ENVIRONMENTAL VALUATION: DAMAGE SCHEDULES

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Abstract

Increasing concerns over environmental degradation have amplified the role of environmental economics and the valuation of non-pecuniary environmental resources as tools of analysis to facilitate the design of policies. To date, however, environmental valuation methods have continued to be unreliable, misleading and contentious as a guide to resource allocations and damage compensations.

Damage schedules, however, offer several advantages over most current post-incident economic valuation methods. One such advantage is predictability by stipulating damage or compensation awards and remedies in advance instead of waiting until the damage has taken place.

In this paper, a damage schedule is developed based on the scales of relative importance translated from people's judgments about values of various environmental damages or losses. The variance stable rank method is applied to the paired comparison responses to obtain the scale values as well as the importance of rankings. Statistical tests of significance are used to determine the level of the agreement among the survey respondents and the degree of correspondence between different respondent groups. This will determine the number of relative importance scales required to adequately represent the responses from all respondents. The scales of relative importance will then be translated into damage schedules.

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1. INTRODUCTION

Increasing concerns over environmental degradation have amplified the role of environmental economics and the valuation of non-pecuniary environmental resources as tools of analysis to facilitate the design of policies. To date, however, environmental valuation methods have continued to be unreliable, misleading and contentious as a guide to resource allocations and damage compensations.

Damage schedules, however, offer several advantages over most current post-incident economic valuation methods. One such advantage is predictability by stipulating damage or compensation awards and remedies in advance instead of waiting until the damage has taken place. In turn, this advance knowledge can lead to more effective and efficient deterrence incentives because parties responsible for potential losses are now more aware of the penalties involved, thereby causing them to be more cautious in their planning and taking appropriate levels of precaution. Similarly, enforceability of sanctions will prove to be much easier. If the liability can be established in any particular case, one simply needs to ‘foretell’ the consequence from the pre-determined damage schedule. In the same light, using damage schedules should be less costly than engaging in present practices. One reason is that lengthy and costly settlement disputes are averted. There is also no need for new assessments and challenges for the occurrence of new events or incidents as the schedule can be expanded through interpolation and extrapolation from

previously assigned damages. Thus, the damage schedule approach appears to be a serious contender in the domain of environmental valuation.

This paper attempts to develop damage schedules based on scales of relative importance translated from people's judgments about values of various environmental damages or losses and further tests for the empirical feasibility of developing such a schedule for a basket of environmental goods on the basis of the perceptions of Singaporeans. Damage schedules base damage assessments on a pre-established fixed schedule of loss values to guide environmental resource allocations and to determine damage awards. It is a non-monetary valuation approach as individuals are only required to indicate their preferences and values about environmental losses in consideration without any reference to monetary values of any kind. Thus, it is not subjected to problems such as the empirical inequivalence of willingness to pay (WTP) and willingness to accept (WTA) measures (Knetsch, 1988). In addition, it has been shown that comparing sums of money and goods using the method of paired comparison can yield conservative but robust estimates of WTA without loss aversion (Lomis, et al., 1998; Champ and Loomis, 1998). In this paper, we attempt to elicit minimum WTA without loss aversion (i.e. from an individual's reference point) using the method of paired comparison as the underlying methodology of the survey.

The variance stable rank method (Dunn-Rankin, 1983) is applied to the paired comparison responses to obtain the scale values as well as the importance of rankings. Nonparametric statistical tests of significance are used to determine the level of agreement among the survey

respondents and the degree of correspondence between different respondent groups which will in turn determine the number of relative importance scales required to adequately represent the responses from all respondents. Finally, the scales of relative importance will be translated into damage schedules.

The next section reviews a selection of related literature and outlines the various existing damage or compensation schedules. The application of the methodology adopted for this study and results of the empirical analysis is presented in section three, with section four providing concluding remarks as well as a discussion of possible limitations and corresponding suggestions pertaining to potential areas for future research.

2. LITERATURE REVIEW

2.1 Damage schedules

Many environmental policy and management issues focus on the economic value of changes in environmental resources and amenities that are consistent with community preferences and objectives. Consequently, much attention has centered on monetary assessments of their degradation or changes in their provision (Knetsch, 1998).

Amongst various methods and techniques to account for people’s environmental preferences and objectives, the alternative of basing damage assessments on a pre-established fixed schedule has, by far, received somewhat limited attention, relative to other measures of providing socially useful guidance to environmental management and damage assessment. To the extent that damage schedules can

be made to reflect community preferences, they may capture most of the benefits of more limited and problematic monetary assessments with minimal costs (Knetsch, 1998).

In addition, there appears to be an intuitive appeal in damage schedules which other alternatives fall short of. Not only do these schedules exist in various forms but they also have been widely utilized and applied in many other areas. Hence, damage or compensation schedules are objects of familiarity. They also seem to provide a widely accepted basis for actions in various circumstances in which monetary values or other indices of community values are not readily apparent, costly to produce, or intractable. Though damage schedules may not be a new concept, interest in it has certainly been rekindled for a new area, i.e. valuation of non-pecuniary environmental goods, as a more reliable and less costly alternative to the prevalent contingent valuation (CV) method typically plagued with problems such as the anchoring bias and the embedding effect (Knetsch, 1998).

2.2 Some examples

At present, damage or compensation schedules come in various forms and have been extensively utilized in dealing with non-pecuniary losses or damages. One area is in workers' compensation schemes. Other existing applications of damage schedules include damage schedules for tort reforms and environmental value schedules (Rutherford et al., 1998).

The amount of compensation that can be claimed by employees for permanent workplace injuries varies with the level of severity specified in a predetermined workers' compensation schedule. In the event of a permanent

workplace injury, the value of the injury in question will typically not be assessed as employees are guaranteed ‘no-fault’ administrative recovery of compensation for not only economic losses such as lost wages and medical expenses but also, implicitly, for non-pecuniary losses such as pain and suffering. However, Rutherford et al. (1998) cautioned that workers’ compensation schedules are, in principle, designed to compensate pecuniary or economic losses implying that a direct comparison with non-pecuniary environmental damage schedules is not possible. On the other hand, they maintained that the broad acceptance of these workers’ compensation schemes might substantiate the set-up of monetary damage awards for losses that are found to be exceptionally difficult to value based on the relative importance of losses. Finally, it is believed that the benefits derived from ‘predictability, efficiency and dependability’ will outweigh the inherent inaccuracy of such compensation schemes based on perceptions of average losses when applied to unique circumstances.

Schedules of personal injury losses have also been extended to tort reforms in several areas, for instance, no-fault compensation for non-pecuniary losses as a part of non-fault car insurance schemes in Canada. However, the impairment in question must be objectively determined in order for the appropriate no-fault compensation award to take place. The key reason is that uncertainty and disputes (hence, costs) can be minimized. Nonetheless, it ought to be noted that the relative pain and agony will reflect, quite fairly, the degree of impairment.

Tort reform in the United States has been triggered by the high transaction costs of assessment and recovery as well as the excessive variability of jury-determined

compensation awards for non-pecuniary damage. As Blumstein et al. (1990) puts it, ‘determination of awards on an ad hoc and unpredictable basis, especially for “non-economic” losses, also tends to subvert the credibility of awards and hinder the efficient operation of the tort law’s deterrence function’. In light of this, Blumstein et al. propose three alternatives in a bid to reduce the variability of personal injury awards as well as to standardize these non-economic personal injury awards. One such proposition includes the specification of a fixed damage schedule for non-economic losses. This proposition (as well as the other two proposed alternatives) hopes to ensure a more just, predictable and less costly compensation scheme for personal injuries. Nonetheless, should the variability in jury awards be partly due to the problem of making monetary assessments of non-economic values, a fixed damage schedule based on past values may in fact institutionalize errors instead of advancing towards an accurate representation of the actual values (Blumstein et al., 1990). Hence, if there exists difficulty in expressing non-pecuniary losses in monetary terms, a damage schedule established using judgments of relative importance is a more superior tool of assessment than one which is established upon past values. In New Zealand, personal injury damage schedules have taken a step further, displacing common law rights of action. In place of it is a statutory compensation scheme which includes a compensation schedule for non-pecuniary losses.

Environmental value damage schedules with the aim of standardizing natural resource damage assessments and reducing costs of assessment have been predominant in the United States. Many states are found to have adopted pre-established damage schedules based on formal replacement

cost calculations or on informal replacement cost tables. Such damage schedules allow for easier, more effective and less expensive post-incident damage assessments.

Some fifteen years ago, a survey revealed that nine US states adopted damage schedules on the basis of formally computed replacement costs while another thirteen states relied on replacement cost tables as informal guides for post-incident damage assessments. Furthermore, this survey found that some jurisdictions did not rely on the use of replacement cost but instead, establish arbitrary monetary charges. On the other extreme, some states employed more extensive measures of value (compared to replacement cost) to set up pre-established charges for environmental harms. An example of this can be found in Texas where species are ranked according to a set of eight criteria of value. The rankings are subsequently converted to a monetary liquidated damages scale. Damage schedules for environmental losses such as oil or other harmful liquid spills attempt to ‘quantify and standardize the expected damage from a given spill in a given area’. Thus the damages in a given schedule are specified ‘in terms of the type and volume of liquid spilled and the type of environment affected’ (Rutherford et al., 1998). Meanwhile, efforts are made to incorporate non-pecuniary values into the assessment. Existing applications of environmental damage schedules, as briefly discussed previously, specify the compensation or damage awards based on the following: replacement or restoration cost; openly arbitrary monetary sums; estimates derived from contingent valuation studies or other valuation methods; judgments of physical and biological importance by different interest groups. However, the pre-determined compensation figures set up

using these above approaches are either problematic or limited in their applications to value assessments.

2.3 Further research on damage schedules

Rutherford et al (1998) suggested that a damage schedule based on consistent judgments of environmental importance may be capable of providing more accurate and acceptable indicators of community values if such judgments can be elicited directly from the public. In particular, survey respondents are made to choose between pairs of non-pecuniary environmental losses whereby the results are then used to construct an interval scale of relative importance of these losses which can be developed into an interim damage schedule. Fifty two graduates were given a questionnaire whereby four different environmental losses resulting from oil spills were presented in pairs. For any given pair, respondents were required to select the loss which would warrant a greater sum of compensation. A brief hypothetical description of each spill site and the relative magnitude of three characteristics of resource vulnerability were given. Although hypothetical, such oil spill settings enabled the assigning of approximate numerical rankings. To simplify and standardize oil spill and habitat description, factors such as size of oil spill, oil type, season, dissipation time and effect on commercial and recreational fisheries ought to be held constant. This is intended to provide respondents with sufficient information to make informed choices. Included were descriptions of spill sites to help invoke intrinsic feelings. For the same reason, vulnerability rankings were given in words like ‘high, low or medium’ rather than in quantitative terms. Also, in order to invoke a sense of

loss as well as to elicit non-use values and use values, the spills were outlined as ‘damage to publicly owned locations’. The majority of the respondents made consistent choices between all the pairs presented, implying that rational and consistent choices can be made among such non-pecuniary losses (Rutherford et al., 1998).

Chuenpagdee (1998) investigated the applicability of two kinds of damage schedules i.e. a loss schedule and an activity schedule in each of the two coastal areas of Thailand. In an attempt to assess the relationship between the most damaging activity and the most important resource loss, the correlation of the two schedules was examined. Two different groups of respondents were studied, namely formal experts and lay experts. The results show a significant agreement among respondents, both in the total sample and in all sub-groups, in the rankings of importance of resource losses and activities. The scale values and rankings were insensitive to the level of intransitivity. Overall, her study showed that meaningful scales of relative importance of resource losses and impacting activities could be obtained based on people’s judgments. When losses of different magnitudes occur over time, adjustments can be made to these schedules through interpolation or extrapolation of the initial scale values. Damage schedules are relatively faster and less costly to develop, compared to current valuation methods. To a large extent, the efficacy of the damage schedule pivots on it being utilized by policy-makers as guides for their decision-making process on environmental resources (Chuenpagdee, 1998).

In the next section, the methodology of the damage schedule approach will be discussed in relation to its findings when applied to a basket of environmental goods.

3. EMPIRICAL APPLICATION AND ANALYSIS

3.1 Methodology for the damage schedule approach

There are several methodologies that can be applied to evaluate community preferences and choices. A simple and promising method is the method of paired comparison. This is a well established psychometric method for ordering preferences among the elements of a choice set. Hence it is by no means mere coincidence that the damage schedules developed by Rutherford et al. (1998), Chuenpagdee (1998) and Chuenpagdee et al. (2001) made use of this method to elicit scales of relative environmental importance.

The paired comparison method is used primarily in cases where subjective judgments are called upon to compare between objects (David, 1988). The method involves presenting a given set of objects independently in pairs as binary choices to each respondent. The set of objects could be gains, losses, activities, environmental resources or whatever is being scaled. If the choice set does not contain too many objects, all possible pairs can be presented to each respondent. The total number of possible pairs of n objects is $n(n-1)/2$.

Note that a simple ordinal ranking of all objects may be preferred when the comparison of these objects simultaneously can be easily achieved. However, when the differences between objects are subtle, it is desirable to

make the comparison between the pair as free as possible from any extraneous influences caused by the presence of other objects. Thus, paired comparison offers certain advantages when a fine judgment is needed. Nonetheless, pair-wise ranking can only be done quickly when differences between objects are fairly clear. Also, if there are too many objects, pair-wise ranking becomes impracticable and neither is it necessarily possible to achieve a wholly satisfactory ranking (David, 1988).

An advantage of the paired comparison method is that repetitive choices between different objects in the choice set can reveal inconsistent choices as circular triads. If no circular triads are produced, the result will be a perfect rank ordering of the objects. However, we cannot expect all the respondents to be perfectly consistent in their choices. Inconsistency may be due to systematic intransitive choice, incompetence of the respondent, random choice when the pairs are too close to call or simply pure errors. Systematic intransitive choice is more probable when the objects are multidimensional such that the prominence of different characteristics may vary according to the pair of objects that is being compared (Kahneman et al., 1999). In a study to evaluate the transitivity axiom for the method of paired comparison, Peterson and Brown (1998) found that a large proportion of the circular triads in their data were due to close calls.

3.2 Experimental design

In this study, two series of paired comparison questions were administered by means of two similar computer programs. Tables 1 and 2 list the options and

provide brief descriptions. There are eight options in Table 1 and fourteen options in Table 2. Respondents are to refer to Table 1 for the first survey and to Table 2 for the second.

(Tables 1 and Tables 2 here)

Both computer programs present the pairs of options on the screen and require the respondents to make a choice. No ties are allowed. The pairs of options are presented in random order to the respondents so as to control for order effects. The programs automatically record the respondents' choice for each question. If there is an inconsistent choice, the response will be marked as a contradiction. Such inconsistent responses are repeated at the end when all possible paired options have been asked. Three consistent pairs, chosen at random by the computer, are also repeated and randomly mixed with the repeats of the inconsistent pairs. There is nothing to indicate when all the possible paired comparisons ended and when the repeats began. This is done to ascertain preference switches for inconsistent choices.

A simple random sample of 100 respondents is taken for each of the surveys. In each of the sample, the respondents are then segregated by age, income and educational level. At any point in time during the survey, respondents are able to clarify with the investigator if any doubts arise. The respondents only need to use the mouse to click on the option selected. Several pre-tests were done to fine-tune the procedures for the survey. From these pre-tests, revisions were made to the procedures and instructions until it was felt that the respondents were fully capable of understanding what is required of them.

3.3 Empirical application of the damage schedule approach

A damage schedule is developed based on the preferences of Singaporeans using the method of paired comparisons. The first series of paired comparisons is between different states of environmental quality for different resources. A pilot survey was conducted to determine the four most important environmental goods perceived by Singaporeans. Table 3 shows the results of the pilot survey.

(Table 3 here)

The four most important environmental problems are degradation of coastal and marine environment, polluted air, ozone depletion and unhygienic environment relating to food and water. Each of the four different environmental problems was further varied at two different levels of environmental quality namely, moderate and severe. Hence, there will be a total of eight options for comparison (see Table 1), giving rise to a total of 28 possible pairs. However, it is assumed that the severe environmental problem of each type always matters more relative to the moderate level of the same type. Thus, such pairs are excluded leaving 24 possible pairs for comparison in the first survey.

A simple way to evaluate paired comparison data is to use the preference score for each item which is defined as the number of times the respondent prefers that item over other items in the choice set (Peterson and Brown, 1998). Thus, each item has a maximum score of (n-1) where n is the total number of items in the choice set. The individual preference scores will be obtained from the paired comparison results and aggregated across all respondents.

The most straightforward method that may be used to summarize the respondents' choices among the pairs is the variance stable rank method (Dunn-Rankin, 1983). In this method, the proportion of times that each item is chosen relative to the maximum number of times it is possible to be chosen by all respondents in the sample is calculated. This proportion indicates the collective judgment of the relative importance of the different items being compared (Chuenpagdee, et al. 2001). A scale from 0 to 100 is obtained when multiplying this proportion by 100.

3.4 Data analysis and results

The results from the 100 respondents are summarized in Table 4 where the scale values for all eight losses are listed for the entire sample and for each sub-sample divided by age, monthly income and educational level. A striking finding is the close correspondence of the scale values across most of the sub-samples as indicated by the relatively large Kendall's W or coefficient of concordance.

(Table 4 here)

The null hypothesis that Kendall's W is zero is rejected in the each of the cases judging from the very small associated asymptotic p-values. Hence, there is good consensus among respondents in the ranking of the relative importance of environmental problems. The close correspondence of the scale values among the sub-samples is further evident in the high Kendall's Tau correlation coefficients shown in Table 5. The null hypothesis of no correlation is rejected at the 5% level of significance. It is thus concluded that all sets of rankings were related.

(Table 5 here)

Severe air pollution is ranked either first or second and has scale values of at least 80, except for the ‘Below 800 SGD’ sub-sample which appears to be specifically more concerned with food and water contamination. Air pollution is generally not perceived to be as important (ranked third for severe and seventh for moderate). A plausible explanation is that people with lower income may care more for basic healthcare needs such as food and water hygiene. Only for the ’31-40 years’ group is severe ozone depletion viewed as slightly more important than severe food and water contamination, even though ozone depletion is not a prominent issue in Singapore. A possible reason could be that respondents in this age group are more exposed to international media and hence more aware and concerned about international environmental issues.

Thirty six percent of the paired comparison responses are found to be intransitive. The effects of intransitivity was tested using Kendall’s W and Tau. For the transitive respondents, Kendall’s W is 0.6379 and its asymptotic p-value (based on a chi-square distribution with 7 degrees of freedom) is 0.0022. Thus the null hypothesis of no agreement among the respondents’ rankings can be rejected. Agreement among intransitive respondents is also found to be very significant as shown by the small asymptotic p-value of 0.0059 and Kendall’s W of 0.6169. Next, the null hypothesis of no correlation between these two respondent groups is rejected as Kendall’s Tau is 0.7857 with a p-value of 0.0062. Finally, the null hypothesis of no correlation between the transitive group and the entire sample is also rejected at the 1% level of significance. The correlation coefficient for this two groups is 0.9286.

The findings suggest that inclusion of intransitive responses into the sample did not significantly alter the resulting scale values of the environmental problems in the choice set. Out of a total of 60 inconsistent responses recorded, 51 of them were reversed on retrial. Thus, a large proportion of the inconsistent choices are, in fact, switching behaviour on indifferent choices and hence do not violate the transitivity axiom. Hence, it is appropriate to use a single scale of relative importance to represent all the respondents as shown in Figure 1.

(Figure 1 here)

3.5 Comparison of demographics across samples

Before applying the data from the second survey to measure WTA, we need to test if the two samples are from populations which are identically distributed in terms of the demographics, namely, age, income and education. Using the Kruskal-Wallis test, for age the test statistic was 0.04762 with p-value of 0.8273, for income the test statistic was 0.0833 with p-value of 0.7728 and for education the test statistic was 0.04762 with p-value of 0.8273. Thus the null hypothesis of the populations being identically distributed cannot be rejected.

3.6 Using the paired comparison method to measure WTA

Using the paired comparisons in the second survey, each respondent will be asked to make a choice between two alternative gains, for example, a gain of 4,700SGD (i.e. Singapore dollars) or an air quality improvement from an unhealthy level to a good level (see Table 2 for the complete list of gains). If air quality improvement is chosen, one can infer that the lower bound for WTA for air

is greater than 4,700SGD. Given that the individual is comparing two alternative gains, the apparent loss aversion associated with the standard CV method is avoided as the choice is made from the chooser reference point (Loomis et al., 1998).

Only the two most important environmental problems, air pollution as well as food and water contamination, from the pilot survey results are included in the choice set together with ten sums of money. Again, the environmental problems are varied at two levels, moderate and severe, each. Hence the total number of possible pairs for comparison is 91. However, comparisons between the environmental problems will not be needed as they have been previously done in the first survey. Also, it is unnecessary to include paired comparisons between sums of money. Hence, the only meaningful comparisons are those between environmental problems and monetary sums. The number of such pairs for comparison reduces to 40. It was carefully explained to the respondents that the different levels of money are not used as compensation for not receiving the environmental improvement.

The method used here allows us to bracket the WTA within two values. For example, the point of indifference can be identified by asking respondents if they would choose 2,700SGD or an air quality improvement from a very unhealthy to a good level, and a second choice between 3,200SGD or an air quality improvement from a very unhealthy to a good level. Rejecting 2,700SDG but accepting 3,200SGD would imply that the minimum WTA lies between 2,700SGD and 3,200SDG. A nonparametric method is used to calculate the WTA. From the responses, an empirical

cumulative distribution function is calculated and the median estimated.

The median for each environmental gain for the total and various sub-samples are rank ordered. Subsequently, the WTA estimates will be determined by these median rankings. For example, the median ranking of the entire sample for an air quality improvement from a very unhealthy level to a good level is 9. As it is only compared with the ten monetary sums in the paired comparisons, the median ranking of 9 implies that more than half of the sample of respondents chose this particular air quality improvement over the first nine monetary sums, that is from 700SGD to 4700SGD, except the tenth amount of 5200SGD. The minimum WTA is thus estimated by calculating the mid-point of the interval (4700 to 5200SGD) which is 4950SGD. Table 6 shows the median rank orders for the total sample of 100 respondents and their corresponding minimum WTA estimates.

(Table 6 here)

The findings shown in Table 6 seem to be rather consistent with those obtained in the first survey where severe air pollution is ranked the most important (scale value of 81), followed closely by severe food and water contamination (scale value of 80). Moderate air pollution (scale value of 33) is ranked just above moderate food and water hygiene (scale value of 32) in the first survey while in the second, the improvement in food and water hygiene from moderate to minimal contamination and air quality improvement from a moderate to a good level are equally ranked.

In the second survey, inconsistency is no longer detected by means of circular triads. A response is found to be inconsistent when a resource gain is chosen as more

important than say 4700SGD but is chosen as less important than any of the amounts less than 4700SGD. It is found that only five respondents made inconsistent choices. All of them switched their inconsistent choices on repeats, implying that such inconsistencies are random and not systematic. Hence, the overall consistency of all the respondents is deemed to be quite high.

As in the first survey, the total sample is divided using the three demographic characteristics, age income and education. Tables 7, 8 and 9 give the median rank orders by each of these characteristics and their corresponding minimum WTA estimates.

(Table 7 here)

The median rankings of the various age groups are rather similar, thereby inducing rather similar minimum WTA estimates too. This suggests that the WTA of such environmental goods does not vary much across individuals of different ages. From Table 8, the median rankings of different income groups are quite close, thus suggesting that there are no large differences in their minimum WTA estimates. It can also be noted that the two higher income groups appear to rank air quality above food and water hygiene. One suggestion could be that lower income groups tend to be more concerned with basic healthcare needs while greater affluence will induce one to be more environmentally conscious. As can be seen from Table 9, respondents with different educational levels do not seem to differ much in their perceptions of WTA for air quality as well as food and water hygiene. All three educational groups ranked air quality improvement from a very unhealthy level to a good level as the most important. This suggests

that regardless of educational level, individuals feel that air quality matters the most to them.

In general, these findings show that minimum WTA estimates do not vary by much across age, income and education. Thus, it is evident that Singaporeans not only display consistent judgments of relative importance for various environmental problems and issues in the first survey, but also consistent minimum WTA compensation to forego improvements in air quality as well as food and water hygiene across different age groups, income groups and educational levels.

4. CONCLUSION

The damage schedule approach shows great promise in the valuation of environmental goods. First, internally consistent judgments of relative environmental importance can be elicited without any reference to monetary values, as shown by the findings of the first survey. Furthermore, there exists a high degree of agreement among respondents in the total and all various sub-samples, divided according to age, income and education. Also, there is a relatively high level of correspondence between all the different sets of rank orders by all the various sub-samples. Intransitive responses have a negligible impact on the scale values and importance of rankings, implying that a single scale of relative importance can be used to represent the entire sample. The findings of the second survey show that Singaporeans, regardless of age, income and educational level, can provide consistent minimum WTA compensation to forego improvements in air quality as well as food and water hygiene.

The study found that Singaporeans perceived severe air pollution (scale value of 81) as the most important environmental problem followed closely by severe food and water contamination (scale value of 80). Severe ozone depletion (scale value of 78) ranks third followed by severe damage to coastal and marine environment (scale value of 49). Likewise, the same environmental problems at the moderate level are ranked in a similar order with moderate air pollution at fifth position (scale value of 33), followed by moderate food and water contamination (scale value of 32), moderate ozone depletion (scale value of 29) and moderate damage to coastal and marine environment (scale value of 19). The computed minimum WTA estimates that Singaporeans are willing to accept 4950SGD to forego an air quality improvement from a very unhealthy to a good level, 4450SGD to forego an improvement in food and water hygiene from severe to minimal contamination, 1950SGD to forego either an air quality from a moderate to a good level or an improvement in food and water hygiene from moderate to minimal contamination. Though these WTA estimates are very rough measures, they are at the very least, reflect some form of monetary valuation based on community preferences that can be used as provisional damage or compensation awards.

Paired comparisons have the added advantage of detecting inconsistent choices through circular triads in the data. The results show that a large proportion of the inconsistent responses are reversed on retrial, implying that these inconsistencies are mostly not a consequence of intransitivity but rather close calls or indifference.

When comparisons are only made between sums of money and environmental problems, individuals may feel that the

two are incommensurate, implying an unwillingness to make the trade-off between money and environmental goods. However, as long as some form of comparison can be consistently made either in terms of severity or importance, a useful scaling can be attained (Sunstein, 1994).

The damage schedules established based on public judgments of relative importance of changes in environmental quality may not necessarily bring about optimal deterrence as well as maximum efficiency in the allocation of environmental resources. However, for many purposes, inclusive of the provision of socially useful incentives and dependable consistent compensations, the objective of optimal deterrence and maximum efficiency is not essential, provided that sanctions, incentives and awards are in accord with the relative importance of environmental changes.

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Table 1

Option A	**Severe food and water contamination** causing diseases such as cholera, typhoid etc with some of them being contagious
Option B	**Moderate food and water contamination** where hygiene is not at its highest level. It may cause slight food poisoning or feeling of nausea.
Option C	**Moderate level of damage to coastal and marine environment** where mangrove forests are only partially cleared and coral reefs are marginally threatened, implying that such losses are less irreversible.
Option D	**Severe damage to coastal and marine environment** where coral reefs are badly destroyed and mangrove forests are extensively cleared. Habitat loss thus occurs, in turn causing losses of various important marine and coastal species.
Option E	**Moderate level of air pollution**, PSI between 51 and 100, where the concentration of pollutants is such that adverse health effects are not observed. Unpleasant smells from landfills and slight haze prevail.
Option F	**Severe air pollution,** PSI between 200 and 299, where air quality is at a very unhealthy level. Respiratory health and vision is adversely affected.
Option G	**Severe ozone depletion** leading to a sharp rise in UV-B radiation (UV index above 7) where sunburn time is roughly 20 minutes or less, resulting in health problems like skin cancer, eye damage and premature aging as well as harmful effects like increased global warming and climate change.
Option H	**Moderate ozone depletion** where sunburn time is more than 30 minutes, implying minimal biological effects to living organisms. Adverse harmful effects such as skin cancer, eye damage may only result after constant prolonged UV exposure.

Table 2

Option A	A **gain** of **700SGD** every year.
Option B	A **gain** of **1200SGD** every year.
Option C	A **gain** of **1700SGD** every year.
Option D	A **gain** of **2200SGD** every year.
Option E	A **gain** of **2700SGD** every year.
Option F	A **gain** of **3200SGD** every year.
Option G	A **gain** of **3700SGD** every year.
Option H	A **gain** of **4200SGD** every year.
Option I	A **gain** of **4700SGD** every year.
Option J	A **gain** of **5200SGD** every year.
Option K	**Air quality improvement** from a very unhealthy level (PSI between 200-299) to a good level (PSI between 0-50). Adverse health effects are completely removed. Air quality is restored to a safe and healthy level.
Option L	**Air quality improvement** from a moderate level (PSI between 51-100) to a good level (PSI between 0-50). Unpleasant smells from landfills and slight haze are eliminated in order to restore air quality to a safe and healthy level.
Option M	**Improvement in food and water hygiene** from severe contamination to minimal contamination. Chances of food and water borne diseases are being greatly reduced so that food and water hygiene are being restored to its highest level.
Option N	**Improvement in food and water hygiene** from moderate contamination to minimal contamination. Chances of slight food poisoning are reduced in order to restore food and water hygiene to its highest level.

Table 3: Simple Ranking of Environmental Problems by Sixty Respondents

List of Environmental Problems	**Rank**	**Frequency each item was chosen**
Noisy environment	5	27
Loss of scenery	8	15
Degradation of coastal and marine environment	4	29
Loss of biodiversity	6	25
Polluted waterways and surrounding seas	7	23
Polluted air	1	43
Ozone depletion	3	38
Unhygienic environment (relating to food and water hygiene)	2	40
Others	9	0

Table 6: Median Rankings and Corresponding Minimum WTA Estimates for 100 Respondents

Improvement in Environment Quality	**Median Rankings**	**Minimum WTA Estimates**
Air quality improvement from a very unhealthy to a good level	9	4950
Air quality improvement from a moderate to a good level	3	1950
Improvement in food and water hygiene from severe to minimal contamination	8	4450
Improvement in food and water hygiene from moderate to minimal contamination	3	1950

Table 7: Median Rankings and Corresponding Minimum WTA Estimates for Various Age Groups

Improvement in Environmental Quality	**15-20 years**		**21-30 years**		**31-40 years**		**Above 40 years**	
	Rank	**WTA**	**Rank**	**WTA**	**Rank**	**WTA**	**Rank**	**WTA**
Air quality improvement from a very unhealthy to a good level	8	4450	9	4950	9	4950	9	4950
Air quality improvement from moderate to good level	2	1450	3	1950	3	1950	3	1950
Improvement in food and water hygiene from severe to minimal contamination	8	4450	9	4450	8	4450	9	4950
Improvement in food and water hygiene from moderate to minimal contamination	2	1450	3	1950	3	1950	3	1950

Table 8: Median Rankings and Corresponding Minimum WTA Estimates for Different Income Groups

Improvement in Environmental Quality	**Below 800**		**801-2000**		**Above 2000**	
	Rank	**WTA**	**Rank**	**WTA**	**Rank**	**WTA**
Air quality improvement from a very unhealthy to a good level	8	4450	9	4950	9	4950
Air quality improvement from moderate to good level	2	1950	3	1950	3	1450
Improvement in food and water hygiene from severe to minimal contamination	9	4950	8	4450	8	4450
Improvement in food and water hygiene from moderate to minimal contamination	2	1450	2	1450	3	1950

Table 9:Median Rankings and Corresponding Minimum WTA Estimates for Different Educational Levels

Improvement in Environmental Quality	**Secondary School or below**		**A-level or Diploma**		**Degree**	
	Rank	**WTA**	**Rank**	**WTA**	**Rank**	**WTA**
Air quality improvement from a very unhealthy to a good level	9	4950	9	4950	9	4950
Air quality improvement from moderate to good level	2	1450	3	1950	3	1950
Improvement in food and water hygiene from severe to minimal contamination	9	4950	8	4450	8	4450
Improvement in food and water hygiene from moderate to minimal contamination	3	1950	2	1450	3	1950

Figure 1: Scale of Relative Importance of Environmental Problems Based on the Perceptions of Singaporeans

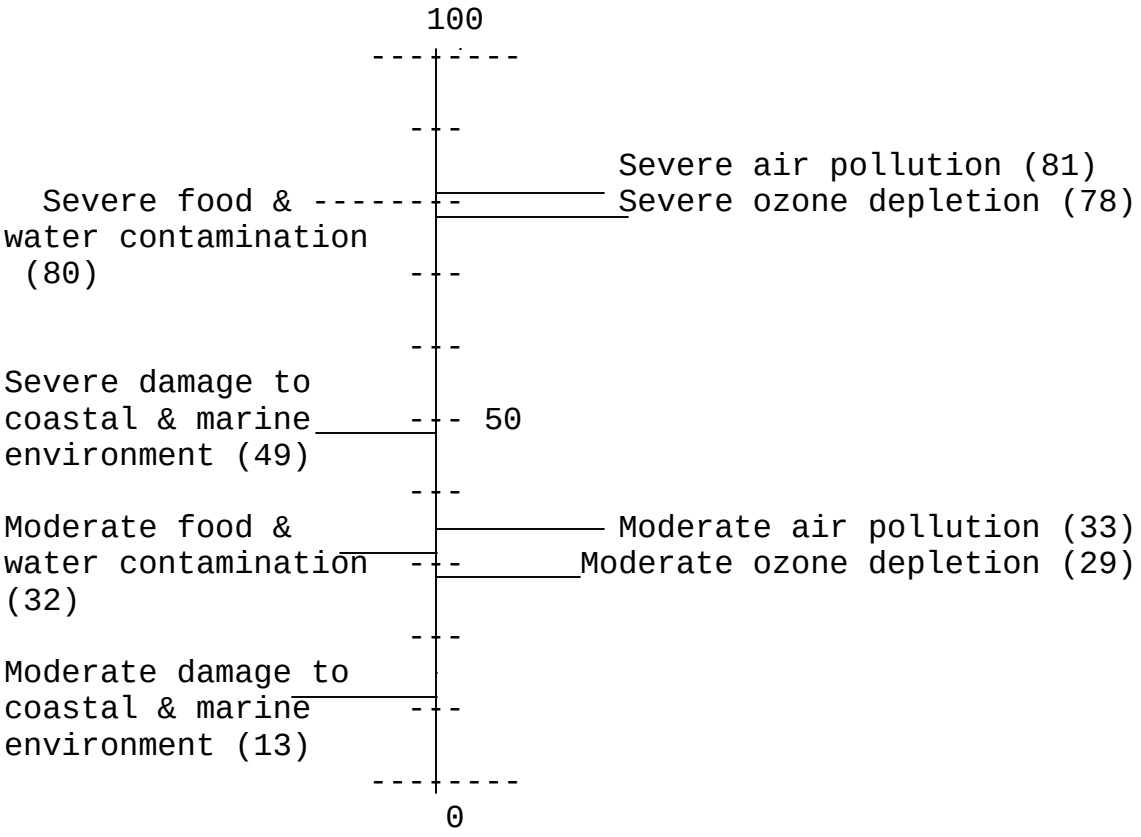

Table 4: Scale Values of Environmental Problems

		AGE (in years)				INCOME (in SGD)			EDUCATION		
Environmental problem	**Total**	**15-20**	**21-30**	**31-40**	**Above 40**	**Below 800**	**801-2000**	**Above 2000**	**Sec. School or below**	**A-level/ Diploma**	**Degree**
Severe air pollution	81	83	85	84	80	74	88	87	84	80	87
Severe food and water contamination	80	90	80	80	82	83	80	82	79	82	82
Severe ozone depletion	78	71	78	81	75	82	77	76	77	80	76
Severe damage to coastal and marine environment	49	43	48	43	43	40	47	47	52	42	44
Moderate air pollution	33	27	37	34	35	34	37	33	30	33	37
Moderate food and water contamination	32	42	31	34	42	42	34	31	27	39	34
Moderate ozone depletion	29	28	31	36	31	37	26	33	37	35	28
Moderate damage to coastal and marine environment	13	17	11	8	13	8	12	12	13	9	12
Number of respondents	100	15	41	33	11	28	30	42	18	38	44
Kendall’s coefficient of concordance	.6240	.6050	.6336	.6559	.5517	.5895	.6626	.6451	.6383	.6156	.6473

Table 5: Kendall's Tau Correlations of Scale Values of Environmental Problems

		AGE (in years)				**INCOME (in SGD)**			**EDUCATION**		
		15-20	21-30	31-40	40-	< 800	801-2000	>2000	Sec. School or below	A-level/diploma	Degree
AGE	15-20	1.00	.7857	.7500	.9286	.8571	.7857	.7638	.7857	.9286	.7857
	21-30		1.000	.7500	.8571	.6429	.9867	.9092	.8571	.7143	.9891
	31-40			1.000	.6786	.6183	.7638	.8889	.9092	.6910	.7638
	40-				1.000	.7857	.8571	.7638	.7143	.8571	.8570
INCOME	<800					1.000	.6429	.6071	.6429	.9285	.6407
	801-2000						1.000	.8929	.8571	.7140	.9823
	>2000							1.000	.9820	.6910	.9099
EDUCATION	Sec.School or below								1.000	.7143	.7143
	A-level/diploma									1.000	.8571
	Degree										1.000