Side effects methods

1. Choice Modelling or Choice Experiments

This pertains to the family of techniques known as conjoint analysis[1]. This model contains elements from microeconomic theory of consumer behaviour and theory of value: namely rational choice and several assumptions from the theory of the preferences from the former (individuals allocate their limited budget among a variety of goods and services in a way that maximises utility).

From the theory of value, is postulated that individuals get utility (satisfaction) from the characteristics of things (goods, services or ideas), rather than from the good as a whole.

Objective

To value the external effects derived from the implementation of a countermeasure through its decomposition in relevant characteristics[2].

In general, the interest is in how people will react to changes in objective aspects embodied in the countermeasure being under scope. Choice experiments will produce estimates of the value of those changes individually as well as the aggregate value of the countermeasure.

Stages

1. Definition of the situation

2. Selection of the sample

The two first stages are common with the contingent valuation method. So we refer the reader to the above document.

3. Design of the experiment itself:

Individuals are asked to make choices[3] as they do in real life. Each choice is between the actual situation (status quo) and a number of different alternatives[4] from which individuals must choose the most preferred.

[1] As the other approaches summarised here the basic purpose of this method is to estimate non-market values, quantifying a person's willingness to pay in order to achieve (potentially) some environmental improvement or to avoid (potentially) some environmental harm from the implementation of the countermeasures

[2] Following Lancaster the relevant characteristics should be defined not in terms of an individual's reaction to the good (countermeasure in our case) but rather in terms of objective measures.

[3] The number varies but in most applications the range is from six to eight

[4] These models are based on the assumption that individuals make choices among alternatives so as to maximise the mathematical expectation of utility, that is, the sum of the utilities from the alternative states of the world each weighted by its probability of occurrence.

So, the basic issues in choice modelling are:

- Determination of the alternatives: attributes and levels

Attributes: They are descriptors which must be chosen in terms of objective measures actually describing the good.

Levels: All the alternatives can have the same or different attributes but in any case they are defined in terms of the possible levels the attributes could take.

In the study of costs and benefits of countermeasures, the alternatives could be the countermeasures themselves. Among the attributes, the efficiency in removing the contamination and the *other* impacts such as environmental (those that affect biodiversity, ecology, aesthetics, etc.). Another variable or attribute to be included is the economic cost or *price* of the countermeasure implementation.

Variations across the proposed alternatives in the choice sets are achieved by assigning different levels to the attributes. Different levels are assigned to attributes to create the proposed alternatives according to a systematic process known as experimental design. In our case, countermeasures exhibit different degrees of efficiency in removing radioactivity, so these differences could be considered as levels for this specific attribute.

By observing and modelling how people change their preferred option in response to the changes in the levels of the attributes, it is possible to determine how they trade-off between the attributes, that is, it is possible to see what they are willing to sacrifice in order to get *more* of another attribute. For example to pay more to get sooner effects of the removal of radioactivity, or to have a worsen landscape to enjoy a safer environment.

Given that one of the attributes involved is a kind of price, it is also possible to estimate the amount that people are willing to pay to achieve more of an environmental attribute. These results make possible to infer the amounts people are willing to pay to move from the status quo (the situation they will have without countermeasures) to specifically defined impacts (good and bad) that corresponds with countermeasure outcomes of interest. In other words, the willingness to pay for a specific countermeasure. These estimates of compensating surpluses are consistent with the principles of welfare economics and are therefore suited for inclusion as value estimates in benefit cost analyses of policy alternatives.

Moreover, achievements in removing radioactivity can be made possible with a number of competing countermeasures among which decisors must choose. In this context, it could be necessary or, at least, interesting, to know the relative support that the different alternatives could be expected to receive from the public. Choice experiments can be designed to know this acceptation by the public.

- Experimental design

Once the attributes and levels have been selected it is necessary to *build* the cards, including in each card-selected levels of the attributes a price for the option. The cards will be grouped (two or three plus the *status quo*) forming *choice sets*.

The number of choice sets is an important issue. The more choice sets the better ability to infer information (to be able to establish statistically the impacts of the attribute levels on choices) and the more difficulty for getting sensible responses. The ideal to be able to separate out the effects on choice of every single attribute level, would be to present all possible combinations of attribute levels to the respondents (namely full factorial design). Given that the number of combinations of attribute levels can be very large to be processed by respondents a reduced combination should be pursued.

Two strategies to overcome this problem have been defined: the use of fractional factorial design and the blocking of the experimental design.

The former is a selection of the available combinations maintaining the orthogonality property[5]. The more reduced is this number with respect of full factorial the less is the capacity of identifying all possible interactions that may occur among attributes.

The blocking refers to segment the fractional factorial into blocks, each of them will be exposed to different respondents. In this case, each respondent will be faced with only one block, minimising the number of choice sets showed to him/her.

- Implementation of the survey

The survey can be done via personal interview, personal drop-off - collecting the questionnaire later, telephone interview and mail out and back.

For choice experiments where graphic material has to be shown telephone and even mail shots are not advisable. The best, but more expensive, to generate high rate of responses, is the personal interview, however, this process could be influenced by the so called 'interviewer bias'[6].

- Choice of a model

Individuals can employ a variety of strategies to make choices[7]. Due to its straightforwardness, the most used strategy by economists is optimising: individuals are thought to optimise their choices. This involves comparing the value of the countermeasures in terms of expected costs and benefits and choosing the option that maximises satisfaction[8]. In this case, a countermeasure is preferred over another if the utility derived from the attributes of the former is higher than that derived from the second, these are assumed to follow *additive utility models*.

In any case the behavioural basis of choice experiments is random utility theory (RUT). Under RUT the object of choice is decomposed into a deterministic or observable component (function of its own characteristics and those from individuals) and a stochastic

[5] No correlation between attributes
[6] For a description of all possible bias in stated preference techniques reader is referred to Morrison M.D., Blamey, RK., Bennett, JW, Louviere, JJ. *A comparison of stated preference techniques for estimating environmental values*. Choice Modelling Research Reports, no 1, 1996.
[7] More on decision strategies on Blamey et al. 1997.
[8] Keeping certain constraints above a minimum level.

or unobservable part: the error term. Assumptions over the distribution of this error term will determine the model (logit, mother logit, probit ...). The most common assumption is a Gumbel distribution of the error term so the multinomial or conditional logit (MNL) has been the most extensively applied model.

Under the MNL procedure, the probability of choosing a countermeasure is modelled as a function of the impacts and the socio-economic characteristics of the respondents. In this way a countermeasure will have a higher probability of being chosen as its associated level of beneficial impacts rise while the level of costs fall. This probability is then an indicator of the relative satisfaction provided by the countermeasure.

Relevance for STRATEGY

This method is suitable to calculate both use and non-use values and allows consideration of different degrees of damage/benefit. For this reason, it is our recommended method for computing the valuation of the side-effects for most countermeasures in which more than one side effect has been identified.

Countermeasures can affect biodiversity (almost all measures which apply treatments to soil, crops, vegetation) and animal welfare (those countermeasures which change the management of livestock and its longevity etc.) at the same time. The majority of these side-effects can be considered as non-use values. For estimating these values, it is necessary to describe what the implications of the countermeasures are and the degree of change they may cause. It is therefore advisable to collaborate with experts in the affected systems to understand how these changes would be perceived by the general public.

The same countermeasure can impact in different ways. As an example, areas where the recreational/educative use may be affected may also experience effects on biodiversity. This can happen, for instance, with treatments to soils and vegetation or changes in grazing regime, due to their effects on a scenic landscape.

It is important to differentiate the effects if there is more than one from the same countermeasure to separate the values to estimate. That is, for the recreational use of an area it could be suggested that the changes provoked by the countermeasure would imply restrictions for example, no fishing or no swimming while the implications of the same countermeasure in terms of wildlife preservation (if non-use value) could be focussed to fund protective measures to (for instance) preserve subaquatic plants and insects. Because estimation of values is very site and condition specific it is not possible, at the present state of knowledge, to transfer results from one site (with specific deposition characteristics) to another. The present situation and potential of change has to be assessed to better design the experiments for valuation.

For further on choice modelling the reader is referred to

Louviere, JJ., Hensher, D.A., Swait, J.D., (2000) Stated Choice Methods. Analysis and Application, Cambridge University Press.

2. Contingent valuation method (CVM)

This is by far, the most applied approach in the empirical work (in 1995 Carson quoted over 2,000 CVM studies). It has been widely applied from mid 1970s and, due to its simplicity, CVM studies are still growing as the rest of the stated preference models.

Objective

To measure both use and non-use values[9]. Involves survey respondents being asked if they are willing to pay some amount of money to achieve a hypotethical (environmental or other) goal. Basically the method *creates* a market for an environmental quality, that is, given that a beautiful landscape, for example, is not sell or bought in a market (so it has no market price), CVM simulates a situation where people could keep or *acquire* a nice view from their home just being willing to sacrifice something to get it.

Stages

1. *Definition of the situation:*

When a project like the implementation of countermeasures to reduce radio-pollution is considered (costs and/or benefits need to valued) we should seek first to identify the affected population by the environmental feature/s which will be susceptible to change after implementation. Then the survey is carried out on those affected, who technically are the *relevant* population. It is also important to have well defined *how* they will be affected to better classify the attribute as use or non-use.

2. *Selection of a sample:*

Due to the high costs of interviewing, not everybody will be questioned, only a random sample of those identified as relevant.

3. *Design of the questionnaire*

Once the affected population and the environmental feature have been settled, the next step is to design the most suitable questionnaire. At this point different issues come up:

1. The amount of unbiased information (on the feature being under scope and on the whole exercise of valuation) given to the respondents, in order to elicit a sensible response.

2. To construct the hypothetical market, decisions have to be made on the bid vehicle (the means of payment), the payment rule and the provision rule

[9] Use value: when there is a real use (planned or actual) by the individual
Non-Use value: There is not a direct use of the asset but it is the mere existence known by the individual what produces utility. It includes the altruist wish of preserving for future generations.

3. To get WTP (willingness to pay) or WTA (willingness to accept compensation) is necessary to choose among different options like open-ended, ladder payments, dichotomous choice and others.

To illustrate this point let us examine a type of question, which could be posed to assess a real practice or a case study: Supposed a situation of a radioactivity polluted park area where the recommended countermeasure has been *skim and burial ploughing*. External effects of this measure are of the kind of:

- the possibility of getting contaminated groundwater
- soil erosion
- limited tilling
- esthetical effects

All of them seriously affect the welfare of the surrounding population.

In contingent valuation we cannot get a simultaneous valuation of all of these consequences, instead we have to elicit the value one by one. In our example the question will be posed to elicit the welfare losses derived from the changes in the esthetical aspects. To do this, **simulated scenarios** (manipulated photographs) are necessary to better describe the appearance before and after application of the countermeasure. In other cases like contamination of groundwater, could help but are accessory. So the question could be posed in the next terms:

Please take a look at these two pictures which represent how the park looks like and how it would became after the treatment (explanations about the situation and treatment should have been given in advance). Suppose there is the possibility of restoration of the landscape and it does exist a way to give the old look back to this park. This way passes from creating a local fund, with the contributions of the inhabitants of this area being managed privately to recover the site. Will you be willing to contribute to this fund?

Once the individual has decided if he/she comes into the game or not it is the moment to elicit the approximate amount. Different ways of getting the so called bid can be considered. For example:

Could you please tell us how much, at maximum, will you be willing to pay to recover the former aspect of the park?

- The fund could be formed by an annual contribution during the following two years of € 10. Will you contribute with this amount?

This question, if it is answered with a yes, can be followed for example asking him/ her how much more (or maximum) they will be willing to pay; and if not, which will be the maximum, if any, with what they will be willing to contribute to.

- A ladder design (card) can be shown to the individual and require him to signal the amount he/she will certainly pay and/or the amount he/she will certainly not pay.

Summarizing the main issues mentioned are the following:

- the bid vehicle: a contribution to a fund (which is WTP);
- payment rule: two payments in the following two years to a privately managed fund,
- provision rule: private and voluntary contributions, and the kind of bid

The entire situation must be **credible**, but specially the bid vehicle. One school of thought suggests avoiding voluntary contributions and using a kind of compulsory bid vehicle instead (like taxes or entry-fees for example), with the aim of reducing strategic behaviour (for example underbidding).

4. Analysis of data

Once all the responses have been collected, a distinction should be done on the bids. Special analysis deserves the *protest bids* which are the response of zero willingness to pay or accept when individual does not agree with the question posed to him or some parts of it (for example with the payment vehicle, with the hypothetical situation or when the welfare losses are so big that nothing can compensate the loss, etc.). We should not mix real zero bids (also called genuine zeros) of those who really do not value the feature being considered with the protest bids.

After a number of questionnaires have been completed, analysis of responses has to be made. Firstly, WTP and WTA will be aggregated to calculate a sample and a population mean and/or median. Secondly a bid curve analysis will be undertaken to see how the WTP or WTA is influenced by certain characteristics (variables) of the sample.

The different proportions of respondents agreeing to pay the different amounts of money are used to infer the amount overall people are willing to pay for the environmental improvement.

Relevance for STRATEGY

This method is suitable for those impacts affecting both use and non-use of a specific asset, such as all those countermeasures changing biodiversity, animal welfare (all non-use in most of the cases) and use (hunting, walking, etc.) of an area. This is the case for all those countermeasures which involve ploughing in any form (skim, shallow, deep) and which remove or affect the soil and therefore affect the landscape and biodiversity. This is also applicable to other countermeasures affecting the scenic beauty of a place will may affect potential visitors, maybe discouraging visits (if allowed).

Although CVM has be widely used, it has two main drawbacks, namely it is not possible to estimate the value of more than one impact (with one level) at a time and that it is a source of biases.

For more on Contingent Valuation Method reader is referred to:

Hanley N., Shogren J.F., White, B., (1997). Environmental Economics in theory and practice. Macmillan Press LTD.

Carson, R.T., Wright, J., Carson, N., Alberini, A., Flores, N., (1995) *A bibliography of Contingent Valuation Studies and Papers*. Natural Resource Damage Assessment, Inc.

3. Travel Cost Model

This model pertains to the family of revealed preference techniques. Revealed preference techniques are based on the observation of the individuals behaviour in related markets. Revealed preference techniques are known as well as indirect approaches because *uses* a related and demanded market good to infer a value on something which lacks of a market.

This is the oldest approach to environmental valuation, firstly proposed by Hotelling in a letter to the US Forest Service in the thirties. Travel Cost methodology is based on the money expent on travelling as a proxy for the price of visiting a certain site with recreational purposes.

Objective

To establish the relationship between the number of visits/trips to an outdoor recreational site and the costs of each visit. Costs are supposed to increase with distance while the number of visits are inversely related with costs. Those, a demand curve is derived and measures of welfare (for use) can be obtained through integration (consumer's surplus).

Issues

The use of a related market-good implies that if the commodity is not used no value can be infered. Travel cost approach can estimate use value if there is a use of the selected good (in the case of valuation of impacts on a National Park if the individual does not visit the Park it is not possible to infere how the changes affects his/her utility). This property is called *weak complementarity* between the asset and the expenditure (if there are no expenses there is no posibility of valuing with this approach).

Another assumption in travel costs studies is that the recreation activity is *separable* from other activities, both recreational or consumption. That is, the visits an individual make to a close forest is independent of what he/she spends on books for example.

In valuing the impacts of countermeasures, TCM could be applied when a recreational/educational site would be affected, not only environmental assets, but heritage and/or touristic in any sense.

Stages

TC studies can be very simple or very complex, but there are not standard ones. The simplest version collects information on the number of visits and origin, without even interviewing. A visit rate is explained as a function of travel costs. Travel costs rise with distance in its two components: money and time. A common TC study could have the following stages:

1. Definition of the site under scope and identifying the users. It is important to limit the scope of valuation when dealing with wide open areas as well as the activity/ies that can be done on site. In the same way, it is necessary to know if locals make use of the site anyhow. Depending on the importance or fame of the site, visitors' characteristics will

be very different. This issue has to be taken into account in the design of the questionnaire.

2. Design of questionnaire. Data should be collected on origin, perceived distance, costs and time, expected levels of congestion, substitute sites, intentions of travelling, size of the party, number of visits on a certain and limited period of time and socio-economic characteristics.

3. Tracing of the demand curve for visits to the site. A demand curve can be estimated by predicting how number of visits will fall (rise) as travel costs rise (fall). Both visits per capita and visits per limited period can be used as dependent variables.

4. Analysis under different models. Random utility models, hedonic travel cost, hipothetical travel cost, are either variations and/or model which embody some of the critics made to the basic travel cost approach, namely inclusion of substitutes, multi-purpose trips, changing characteristics, among others.

Relevance for STRATEGY

This method is applicable for all those side effects affecting the recreational/educative value of an area. The advantage, as said above, is that this method relies on real behaviour, not hypothetical, but it can only estimate the value of the use/s of the services of an area.

Countermeasures that affect recreational/educative areas are all those which may be implemented in natural/heritage areas, affecting landscape through treating soils, vegetation, cleaning of surfaces, etc.

For more on travel cost method reader is referred to

Bockstael, N., McConnell, K., Strand, I., (1991) *Recreation* in J. Braden and C. Kolstad (eds), Measuring the Demand for Environmental Quality, Amsterdam: Elsevier

Fletcher, J.W., Adamowicz, W., Graham-Tomasi (1990), The travel cost model of recreation demand, Leisure Sciences, 12.

4. Hedonic Pricing Method

This method, as those of the conjoint analysis, is based on the theory of value proposed by Lancaster (1966) and Rosen (1974). It seeks to explain the value of a good as a bundle of characteristics valued by the individual. The value of any good depends on objective and measurable characteristics but also on other external aspects such as the surrounding environment where the good (for example a house) is located. In other words, the price of a good can be decomposed on the prices assigned to each attribute.

Issues

As TC models the hedonic pricing method assumes the weak complementarity property and, as a consequence only use values can be measured. Thus, it is necessary to find a link between the environmental feature of interest and a marketed good (for instance housing).

This approach relies on very strong assumptions. One of them is that each individual has to be considered in equilibrium in the corresponding market, that is, each person has bought exactly the amount which makes equal the marginal cost with the marginal valuation, otherwise the values inferred can not be considered marginal benefits (or costs).

Stages

1. Estimation of a hedonic price function for the good. To accomplish this part it is necessary to collect data on the prices of the good (housing) and on the main characteristics that define the commodity.

2. Calculation of the implicit prices of the variables of interest. Once the curve has been estimated, partial differentiation with respect any variable (characteristics) gives its implicit price. These implicit prices are expected to vary with the level of the characteristic.

3. Derivation of a demand curve for the chosen variable. This is an optional stage and involves regressing computed values of implicit prices against levels of the environmental variable and socioeconomic parameters.

The chosen variable can be an environmental feature as the quality of the view, cleanliness of the air or leafynees of a forest.

Difficulties

There are some statistical difficulties for estimation such as the possibility of multi-collinearity, omision of a relevant variable, the choice of functional form, etc., which can affect seriously the implicit prices. Other difficulties are subjective to the individual such as their individual attitudes to risk. This is the reason why the Kask and Maani (1992) suggest not to use such method on the valuation of risky environmental events such as the study of earthquakes risks and by extension to radioactivity hazards. In those cases people consistently overvalue very low probability events and consistently undervalue high probability events; moreover people may have too little information making this method either over or underestimate welfare changes.

Relevance for STRATEGY

This method is very useful for predicting values of housing in relation to the potential risk of radioactive hazard. It can be very useful *ex ante* (before an accident), computing the effect of the proximity of a nuclear power station to the residential areas; but not immediately after an accident for estimating any loss of value of dwellings.

To have a complete data set for computing the impact on housing prices after a nuclear accident (*ex post*) a long period of time is needed to allow the market to incorporate the new information about the situation. Information campaigns can deaden the pernicious effect of the knowledge that an area was affected by radioactivity and subsequent countermeasure implementation; this will have an effect on prices of houses too. Because of this, the method is not advisable as a mean of estimation of potential losses on housing.

For more on this method reader is referred to:

Hanley N., Shogren J.F., White, B., (1997). Environmental Economics in theory and practice. Macmillan Press LTD.

Kask, S., Maani, S. (1992), Uncertainty, information and hedonic pricing, Land Economics, 68 (2)

5. Production Function Approaches

Many environmental goods are inputs to the production of goods and services traded in markets. Changes in the quality/quantity of an input may have implications on the prices and quality of the outputs. These implications alter producer's profits and/or consumer's surplus. Treatment of soils can produce a reduction in fertility affecting production costs or the instrinsic characteristics of the green product itself. Dose-response models, averting behaviour and ecosystem function valuation are examples of this class of methods. The former have been extensively applied to study the effects of air pollutans on agricultural crops and forests.

Under the ecosystem function valuation, different functions of an ecosystem are identified in order to assign a monetary value where possible, and where not, it is expressed in qualitative terms (for example, damage to buildings after radioactivity removal).

Issues

Ecosystems are interlinked within and with the economy. System analysis is an useful tool to express all this complex connections and relationships. Rankings are made with the monetary and non-monetary valuation, under different management alternatives.

Dose-response approaches take natural science information on the physical effects of a pollutant and introduces this data in an economic model.

Dose-response functions: Stages

More than stages, two parts can be identified: First the inference of the response function consequence of the pollutant dose; sencond the application of the economic model. Under the former, biological information provide the link between the pollutant and the production impact. To assess the changes in welfare (consumer and producer's gains and losses) requieres knowledge not only on biological processes but on technical possibilities and producer's willingness to react. This information can be inferred, producer's observed behaviour or derived from secondary data (or a combination of all) which makes this technique very useful to elicit welfare measures. Adams (1983) advice on the use of production and costs functions because of the avoidable need of explicit dose-response functions. The problem with this approach is the statistical difficulties on the implementation.

Relevance to STRATEGY

This method is applicable for all those countermeasures that affect direct or indirectly the productivity of soils (all treatments which affect fertility or quality of products) and biological functions of ecosystems (i.e. reduction in extent of forests as a result of treatment of wood/trees, composition and variety of plant/animal life, etc.).

For more on this subject reader is referred to

Bockstael, N., Freeman, AM., Kopp, R., Portney, R., Smith, V.K., (199) On valuing nature. Mimeo

Hanley, N., Spash, C., (1993) Cost-Benefit Analysis and the Environment. Edward Elgar.

Authors: Begoña Álvarez-Farizo (SIA-DGA)

José M. Gil (DEAB-UPC)