Journal of Environmental Management 146 (2014) 470–480

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Valuing air quality impacts using stated choice analysis: Trading off visibility against morbidity effects

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ARTICLE INFO

Article history:
Received 26 September 2013
Received in revised form
18 June 2014
Accepted 12 August 2014
Available online 6 September 2014

Keywords:
Stated choice analysis
Valuation
Visibility
Morbidity
Air pollution

ABSTRACT

Direct valuation of air quality has as a drawback; that estimated willingness to pay figures cannot be apportioned to the several environmental goods affected by air quality, such as mortality and morbidity effects, visibility, outdoor recreation, among others. To address this issue, we implemented a survey in Santiago de Chile to identify component values of confounded environmental services by means of a choice experiment. We designed a survey where two environmental goods, a morbidity health endpoint and improved visibility, had to be jointly traded off against each other and against money in a unified framework.

The health endpoint is a respiratory illness that results in an emergency room visit with a probability of hospitalization being required for appropriate treatment. Visibility is described as an aesthetic effect related to the number of days per year of high visibility.

Modeling comprises both a logit model with covariates and a mixed-logit model. The results suggest that the health endpoint midpoint value is in a range from USD 2,800 to USD 13,000, mainly depending on the model and age stratum. The mid point value of an extra day of high visibility per year ranges from USD 281,000 to USD 379,000.

1. Introduction

Poor air quality negatively affects agricultural production, materials and buildings, visibility, the health of the population and ecosystems (Larsen et al., 2008; Rabl, 1999; WHO, 2005). In terms of health, fine particulate matter ($PM_{2.5}$), has been identified as being primarily responsible for the health impact of air pollution (Larsen et al., 2008). However, other pollutants such as ozone (O_3), Sulfur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) also affect health negatively (MMA, 2013). In the Metropolitan Area of Santiago, Chile, over six million people are exposed to concentration levels of fine particulate matter ($PM_{2.5}$) above the national air quality standard, an annual average of 20 μg/m3 (MMA, 2012). As a consequence, the Law 19.300 mandates the elaboration of decontamination plan to bring air quality to safe levels.

The aforementioned plan aims to reduce emissions of fine and coarse particulate matter and its precursors (mainly NO_x and SO_2 emissions). It comprises actions such as establishing more stringent emission standards for new vehicles, reducing fuel sulfur concentration to 15 ppm, paving and washing all streets in greater Santiago, improving the quality of public transport services, requiring higher emission reduction for the industrial sector, improving heating systems in the residential sector, promoting afforestation and constructing more green spaces, strengthening efforts in the area of education and intensifying enforcement for all these measures. The law also requires a social cost-benefit analysis of the different components of the plan to establish priorities among them. Hence, it is relevant to know the social worth of each effect to prioritize the plan components.

The most direct approaches to value this type of benefits are hedonic pricing methods (Rosen, 1974) and contingent valuation techniques (Arrow and Solow, 1993). The first is based on revealed-preference data and attempts to capture the premium that people are willing to pay for homes with better air quality. Hedonic pricing relies on available information about housing prices and indirectly elicits a value for the good under the assumption of performing

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http://dx.doi.org/10.1016/j.jenvman.2014.08.009
0301-4797/

efficient housing markets. This method, however, does not permit to assess how much value households apportion to each of the health and visibility benefits (Delucchi et al., 2002). Furthermore, one would suspect whether people could actually understand the full consequences of diminished air quality on their personal welfare, especially regarding long-term impacts.

Contingent valuation surveys rely on stated-preference data (Mitchell and Carson, 1989). When this method is used to elicit respondents' willingness to pay (WTP) for improved air quality, it is also subject to similar drawbacks already mentioned for hedonic pricing (Hausman, 1993). For example, Ortúzar and Rodriguez (2002) estimated the value of reducing the number of days of environmental alert in Santiago de Chile at approximately USD 110 per household per year, but could not establish how this value would be distributed among health, visibility and other effects. In a few cases (McClelland et al., 1991), after respondents have stated their WTP for improved air quality, they are also required to state what percentage of their WTP accounts for health, better visibility, etc.

Hence to assess the benefits of improved air quality, economists usually rely on the impact pathway approach (EPA (1991)). This approach comprises a series of models that link (1) emissions of pollutants, (2) concentration of criterion pollutants (e.g. $PM_{2.5}$, O_3, NO_x or SO_2), (3) effects on health, visibility, etc., and (4) economic valuation of these effects. Under this approach, the modeler needs to know the value of reducing the risks of morbidity/mortality, the value of visibility and so on. Valuation studies are then designed to elicit the value of each of these non-market goods. When all the relevant monetary values are available, the researcher is able to carry out a full cost-benefit analysis of air quality.

Following step (4) above, there exists a profuse literature estimating the value of reducing the many effects generated by poor air quality by means of a ‘step by step approach’; that is, only valuing one effect at a time. The most adverse consequence of poor air quality is the risk of premature death. Viscusi and Adly (2003) provide an excellent critical review of more than 60 studies on the value of reducing mortality risks. Other health endpoints have also been estimated: EPA (1999) reports many such values, among other the valuation of reduced hospital admissions, chronic bronchitis, chronic asthma and other symptoms.[1] On the other hand, many contingent valuation studies elicit the value of a permanent improvement in visual range in an urban context such as Brookshire et al. (1979), Trijonis (1982), Trijonis et al. (1984), Tolley et al. (1986), Randall (1987), Tolley and Fabian (1988), McClelland et al. (1991), Loehman et al. (1994), Roe et al. (1996), and Le Clue (2004). Others such as Rowe et al. (1980); Chestnut and Rowe (1990); Balson et al. (1990); McClelland et al. (1991); Stevens et al. (2000), and Legget et al. (2004) value visibility in natural parks.

There are, however, very few studies that attempt to value several environmental effects simultaneously. This is a hard task to accomplish. If we only regard health benefits, there are many as we have already mentioned. In most survey efforts, only one effect is valued – otherwise the cognitive burden imposed on respondents would be prohibitive. Notwithstanding, stated choice surveys have emerged to overcome some of the limitations of earlier contingent valuation surveys that usually elicited willingness to pay by direct interrogation. Choice experiments, as proposed by Louviere et al. (2000) and McFadden (2005), consists of designing choice scenarios where people have to choose among a few alternatives, each one being characterized by different levels of the relevant attributes assumed to influence the choice decision, thus simulating a market environment. The choices implicitly reveal respondents' willingness to pay for the different attributes. Choice experiments therefore provide a simple way of controlling the presence of companion goods and has long been in use in transport and marketing studies (Ortuzar and Willumsen, 2001; Louviere et al., 2000) and more recently in environmental economics (Scarpa and Alberini, 2005). In our case, it provides an excellent way to value health and visibility improvements simultaneously. To our knowledge, only two studies are comparable to ours, Muller et al. (2001) and Yoo et al. (2008).

The methodological contribution of this paper is to identify component values of confounded environmental services by means of a choice experiment. We designed a survey where two environmental goods, a health endpoint and improved visibility, had to be jointly traded off against each other and against money in a unified framework. Our working hypothesis is that it is possible to place a monetary value on these two environmental goods by means of a well-designed choice experiment survey. The health endpoint is defined as a respiratory illness that requires a visit to an emergency room with a 32 per cent probability of requiring hospitalization. Our work contributes to extend the application of choice experiment to this field. Furthermore, this study will provide valuable information in the context of environmental cost-benefit appraisal in Chile and these values could be transferred to other developing countries with more confidence than values estimated in the developed world.

The remainder of the paper has the following structure. Section 2 describes the context of the survey; Section 3, its statistical design; and Section 4 explains how the survey was conducted and shows some summary statistics. Section 5 presents the modeling results and Section 6 closes the paper with a discussion of the results.

2. The context and attributes of the stated choice experiment

Hensher (1994) recommends that the hypothetical context of a stated choice survey should be realistic and familiar to individuals. In addition, attributes to be included in the choice experiment should be relevant for the individual decision making process. Our survey describes a governmental program that will provide environmental benefits related to reductions of health risks and improved visibility in the short term.

As in most surveys attempting to value positive health impacts accruing from improved air quality, we have to focus on one health endpoint to make the exercise manageable for respondents. In addition, the health endpoint should be such that it makes a trade-off between the endpoint itself and visibility possible. We also have to decide on how to present the aesthetic effect of improved visibility in a way that can be traded off against health. Further, we have to devise a payment vehicle that is credible from the standpoint of individual households: it has to remind household heads about the budgetary constraints of trading off improved health benefits and/or visibility against money.

As previous research attempts have already determined the value of fatal risk reduction in Chile (Rizzi and Ortúzar, 2003; Iragüen and Ortúzar, 2004; Hojman et al., 2005; Cifuentes et al., 2000), in the present research context we have decided to value a morbidity endpoint, whose scope of illnesses related to air pollution was as large as possible. Consequently, we defined a *respiratory illness* as a combination of different physical symptoms that affect the individual, not necessarily occurring simultaneously, listed in the international classifications of disease code as ICD 9 RSP(480–519). This *respiratory illness* can have different levels of

[1] Some morbidity endpoints are usually valued by means of less demanding methods such as cost of illness (COI) witch commonly only considers medical costs of treating the patient (EPA (2002)).