR POLLUTION

Let us consider two possible policies for the coming decades that the European Union could implement and its benefits in terms of life expectancy:

**Policy I**, will impose a 3% reduction per year in the emission of air pollutants for 20 years:
(which means a total reduction of 60% by 2025)
Afterwards the emission of air pollutants will be maintained at this lower level whatever the economic growth

The benefit in terms of life expectancy would be an average increase of:

**6 months**

**Policy II**, will impose a 1,5% reduction per year in the emission of air pollutants for 20 years:
(which means a total reduction of 30% by 2025)
Afterwards the emission of air pollutants will be maintained at this lower level whatever the economic growth

The benefit in terms of life expectancy would be an average increase of:

**3 months**

* These policies do not concern the emission of greenhouse gases but only the pollutants with direct health effects such as fine particulates and sulphur dioxides.

Stricter limits on emissions will be imposed on all member countries of the UE and will be closely monitored and enforced by the European Commission.
This gain in life expectancy comes from an improved health status which will **slow down your ageing process** and consequently increase your life expectancy by an average of 6(3) months.

This is an average gain calculated for the whole population; some individuals could gain more than the average 6(3) months predicted while other individuals less vulnerable to air pollution could gain less than the average 6(3) months predicted.

The current the level of knowledge does not allow to predict more precisely what could be your individual gain in life expectancy.

(“We know that many factors are at play, including the environmental factor. Specialists believe that there is a genetic predisposition could significantly change the risk perhaps by a factor of three, but this is still an area of research” Doctor Aubier, Chief of Respiratory illnesses at Hopital Bichat in Paris, France)

Individuals potentially more vulnerable to air pollution:
- children
- the elderly
- pregnant women
- cardiac patients
- those with respiratory illnesses
- asthma sufferers
- those with chronic bronchitis
- those who through work have to be in contact with chemicals

To better explain what an average gain of 6 (3) months means, here is an illustration to give you an example

*Show the graph*

The graph shows very schematically the ability of the body to survive as a function of age. If air pollution is reduced, there is less damage to the body. Thus, people are more able to fight off the effects of illness and are more likely to survive longer, as shown by the blue line. They age less rapidly than with the current level of pollution. This is particularly noticeable above age 50, although it has some effect already earlier.

The black line represents the situation we have today with current levels of air pollution. The blue line shows what would happen if we reduce air pollution (although the gain is exaggerated to make it more clearly visible on the graph). The average LE gain is about 6 months if the air pollution is decreased by 60%.

The benefit begins as soon as pollution is reduced and reaches gradually the full level, as suggested by the arrows in the graph.

Note that the gain is not just a few months at the end of life when people tend to be in poor health. To emphasize this fact, the dashed horizontal line has been added to the graph corresponding to a state of “good health”. The age where the black and the blue curves
intersect this line could be called “healthy life expectancy”, at this state of good health. The gain of “healthy life expectancy” is about the same as the LE gain, 3 or 6 months, respectively, that we are talking about in the questionnaire.

Are the benefits of these policies clear to you? If you have any question please ask.

IV. THE COST FOR SOCIETY

If a policy for reducing air pollution is implemented, all polluters (industries, municipalities, households) will have to respect stricter emission limits to improve air quality. All sectors of the economy will be affected and will need to increase their efforts to reduce pollution by such means as modifying production processes and producing less polluting cars, heating systems etc…

This will increase the costs of industry, and as a consequence there will be a general increase in the cost of living. It would mean a cutback in your daily consumption of goods and services and/or savings if you can afford to save.

Show illustration on product price increase

To decide what financial cost will be imposed on the economy it is necessary for you to express the value you attribute to a gain in your life expectancy.

One way of communicating this value is to estimate how much money, in terms of a higher cost of living, you are willing to give up each month to obtain this benefit. In other words, what financial effort are you willing to make each month for this gain in life expectancy?

Are these explications clear?
Don’t hesitate to ask questions

Q10 Are you willing to accept a higher cost of living, therefore an increase in your daily expenses, to gain an increase in your life expectancy?

☐ yes
☐ no

If not, why?
___________________________________________________________________________
___________________________________________________________________________

Would you be willing to accept an increase in the cost of living for any benefits of improved air quality?

If yes
Q11  Average gain of 6 months

Please consider only your personal gain of life expectancy:

What is the maximum amount you are willing to pay in the form of higher expenses to gain an average of 6 months in your life expectancy?

The largest amount of your “Yes, I would pay” cards:

_____ per month (for the rest of my life)
_____ per year (for the rest of my life)

Please take your time to answer, it is an important question. If you have any question please ask.

Q12  Average gain of 3 months

Please only consider your personal gain of life expectancy:

What is the maximum amount you are willing to pay in the form of higher expenses to gain an average of 3 months in your life expectancy?

The largest amount of your “Yes, I would pay” cards:

_____ per month (for the rest of my life)
_____ per year (for the rest of my life)
To better understand your answers…

13. Do you think it is likely that a decrease in air pollution will extend your life expectancy?
   □ yes
   □ no

14. Does this questionnaire clearly illustrate that the 6 months and 3 months gain in life expectancy are averages based on the entire French (insert your country here) population and that this gain can be different for each one of us?
   □ yes
   □ no

15. Did you think your personal gain of life expectancy would be:
   □ close to the national average
   □ different from the national average

16. What reasons do you have to think that your gain could be different than the national average?
   ____________________________________________________________

   for those whose willingness to pay is not proportional to the gain:

17. Why did you indicate an increase in your expenditures that is not proportional to your gain in life expectancy?

18. How confident are you of the amount you stated you were willing to pay to increase your life expectancy an average of 6(3) months?
   □ yes I am sure
   □ no I am not sure

19. If you would like to change the amount you stated, please do so now. If not, go to the next question.
   I would like to pay: ____ per month for an average of 5 months
   I would like to pay: ____ per month for an average of 2 months

20. When you picked an amount, what did you think about the most?
   □ only about your life expectancy
   □ cleaner air and its overall benefits on health (I will breathe better, will be in better health)
   □ a bit of both
   □ other __________________________________________________________

21. Did you think about the length of time during which you will have to pay? (your whole life)
   __________________________________________________________

22. If you live in a 2 income household, when stating your amount did you think about:
23. If you are approaching retirement, what did you think about when stating your amount?
   □ current income
   □ future retirement income (what amount per month would you receive? _____)

24. What expenses did you think about that you would forgo when you were thinking of an amount for your willingness to pay?
   __________________________________________________________________________

25. Do you have a complementary (private) health insurance?
   □ yes
   □ no

26. Have you donated any money to charities in the past year?
   □ yes
   □ no

27. Approximately how much? ______________
Demographics

How many people live in your household? Including yourself: __________

Number of children that live in your household: __________

Age of the children: _____________________________________________

Do you rent or own your house/apartment?

Education level:
☐ primary
☐ secondary
☐ superior

Your net revenue (per month):
☐ less than 1000 Euros
☐ 1001 Euros to 1500 Euros
☐ 1501 Euros to 2000 Euros
☐ 2001 Euros to 3000 Euros
☐ 3001 Euros to 4000 Euros
☐ 4001 Euros to 5000 Euros
☐ 5000 Euros to 6000 Euros
☐ more than 6000 Euros

Household net revenue (per month):
☐ less than 1000 Euros
☐ 1001 Euros to 1500 Euros
☐ 1501 Euros to 2000 Euros
☐ 2001 Euros to 3000 Euros
☐ 3001 Euros to 4000 Euros
☐ 4001 Euros to 5000 Euros
☐ 5000 Euros to 7000 Euros
☐ more than 7000 Euros

TO BE FILLED BY THE INTERVIEWER:
How cooperative have you found the person interviewed to be?

1 2 3 4 5
Not much Much

How much attention has the person interviewed paid?

1 2 3 4 5
Not much Much

Degree of comprehension

1 2 3 4 5
Not much Much

During the interview did the person think of another person or only of him/herself?

☐ Yes
☐ No

If yes did he/she mention some person in particular?

Duration of the interview

Address of the interview

Name of the interviewer

Interviewer comments
The usual effects are:
- Eye irritation, headaches
- Bronchitis, asthma, emphyzema
- Decrease in life expectancy due to the body’s weakening by air pollution
We estimate that about ten percent of lung cancer cases are due to air pollution.
New emissions to decrease air pollution

The consequence: an increase in prices at the production and consumption levels

Everything will be a little more expensive

- electricity
- food
- transportation (public and private)
- gas
- furniture
Gain of life expectancy (LE) when air pollution is reduced
(example of someone who has age 20 now)

Ability to survive

Gain of "healthy LE"

LE, current air pollution

LE, reduced air pollution

Gain of life expectancy (LE) when air pollution is reduced
(example of someone who has age 30 now)

Ability to survive

Gain of "healthy LE"

LE, current air pollution

LE, reduced air pollution
(example of someone who has age 40 now)

(figure showing the ability to survive with different age groups and air pollution scenarios, with labels for current and reduced air pollution, and LE gain of "healthy LE")

(figure showing the ability to survive with different age groups and air pollution scenarios, with labels for current and reduced air pollution, and LE gain of "healthy LE")

(figure showing the ability to survive with different age groups and air pollution scenarios, with labels for current and reduced air pollution, and LE gain of "healthy LE")
(example of someone who has age 60 now)

[Diagram showing ability to survive over age with lines indicating current and reduced air pollution, and a gain of "healthy LE".]  

(LE, current air pollution)  

(LE, reduced air pollution)  

(LE gain)

(LE gain)

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