A Fair Go:
Attitudes towards equity in natural resource management in WA

Michael Burton

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Michael Burton*
School of Agricultural and Resource Economics
University of Western Australia

Abstract

In this paper a methodology is proposed which allows one to estimate preferences over the distribution of policy outcomes within a community, using a random utility model and a CES utility function. Application to dryland salinity in WA using a convenience sample of students indicates a relatively low level of inequality aversion, but a strong 'reference' effect, linked to a potential policy outcome with strong equity levels.

Keywords: equity; preferences; resource management
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*Michael Burton
School of Agricultural and Resource Economics
Faculty of Natural and Agricultural Sciences
University of Western Australia
35 Stirling Highway, Crawley, WA, 6009
Australia

mpburton@agric.uwa.edu.au
tel +61 8 9380 2531
fax +61 8 9380 1098

Introduction

Identifying community attitudes towards equity issues relating to natural resource management (NRM) is important for two reasons. Firstly, social welfare will not be maximised if a 'classical utilitarian' perspective is assumed (maximizing aggregate welfare, irrespective of distribution), if in fact there is an inequity aversion. Secondly, if there is a need for community acceptance and engagement in policy implementation one may find that policies fail to achieve even their technical capabilities if there is strong resistance to their equity implications.

There have been relatively few attempts to empirically identify the degree of inequity aversion, as it applies to public goods or the provision of public services. This cannot be revealed by actual behaviour, and experimental economics is limited to situations where the good can realistically be purchased, or the policy implemented. Such attempts that have been made have relied on direct surveys of attitudes (e.g. Dolan and Robinson, 2001, Amiel et al, 1999). In this paper the survey approach is followed, but using an alternative, random utility format. Estimates of inequality aversion, and the significance of reference points are provided, based on salinity management, which is currently one of the most pressing issues in natural resource management in Australia. It should be noted that this paper does not propose a mechanism for constructing a conventional 'social welfare function' (*à la* Bergson, 1938), but rather to identify individual preferences for distributional equity.

Approaches to inequality aversion

Previous attempts to empirically identify inequality aversion have been based on *leaky-bucket* experiments. In these, respondents are asked to identify different allocations of resources across hypothetical populations which leaves them (the respondent) indifferent. For example, Dolan and Robinson (2001) identify two hypothetical individuals with equal health status (measured on a cardinal scale), and then require respondents to identify an unequal distribution of health status which they consider to generate an equivalent level of social welfare. Amiel et al (1999) require respondents to consider the level of money to transfer to a 'poor' person that would compensate for the transfer of an amount from a 'rich' person. On the basis of these revealed amounts, they either identify 'Atkinson' measures of inequality (Atkinson, 1970) or estimates of the utility function itself.

The approach taken here is similar, but is based on a random utility framework. Respondents are given the choice between two resource allocations and required to identify the one they prefer. Specifying a functional form for the utility function and a distribution for the random component of utility allows the parameters of the utility function to be retrieved using conventional discrete choice methods.

The 'indifference' *v* 'preference' modes is similar to the distinction between open-ended 'willingness to pay' and discrete choice 'referendum' models in conventional non-market valuation techniques. In the former, respondents are presented with a change in (e.g. environmental) attribute level, and then asked to identify the level of payment they would be prepared to make to achieve that change: to return them to their initial level of welfare. In discrete choice respondents are presented with a change in attribute level and a payment level, and then asked if they prefer this to the status quo. The discrete choice mode is becoming the standard within the environmental literature (e.g. Arrow et al. 1993;Hanemann and Kanninen, 1999).

Measuring inequity aversion using a random utility model.

Assume that utility arising from policy alternative p (U_p) is defined over the level of some good, enjoyed by two individuals (or groups) x and y. Further, assume a specific functional form: a Constant Elasticity of Substitution (CES) function:

$$U_p = \left[\delta x_p{}^{-\theta} + (1-\delta) y_p{}^{-\theta}\right]^{1/-\theta} \qquad (1)$$

where δ defines a relative weight given to each, and θ measures the curvature of the indifference curve. As both individuals are described as identical, and anonomised to the respondent one would expect δ=0.5 (although see below). The elasticity of substitution is given by:

$\sigma = 1/(1+\theta)$ so that:

if θ=-1, $\sigma = \infty$ and the two individuals are viewed as perfect substitutes:

if $\theta = \infty$, σ =0 i.e. the indifference curves are rectangular, or Rawlsian, so that no substitution is possible to compensate for a reduction in the good enjoyed by one person.

The issue then is how one may retrieve the underlying parameters of the utility function. Here we propose to employ a 'preference' experiment, where the respondents are told the 'equity' attribute levels (x_e,y_e), and the 'inequity' levels (x_u,y_u), and simply asked to select the one they prefer. Retrieving information about preferences then requires a formal statistical model. If one assumes that utility is derived by equation 1 above, augmented by a random error term:

$$U_p = U(x_p,y_p) + \varepsilon, \qquad p=e,u \tag{2}$$

and ε is distributed with a Gumbel distribution then one gets a conditional logit model. Let Y be a random variable that indicates the choice made: Y=1 if the equal allocation is preferred and zero otherwise, then

$$PROB(Y=1) = \frac{e^{U(x_e,y_e)}}{e^{U(x_e,y_e)} + e^{U(x_u,y_u)}} \tag{3}$$

$$PROB(Y=0) = \frac{e^{U(x_u,y_u)}}{e^{U(x_e,y_e)} + e^{U(x_u,y_u)}} \tag{4}$$

If respondents are presented with a wide range of attribute levels, then knowledge of the choices made, and the attribute levels, allows one to estimate the parameters of the utility function.

Application: salinity management in Western Australia

Dryland salinity is currently a major threat to the economic, social and environmental welfare of rural Western Australia. Caused by the fundamental shift in the hydrological balance arising from the transition from native vegetation to broadacre farming, salt stored deep in the soil profile migrates to the surface as the water table rises. When it reaches the surface it severely impacts agricultural productivity, causes damage to infrastructure such as roads and towns and potable water supplies, and affects ecological resources either by killing pockets of remnant vegetation, or by the flow of saline water into rivers and wetlands.

It has been estimated that 1.8m ha (10%) of agricultural land were affected by salinity in WA in 1994 (defined as reducing potential wheat yields by 50%: Ferdowsian et al, 1996) and that the area at risk (water table less than 2 m from surface, or within 2-5m and rising) is currently 4.4m ha and will be 8.8m ha by 2050 (Water Resources Audit, 2000). Most or all of the ecological communities in the lower parts of catchments will be lost to salinity without intervention (George et al., 1999) with e.g. 450 plant species at high risk of extinction (State Salinity Council 2000; Keighery, 2000).

Significant resources have been devoted to attempting to resolve this issue at both state and federal level: a National Landcare Program was launched in 1989, and a salinity National Action Plan committed $1.4 billion in 2000. However, it has been argued (e.g. Pannell, 2001) that previous programs have achieved little, in part because technical solutions do not exist that can be adopted economically for many landholders, but also because resources have been distributed too widely, and thinly. The report of the WA Salinity Task Force (Frost et al, 2001) has proposed that ".. it is neither possible in practice nor desirable in principle for Government to provide direct financial assistance..... on the scale needed to manage salinity effectively across the agricultural region." and "Inevitably, a targeted investment strategy in salinity management will result in an unequal distribution of investment across the state." (p33).

A targeted investment strategy will mean that public resources will be directed at those catchments where public benefits can most effectively be achieved, to the private benefit of those property holders who live in those areas, while other areas will have to live with salinity as best they can. Although clearly appropriate from a technical efficiency perspective, it would have profound implications for equity.

It is in this context that the approach to inequality aversion outlined above has been applied, using a convenience sample of 37 third year Agricultural Science and Natural Resource Management undergraduates from the University of Western Australia, all of whom will have been very familiar with the technical and economic issues associated with salinity.

The context given was two identical catchments (x and y above), both with severe salinity problems. Under the first policy intervention funds are allocated to increase the area of protected land in the catchments by an equal amount. In the alternative policy intervention the same level of funding is used, but the area of protected land is different between the two catchments, and (in most cases) the aggregate level of protected land is increased. The students are faced with a tradeoff between equity and efficiency in the use of public funds.

Each student was asked to answer 10 choice questions. A copy of the survey is in the Appendix (note that the survey was completed in class, and a verbal explanation of the task was given to them as well). A total of 358 choices are available (2 students did not turn over the page, resulting in 12 missing answers).

Assuming that the two catchments are identical, and respondents do not distinguish between them so that $\delta=0.5$, the conditional logit model gives the results in Table 1 below.

Insert table 1 here

Note that the estimate of θ is significantly different from -1, implying some degree of inequality aversion, with an elasticity of substitution of 1.23.

Dolan and Robinson (2001) identify significant "reference point" effects e.g. the utility obtained from the unequal level of benefits is influenced by the level of the benefits achieved in the 'equal' outcome. It is possible that these effects are occurring here as well. What this would imply in this context is that the respondents are putting differential weights on the area of land protected in the catchment that 'loses' area i.e. the catchment in the 'unequal' policy regime that has less productive area than that allocated to it in the 'equal' policy regime. This implies a 'loss' aversion component to the utility function (although note that this can only be in relative terms: the catchments are always better off than if there were no policy intervention at all). This can be investigated by sorting the data such that catchment y always has the reduced area (note this was not the case in the survey itself) and then allowing a differential weight to be placed upon the two areas i.e. δ in (1) above is not constrained to equal 0.5. Table 2 reports the results.

Insert table 2 here

This suggests that respondents are placing a higher weight on the area protected in the worse off catchment, but not to a significant extent, as δ is not significantly different from 0.5 .

This formulation allows for a differential weight on 'losing' and 'gaining' catchments, but it does not take any account of the reference point i.e. the area that would be achieved with the equal allocation. This changed within the survey, and hence should be accounted for. A specification which allows for this is:

$$U_u = \left[x_u^{-\theta} + \left(y_e - (1+\delta')(y_e - y_u) \right)^{-\theta} \right]^{1/-\theta} + \varepsilon \qquad (5)$$

or equivalently

$$U_u = \left[x_u^{-\theta} + \left(y_u - \delta'(y_e - y_u) \right)^{-\theta} \right]^{1/-\theta} + \varepsilon \qquad (6)$$

Here, if δ'>0, a change in the area protected in catchment y *below the reference point* y_e has a greater impact on welfare than an equivalent change in area above the reference point. Estimating this model gives:

Insert table 3 here

The elasticity of substitution has shifted to 3, i.e. it has been significantly increased as a result of including the reference point, and would imply that the students do not see the distribution of benefits and issue. However, the estimate of δ is significant and positive, implying that a greater weight is placed on losses, as compared with gains i.e. the level of utility is affected by the implied 'loss' in protected area as compared with the equity policy.

Obviously, in the data set, inequality aversion and loss aversion are linked, as the unequal distribution typically involved a reduction in area for one catchment below the equal area. However, what the statistical analysis indicates is that the two elements can be distinguished from each other. As Figure 1 shows, the implication of this model is that the indifference curve is kinked at the reference point, and this gives a higher curvature in the function than is present due to inequality aversion alone. In fact, over the appropriate range the utility function is very flat, implying little concern for equity *per see*, apart from that implied by the reference point itself. This may well be a feature of the group of respondents, given their predominant training in physical sciences, and the emphasis placed on the technical solution of the problem within that training.

Implications for the resource allocation and salinity management

The large, landscape scale of salinity would appear to require selective public investment of resources. However, social preferences for equality of treatment provide a pressure against this. The survey design is equivalent to a Rawlsian veil of ignorance, in so far as the catchments are anonymized, so these results may be viewed as preferences for equity, rather than self interest. The implication is that some technical efficiency, or aggregate level of public assets, may need to be sacrificed in-order to increase the equity components in the social welfare function.

One question the analysis raises is whether the reference point exists independently of the experimental design. Thus, there may be no prior expectations about the distribution of gains from a resource management policy, in which case one would suggest that $\delta'=0$, and ones assessment of the social welfare gains from a policy should be based on the equity/efficiency implications and θ alone. However, if one believes that there is an implicit presumption among the community that every catchment is due a 'fair go' then this would mean the impacts of loss below the reference point need to be included. A question that then needs to be asked is: what defines the reference point? In reality, the efficacy of policy interventions will differ between catchments, something which underlies the experimental design but which is never set out explicitly. Should the social welfare function define equity (and the reference point) over outcomes (in terms of catchment effects) or the inputs (in terms equal access to funding/resources), or some combination of both? An extended experimental design would be required to evaluate this.

At a technical level, the approach used here seems to offer a number of advantages. It explicitly identifies the curvature of the indifference curve, which is an indicator of social attitudes to inequality. The use of the constant elasticity of substitution utility function has the advantage of generating a single value for the measure of inequality aversion, albeit at the cost of a restrictive functional form. It is likely that in a sample drawn from the general population there would be a significant number of cases where a preference would not be made. This would imply that a 'thick indifference curve' model would be required (Svento, 1993). It would also be possible to introduce individual heterogeneity into the model, by making the estimated coefficients a function of respondent characteristics (e.g. rural v. urban populations). The definition of the outcomes being considered should also be extended. Thus, in the current model, the catchment is described solely by the area of productive land after the policy intervention. In reality the outcomes from policy intervention would be across a range of catchment attributes, such as productive land, biodiversity protection, employment etc. By making x and y functions of a number of catchment attributes, one could jointly determine the weights being placed on these diverse outcomes and attitudes towards equity. However, it is likely that there will quickly be a limit at which the complexity of the problem posed overwhelms the respondent: not unlike the problem of salinity management.

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Appendix: The Survey.

NB: there were two versions of the survey. The first page was identical for both, and includes the description of the exercise, and 4 choice sets. There were two versions of the second page. Below, just the first page of the survey is included. The full set of alternative policy outcomes is listed in table A1 below.

The survey was implemented in a class with a group of students who were well versed in the technical issues. They were also given a brief verbal outline of the task.

Table A1 the alternative attribute levels used

Policy I				Policy II		
Catchment x	Catchment y	Total		Catchment x	Catchment y	Total
3	3	6		2	4	6
2	2	4		1	4	5
4	4	8		5	4	9
4	4	8		2	10	12
2	2	4		1	6	7
6	6	12		10	5	15
7	7	14		9	3	12
3	3	6		9	1	10
7	7	14		10	4	14
8	8	16		8	10	18
5	5	10		10	5	15
6	6	12		9	6	15
2	2	4		9	1	10
6	6	12		8	2	10
5	5	10		9	6	15
2	2	4		9	1	10

First page of survey:
There are two catchments, identical, each of 10,000k^2 in size. You have been asked for your views on the allocation of resources for alleviating salinity in these catchments.

In the examples below, you are allowed to select between two alternative policy interventions, both of which cost the same amount. Without any policy intervention, both catchments will suffer severe degradation from salinity, and the area of productive agricultural land will decline to 1,000 k^2, and the remaining land will be degraded, growing only saltbush.

After the first policy intervention there is an equal area of productive land sustained in both catchments. After the second policy intervention, there is an unequal distribution of productive land in each catchment. The table also reports the total area of productive land achieved for each policy, across both catchments.

Please circle the policy intervention you prefer. If you are indifferent between them, circle both.

Policy I				Policy II		
Catchment x	Catchment y	Total		Catchment x	Catchment y	Total
3 tk^2	3 tk^2	6 tk^2		2 tk^2	4 tk^2	6 tk^2

Policy I				Policy II		
Catchment x	Catchment y	Total		Catchment x	Catchment y	Total
2 tk^2	2 tk^2	4 tk^2		1 tk^2	4 tk^2	5 tk^2

Policy I				Policy II		
Catchment x	Catchment y	Total		Catchment x	Catchment y	Total
4 tk^2	4 tk^2	8 tk^2		5 tk^2	4 tk^2	9 tk^2

Policy I				Policy II		
Catchment x	Catchment y	Total		Catchment x	Catchment y	Total
4 tk^2	4 tk^2	8 tk^2		2 tk^2	10 tk^2	12 tk^2

Figure 1: An estimated indifference curve: reference point =5.5

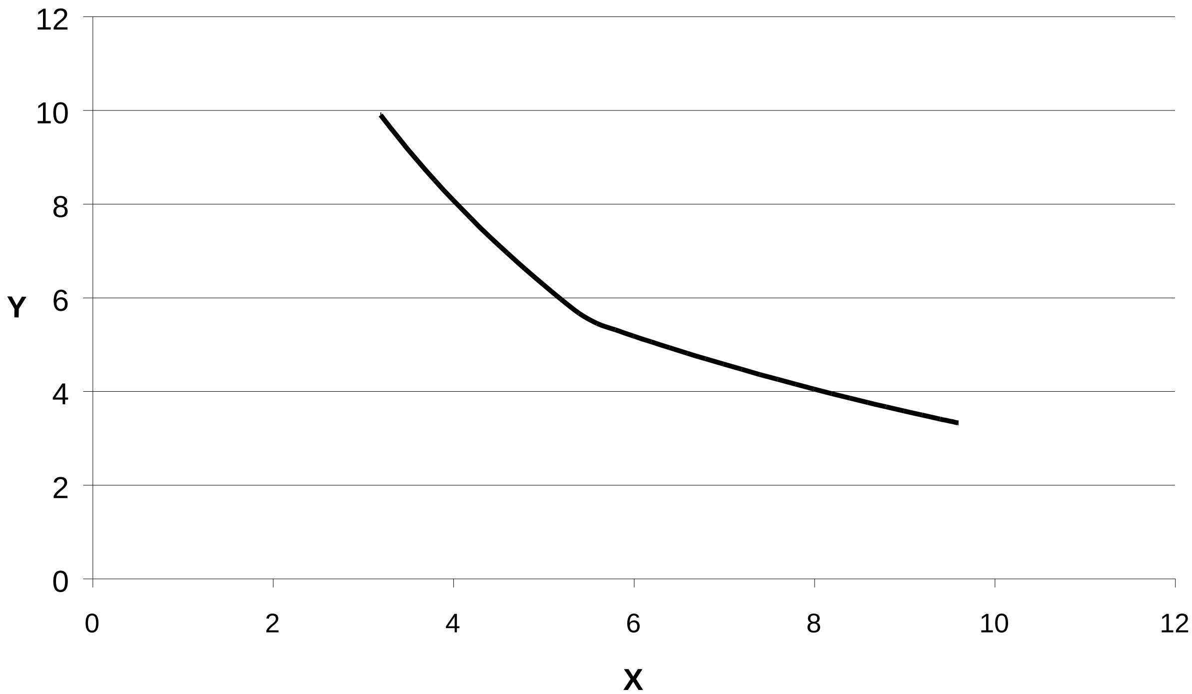
12
10
8
6
4
2
0
Y
0
2
4
6
8
10
12
X

Table 1 Estimate of a CES utility function

Number of obs = 358			
Wald chi2(1) = 2.44			
Prob > chi2 = 0.1179			
Log likelihood = -177.269			
	Coef.	Std. Err.	z
θ	-0.188	0.120	-1.563

The results have been estimated using STATA (version 6) using a maximum likelihood routine.

Table 2 Estimate of a CES utility function, with differential catchment weights

Number of obs = 358
Wald chi2(1) = 2.87
Prob > chi2 = 0.090
Log likelihood = -176.391

	Coef.	Std. Err.	z
θ	-0.657	0.388	-1.693
δ	0.398	0.077	5.162

Table 3 Estimate of a CES utility function, with a reference point

Number of obs = 358
Wald chi2(1) = 26.63
Prob > chi2 = 0.000
Log likelihood = -172.675

	Coef.	Std. Err.	z
θ	-0.638	0.124	-5.160
δ'	0.464	0.097	4.773