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ENVIRONMENTAL BUDGET ALLOCATION: PUBLIC PREFERENCES

Geoffrey N. Kerr
Ross Cullen
and
Kenneth F.D. Hughey

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Commerce Division
PO Box 84
Lincoln University
CANTERBURY

Telephone No: (64) (3) 325 3627
Fax No: (64) (3) 325 3847
E-mail: cullenr@lincoln.ac.nz

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Abstract

It is important for central government to have good information about public preferences regarding budget allocations. Consumer sovereignty, government popularity, and efficiency are all dependent on clear articulation of community preferences. The paper draws upon information gathered as part of a large-scale survey to identify community perceptions about the state of the New Zealand environment (Hughey *et al.*, 2002) to identify public preferences for allocation of government monies. Methods entailed survey participant statements of preferences for spending on specified environmental and conservation items, a balanced macro-budget reallocation exercise, and a choice modelling exercise to reveal willingness to trade-off expenditures on particular budget items.

The environmental budget allocation exercise provides little guidance on which aspects of environmental spending would provide the greatest benefits at the margin. For most items the modal response was no change in current spending. However, more than 50% of respondents indicated they preferred increased spending on pest & weed control, air quality and fresh waters.

The macro-budget reallocation and choice modelling exercises provide similar results. They both indicated that people obtain negative utility from allocating money to income support, and desire cuts to spending on superannuation and income support. Older respondents are not as averse to spending on income support, but are still generally in favour of cuts in spending on this item. Spending on health, education, and the environment all yield positive benefits. Respondents see significantly more benefits from spending on health, than on education or the environment. Willingness to spend on health is not affected by respondent age, but willingness to spend on education and the environment both decline with age.

Contact Author: Geoffrey Kerr, Senior Lecturer in Environmental Economics, Environmental Management Group, Lincoln University, PO Box 84, Canterbury, New Zealand. Tel: +64 (3) 325 3627 extn. 8688.
Email: kerr@lincoln.ac.nz

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1. Introduction

Central government budget appropriations provide an area of ongoing debate as ministers seek to obtain funds to support their portfolios. Public preferences are important. Allocation of money to unpopular activities or failure to allocate funds to perceived good causes not only transgresses the concept of consumer sovereignty, but also has implications for government popularity, and can result in inefficient allocation of resources. Consequently, it is important to have good information about public preferences for central government budget allocations.

This paper reports on research that was designed to identify *inter alia* public preferences for allocation of government monies. The information was gathered as part of a large-scale survey to identify community perceptions about the state of the New Zealand environment (Hughey *et al.*, 2002).

Kemp and associates have previously investigated community values associated with New Zealand government expenditures, primarily using category rating (Kemp, 1998; Kemp and Burt, 2001; Kemp and Willetts, 1995a, 1995b). Kemp's research has shown relatively low correlation between budget allocations and perceived benefits, indicating that transfers of government expenditure from high cost, low benefit categories to low cost, high benefit categories is likely to improve social welfare. While government budget reallocation could be beneficial, it is also important to consider whether benefits exceed costs from government spending. Kemp's research has carefully differentiated between cost and value and has concentrated on measurement of benefits received from government services without comparison to costs of provision.

The approaches in this paper indicate the benefits of government budget reallocation and also address the efficiency of taxing citizens more (or less) to accommodate changed provision of government services.

2. Method

Data collection methods are reported in detail in Hughey *et al.* (2002). In March 2002 a self-completed survey was mailed to 2000 randomly selected people registered on the New Zealand electoral roll. After accounting for known non-delivered surveys, a 45% response rate (n=836) was obtained. Females and the elderly were over-represented in responses to the survey.

Citizen preferences for reallocation of government spending were measured in three ways.

- At the micro-level, respondents were invited to reallocate government spending on items in the *Conservation & the Environment* portfolio. Respondents were requested to maintain a balanced budget within the portfolio, a point of difference from previous similar studies (Ferris, 1983; Lewis and Jackson, 1985) which have not constrained responses in this manner.

- At the macro level respondents were asked to reallocate government spending between the competing areas of *Defence*, *Health*, *Education, Crime Prevention*, *Superannuation & Income Support*, and *Conservation & the Environment*. De Groot and Pommer (1987, 1989) have applied similar budget allocation games.

- A second macro-level budget allocation exercise applied a stated choice method to allow econometric modelling of budget allocation preferences. The four items addressed were *Health*, *Education*, *Income Support*, and *Conservation & Environmental Management*. The total budget for these four items could vary, which would directly influence taxes, as could the allocation of the budget between items. To our knowledge, this approach is novel.

3. Environmental Budget Allocation

In the micro-level analysis respondents were asked to indicate how spending on particular items in the conservation and environment portfolio should change, given that total expenditure on the portfolio could not change. The 5-point response scale was anchored with "We should spend far more" and "We should spend far less".

3.1 Results

Results (Table 1) indicate a reasonably uniform set of responses, with means and standard deviations being similar across all environmental items.

Table 1
Preferred Environmental Budget Allocation

	N	Response frequencies (%)						Mean (1-5)	SD (1-5)
		Spend far more (1)	Spend more (2)	No change (3)	Spend less (4)	Spend far less (5)	Don't know		
Pest & weed control	781	13.4	41.7	34.8	2.2	0.9	6.9	2.31	.78
Endangered Species	783	12.9	36.5	39.0	4.5	1.4	5.7	2.42	.84
Air quality	775	13.5	40.5	35.7	3.5	1.2	5.5	2.25	.81
Native forests & bush	776	6.8	28.1	54.0	5.0	0.8	5.3	2.63	.73
Soils	760	5.3	27.9	46.3	8.6	0.8	11.2	2.68	.76
Beaches & coastal waters	780	11.5	36.4	40.9	4.1	0.5	6.5	2.42	.78
Marine fisheries	782	7.2	26.7	44.9	7.7	1.0	12.5	2.64	.80
Marine reserves	783	7.2	28.7	44.1	6.3	1.4	12.4	2.61	.80
Fresh waters	770	12.3	42.3	36.0	1.9	0.3	7.1	2.30	.73
National parks	778	5.9	25.3	53.5	7.8	1.5	5.9	2.72	.77
Wetlands	783	6.0	26.4	42.1	9.3	1.9	14.2	2.71	.84

Respondents were not good at balancing the budget in this exercise. Mean scores indicate a desire to spend more than at present on all environmental items. Apart from wetlands, no more than 10% of respondents wanted less money spent on any particular item. The modal response was "no change", except for pest & weed control, air quality, and fresh waters, where the modal response was "spend more". These three categories are the only ones for which more than 50% of respondents preferred additional spending to the status quo[1].

[1] In each case the majority is highly significant. 99% confidence intervals for the proportions of respondents wishing to increase spending on these items are:

Pest and weed control	0.55 to 0.64
Air quality	0.53 to 0.62
Fresh waters	0.54 to 0.64

4. Macro-Budget Allocation

In the macro-level budget allocation component survey participants were informed of current government spending on six items and asked to identify their preferred allocation over those items, given that total expenditure could not change from the initial total of $30 billion per year. The items were: *Defence*, *Education*, *Crime Prevention*, *Health*, *Superannuation and Income Support*, and *Conservation and the Environment*.

4.1 Results

564 respondents (67.5%) answered this question and fulfilled the requirement to maintain a balanced budget. Table 2 provides a summary of responses. Figure 1 compares current and mean preferred budget allocations.

Table 2
Preferred Changes in Macro-Budget Allocation

Item	**2001 spending**	**Preferred CHANGE in spending**			
		Minimum ($b)	**Maximum ($b)**	**Mean ($b)**	**Standard Error**
Defence	$1 billion	-1.0	14.0	0.1271	0.048
Education	$7 billion	-7.0	6.0	0.4537	0.062
Crime Prevention	$1.5 billion	-1.5	13.5	0.3617	0.050
Health	$7 billion	-7.0	13.0	0.8651	0.074
Superannuation & Income Support	$13 billion	-13.0	2.0	-2.8275	1.311
Conservation & the Environment	$0.5 billion	-0.5	29.5	1.0199	0.095
Total	**$30 billion**			**0.0000**	

Preferred levels of spending are all significantly different from their current levels (Figure 2). Respondents wanted a substantial decrease in spending on superannuation and income support (95% confidence interval: $2.6~3.1 billion decrease). An increase in spending was desired in all other categories, with the largest desired increase in spending being on conservation and the environment (95% confidence interval: $0.8~1.2 billion increase). Respondents also preferred a substantial increase in health spending.

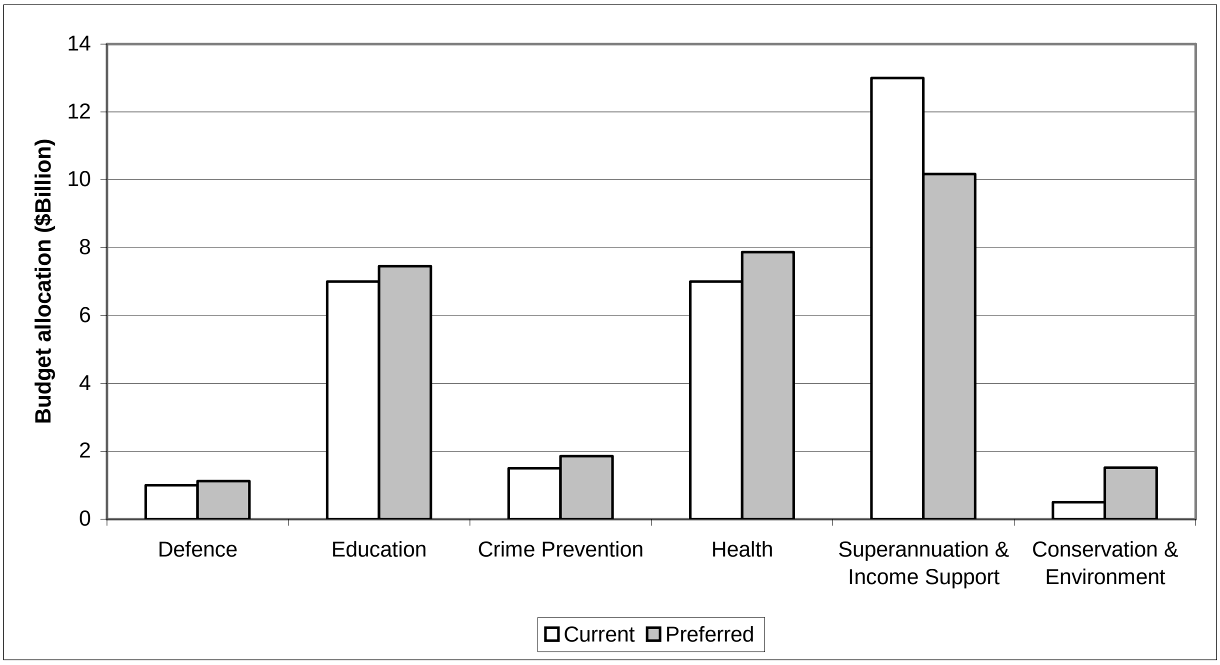
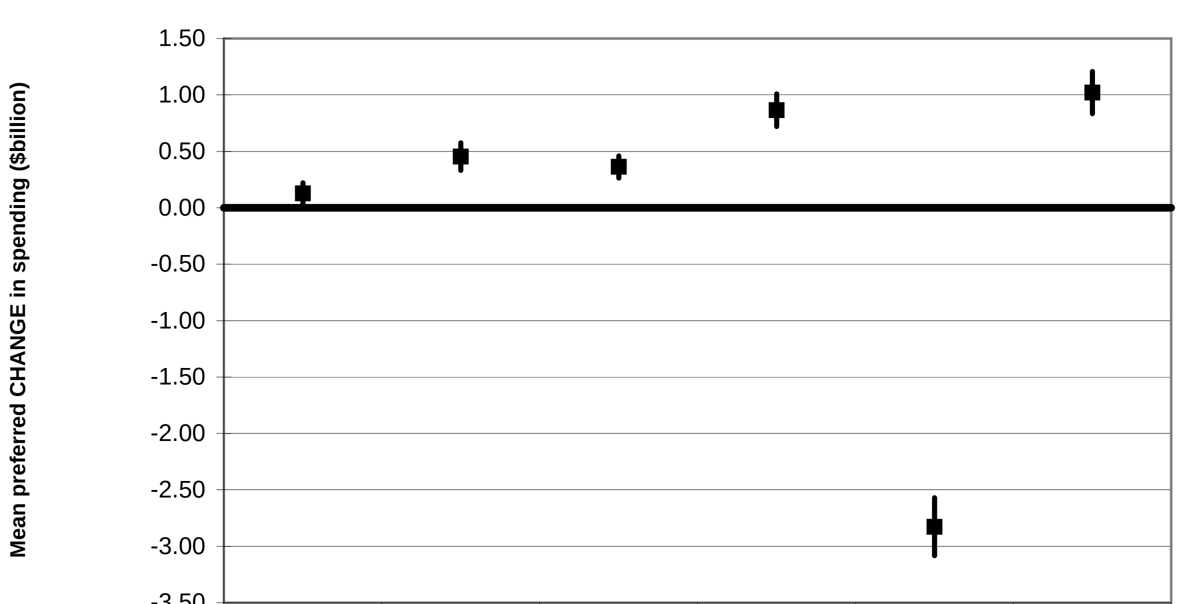


Figure 1
Current and Mean Preferred Budget Allocation ($ billion)



	Defence	Education	Crime	Health	Super	Cons
Upper 95% bound	0.22	0.57	0.46	1.01	-2.57	1.21
Lower 95% bound	0.03	0.33	0.26	0.72	-3.08	0.83
Mean	0.13	0.45	0.36	0.87	-2.83	1.02

Figure 2
Preferred Changes in Budget Allocations ($ billion)

5. Choice Experiment

Choice modelling can be thought of as mimicking a political process. Participants are given several options (alternatives) from which they must pick a single best alternative. The chosen option is assumed to have higher expected utility for the respondent than any other option presented to them. If sufficient information is available on people's choices, then it is possible to use statistical methods to derive estimates of coefficients in a utility function that describes how people made those choices (Bennett and Blamey, 2001; Louviere *et al.*, 2000).

The choice problem can be concisely formulated using random utility theory. For any individual (i), utility associated with alternative k is a function of the characteristics of alternative k ($\mathbf{X_k}$) and characteristics of the individual ($\mathbf{Z_i}$).

$$U_{ik} = U\ (\mathbf{X_k}, \mathbf{Z_i})$$

Utility derived from each alternative has 2 components, observable and random. Letting the observable portion of utility be V (.), then:

$$U_{ik} = V\ (\mathbf{X_k}, \mathbf{Z_i}) + \varepsilon\ (\mathbf{X_k}, \mathbf{Z_i})$$

Individual i will choose alternative k over all others if it is expected to yield the most utility. Probability of choosing alternative k is:

$$P\ (k) = \text{Prob}\ \{V_k + \varepsilon_k > V_j + \varepsilon_j, \forall\ j \neq k\}$$

The probability of choosing any option can only be modelled after assumptions have been made about distributions of the error terms. The most common assumption is that the errors are Gumbel distributed, leading to the multinomial logit model.

$$P(k) = \frac{e^{\mu V_k}}{\sum_j e^{\mu V_j}}$$

The scale parameter (μ) is typically assumed to equal unity, implying constant variance. Model parameters are estimated by substituting for V with a parametric utility function that is dependent on the vector of attribute levels (**X**). For example, a linear utility function takes the form:

$$V_k = V(Z_k) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n = \boldsymbol{\beta}\mathbf{X}'$$

Data analysis entails selection of the coefficient vector $\boldsymbol{\beta}$ that maximises the probability of obtaining the observed choices. This is undertaken using maximum likelihood procedures. Interaction terms and variable transformations mean that the procedure is not constrained to simple linear utility functions. Alternative assumptions about error terms generate different models, although the underlying rationale remains unaltered. Once the utility function has been estimated it is a straightforward matter to estimate the rate at which people are willing to trade off attributes.

5.1 Choice Question Method

The stated preference question provided survey participants with three options for allocation of government expenditure between *Health*, *Education*, *Income Support*, and *Conservation & Environmental Management*. Information was provided on public spending on these items in 2001. The levels of spending on each item defined the options. For any item, spending could be unchanged, could increase by \$50 million per year, or could decrease by \$50 million per year. There was no requirement to balance the budget, so it was possible to have options that entailed total budget changes across the range +\$200 million to -\$200 million. Each respondent faced only one question. However, nine different versions of the questionnaire allowed for combinations of options that allowed estimation of underlying utility functions. Survey participants faced three options and were able to select the single option that they preferred, signaling the combination of budget items that yielded the highest utility. The status quo was not an option. Figure 3 illustrates a representative choice question.

The New Zealand government spends about $36 billion each year on a range of public services.

Suppose the government were thinking about changing the amount it spent on health, education, income support and conservation and environmental management. Any increase in total spending on these items would result in a tax increase, but reduced spending could lower taxes. You are asked for your opinion on the following options. You might think there are better options than these ones, but they are the only options you can choose from for now. Which option do you prefer?

Area of public spending	**Approximate amount spent in 2001 ($ million)**	*Change in spending each year ($ million)*		
		Option 1	**Option 2**	**Option 3**
Health	$7,000 m.	$50 m. less	no change	$50 m. more
Education	$6,733 m.	$50 m. less	$50 m. more	no change
Income support	$13,000 m.	$50 m. less	$50 m. more	no change
Conservation and environmental management	$500 m.	$50 m. less	no change	$50 m. more
Change in total taxes collected		**$200 m less**	**$100 m more**	**$100 m more**

π I like option 1 best

π I like option 2 best

π

Figure 3
<u>Choice Question</u>

Allocation of alternatives to treatments was addressed in the following way: Nine trials were identified (following Hahn and Shapiro, 1966) for the case of 4 variables taking 3 levels each. These trials were then used as starting points in a shifted-triple design to obtain sets of three alternatives. The final design is identified in Table 3.

Diminishing marginal utilities imply that utility functions are not linear. Indeed, internal solutions to the budget allocation exercise require a non-linear utility function. Over small changes in the levels of budget items it is possible to approximate the utility function using a linear form. The range over which the proposed budget changes deviate from the current budget allocations is small, indicating the appropriateness of linear approximations to the utility function.

Maximum change in health budget (X_1) 0.7%

Maximum change in education budget (X_2) 0.7%

Maximum change in income support budget (X_3) 0.4%

Maximum change in conservation and environmental management budget (X_4) 10%

Further evidence in support of the linear utility function assumption is provided by Kemp and Willetts (1995a), who found that there was no significant difference in ratings when respondents were asked about either a 5% increase or a 5% decrease in provision of government services.

Table 3
Choice Experiment Design

Choice set	Alternative 1				Alternative 2				Alternative 3			
	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4
1	-50	-50	-50	-50	50	50	50	50	0	0	0	0
2	-50	0	0	50	50	-50	-50	0	0	50	50	-50
3	-50	50	50	0	50	0	0	-50	0	-50	-50	50
4	0	-50	0	0	-50	50	-50	-50	50	0	50	50
5	0	0	50	-50	-50	-50	0	50	50	50	-50	0
6	0	50	-50	50	-50	0	50	0	50	-50	0	-50
7	50	-50	50	50	0	50	0	0	-50	0	-50	-50
8	50	0	-50	0	0	-50	50	-50	-50	50	0	50
9	50	50	0	-50	0	0	-50	50	-50	-50	50	0

5.2 Economic Modelling

There are three policy options when expenditure on any item is considered:

1) Hold taxes constant and pay for increased spending on item i by reducing spending on item j (or on several items) by an equivalent amount; i.e. $dX_i = -dX_j$ and $X_i = -X_j$.
2) Raise taxes to pay for additional spending on item i, leaving other spending unaffected.
3) Additional spending on item i is accompanied by adjustments in spending on item j (or on several items) as well as tax changes when $dX_i \neq -dX_j$. This is the most general case, allowing taxes and spending on all items to be varied.

The underlying linear utility function is:

$$V = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 TAX \qquad \textbf{(5.1)}$$

Where the X_is and TAX refer to changes in levels of the corresponding parameters, and

$$TAX = X_1 + X_2 + X_3 + X_4$$

$$dV = \beta_1 dX_1 + \beta_2 dX_2 + \beta_3 dX_3 + \beta_4 dX_4 + \beta_5 dTAX$$

$$MU(X_i) = \frac{\partial V}{\partial X_i} = \beta_i \; ^{\dagger} \qquad \textbf{(5.2)}$$

Recognising that tax is a function of the other parameters and substituting to remove tax from the utility function (5.3) illustrates why it is not possible to identify (5.1). The linear dependence between TAX and the sum of the X_is means that vector $\boldsymbol{\beta}$ cannot be identified. However, it is possible to identify (5.4).

† Note that the Marginal Rate of Substitution of good i for good j (MRS_{ij}) = $MU(X_j)/ MU(X_i)$ indicates how many units of j the consumer will give up in order to obtain an additional unit of i. For normal goods, $MRS_{ij} > 0$.

$$V = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5(X_1+X_2+X_3+X_4)$$

$$V = (\beta_1+\beta_5)X_1 + (\beta_2+\beta_5)X_2 + (\beta_3+\beta_5)X_3 + (\beta_4+\beta_5)X_4 \quad \textbf{(5.3)}$$

$$V = \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 \quad \textbf{(5.4)}$$

Where $\alpha_i = \beta_i+\beta_5$

Each α_i is the net marginal utility of spending on item i, which includes the benefits obtained from spending on the item, as well as the disutility associated with having to pay higher taxes in order to fund that additional spending. It then follows that the marginal rate of substitution between items after accounting for changes in tax payments is:

$$MRS_{ij} = -\frac{\alpha_j}{\alpha_i} = -\frac{(\beta_j+\beta_5)}{(\beta_i+\beta_5)} \quad \textbf{(5.5)}$$

In order to maintain the original level of utility, a one-unit increase in expenditure on item i requires a decrease in expenditure on item j of $(\beta_i+\beta_5)/(\beta_j+\beta_5)$. Taxes change by the sum of these expenditure changes, i.e. $(\beta_j-\beta_i)/(\beta_j+\beta_5)$.

Because parameter estimates from the multinomial logit model are unique only up to a scale factor, fixing the marginal utility of money at unity (i.e. $\beta_5 = -1$) does not allow estimation of β. Simple transformations of the utility function, such as the polynomial functional form or the addition of constant terms to the parameters do not resolve this problem.

Policy 1: Linear utility function

Under Policy 1, when spending on one item (X_j) is reduced to allow increased spending on another (X_i) with a balanced budget ($dX_j = -dX_i$), the change in utility is [From (5.1)]:

$$dV = \beta_i dX_i + \beta_j \frac{dX_j}{dX_i}$$

$$\frac{dV}{dX_i} = \beta_i - \beta_j$$

In this case utility is maximized when spending is reallocated from the item(s) with the smallest β to the item(s) with the largest β. The same result is obtained when (5.3) is estimated.

$$dV = (\beta_i + \beta_5)dX_i + (\beta_j + \beta_5)\frac{dX_j}{dX_i}$$

$$\frac{dV}{dX_i} = (\beta_i + \beta_5) - (\beta_j + \beta_5) = (\beta_i - \beta_j)$$

All spending should be transferred to the item with the largest marginal utility net of tax (β_i+β_5). Inability to estimate (5.1) is not problematic for Policy 1.

Policy 2: Linear utility function

β_5 is the marginal utility of taxes, which is expected to be negative. The marginal utility of raising taxes to spend on X_i is β_i+β_5. Raising taxes to increase spending on X_i will increase utility if $\beta_i > -\beta_5$. Consequently, whenever marginal utility net of tax (β_i+β_5) is positive taxes should be increased to allow additional spending on item i. Because the βs are independent of expenditure levels, the linear utility function approximation cannot be used to identify how much additional tax should be raised to provide for increased spending on any item.

Policy 3: Linear utility function

Raising taxes to increase spending on X_i will increase utility if $\beta_i > -\beta_5$. Where $\beta_i < -\beta 5$ spending should be decreased. Consequently, whenever marginal utility net of tax (β_i+β_5) is positive taxes should be increased to allow additional spending on item i. The linear utility function implies that spending should be increased indefinitely on all items with positive marginal utility net of tax (β_i+β_5>0) and spending should cease on items for which (β_i+β_5<0). Because marginal utility is constant, the linear utility function cannot be used to identify the optimal change in spending on any item.

5.3 Results

Results for linear and second order polynomial models are reported in Table 4.

Table 4
Linear and Second Order Polynomial Models

Multinomial logit models (asymptotic t-scores in parentheses)	Model A	Model B	Model C	Model D	Model E	Model F
Health	0.010883 (10.36)	0.011038 (10.31)	0.0072626 (1.96)	0.011594 (10.53)	0.011625 (10.59)	0.01071 (10.00)
Education	0.0082587 (7.89)	0.0083475 (7.79)	0.020786 (5.38)	0.022000 (5.85)	0.022221 (5.92)	0.008683 (7.93)
Income support	-0.0069956 (-6.99)	-0.0073847 (-7.24)	-0.024151 (-6.79)	-0.024724 (-7.04)	-0.024598 (-7.02)	-0.007255 (-7.02)
Environment & conservation	0.0068592 (6.67)	0.012895 (3.21)	0.016429 (3.77)	0.017485 (4.08)	0.021370 (5.81)	0.006865 (6.63)
Age*health			0.000083809 (1.21)			
Age*education			-0.00023861 (-3.38)	-0.00025854 (-3.76)	-0.00026354 (-3.85)	
Age*support			0.00032656 (4.94)	0.00033610 (5.16)	0.00033529 (5.16)	
Age*environment		-0.00020045 (-3.10)	-0.00025605 (-3.69)	-0.00027336 (-4.03)	-0.00027819 (-4.12)	
Nz born* environment		0.0052368 (2.11)	0.0048372 (1.92)	0.0048012 (1.91)		
$Health^2$						0.0000308 9 (0.89)
$Education^2$						- 0.0000546 2 (-1.62)
$Support^2$						- 0.0000360 3 (-1.04)
$Environment^2$						0.0000180 8 (0.52)
McFadden's R^2	0.096	0.110	0.135	0.134	0.130	0.099

These models have moderate predictive ability. However, the core independent variables are highly significant[2]. Marginal utility from health spending appears to be relatively uniform across all ages, whereas the relative benefits from spending on superannuation and income support increase with age and benefits from spending on education and the environment decline with age, and at similar rates. New Zealand born respondents perceive greater value from environmental spending than do others, although this effect is of marginal significance.

Table 5 provides estimates of MRS and differences in marginal utilities, along with 95% confidence intervals that have been derived using 10,000 replications in a Monte Carlo procedure described by Krinsky and Robb (1986).

Table 5
Relative Benefits of Spending: Linear Models [95% confidence intervals]

i,j	**β_i - β_j**		**MRS_{ji}**	
	Model A	**Model E (50 years)#**	**Model A**	**Model E (50 years)#**
Health, Education	0.0026* [0.0000092 ~ 0.0052]	0.0025 [-0.0081 ~ 0.0128]	-1.32¶ [-1.77 ~ -1.01]	-1.29 [-10.2 ~ 6.5]
Health, Income Support	0.0179* [0.0149 ~ 0.0209]	0.0194* [0.0108 ~ 0.0281]	1.56¶ [1.15 ~ 2.20]	1.48 [-4.5 ~ 10.9]
Health, Environment	0.0040* [0.0014 ~ 0.0066]	0.0041 [-0.0098 ~ 0.0177]	-1.59¶ [-2.25 ~ -1.16]	-1.56 [-15.8 ~ 12.6]
Education, Income Support	0.0153* [0.0123 ~ 0.0183]	0.0170* [0.0054 ~ 0.0283]	1.18¶ [0.84 ~1.69]	1.15 [-4.9 ~ 11.6]
Education, Environment	0.0014 [-0.0012 ~ 0.0041]	0.0016 [-0.0075 ~ 0.0109]	-1.20 [-1.77 ~ -0.84]	-1.21 [-8.4 ~ 4.9]
Environment, Income Support	0.0139* [0.0108 ~ 0.0170]	0.0153* [0.0043 ~ 0.0265]	0.98¶ [0.66 ~ 1.45]	0.95 [-12.4 ~ 14.9]

Marginal utility ratios are age-dependent. The marginal utility ratios reported in this table are for a person of the age of the average respondent (50 years).
* Significantly different from zero at the 95% confidence level
¶ Significantly different from negative one at the 95% confidence level

The coefficient differences (β_i - β_j) allow the items to be ranked. A positive difference indicates that transferring spending from item j to item i increases utility. Three coefficient differences in Model E are not significantly different from zero, meaning that Model E is unable to rank Health, Education and Environment, although it does indicate that marginal spending on any of these items provides more utility than spending on Income Support.

The MRS results are interpreted as (using Model A as an example): After considering the tax implications, people are willing to accept a decrease in Education spending of $1.32 to obtain $1 of additional spending on Health (which results in tax savings of $0.32). On the other hand, spending on Income Support is viewed negatively – people desire less spending in this

2 Except for HEALTH in Model C, which is significant at "only" the 95% confidence level.

area. Increased spending on Income Support requires an accompanying increase in spending on other areas. In order to maintain initial utility, each extra dollar spent on Income Support requires extra spending on Environment & Conservation ($1.02), Education ($0.85), or Health ($0.64) respectively[3].

If MRS_{ij} is less than negative one then spending on item i is favoured. The item pairs (Health, Environment) and (Health, Education) are the only instances in Table 5 where the whole 95% confidence range is less than –1. Consequently, it is possible to conclude that health spending provides more benefits than do either environment or education spending. The following hierarchy applies with better than 95% confidence:

$$MU_{HEALTH} > \{MU_{EDUCATION}, MU_{ENVIRONMENT}\} > 0 > MU_{INCOME\ SUPPORT}$$

While the MRS between Education and the Environment is not significantly different to –1, and the differences in marginal utilities are not significantly different from zero, the models consistently rank $MU_{EDUCATION} > MU_{ENVIRONMENT}$

The predictions from Model E vary dramatically with respondent age (Table 6). However, 95% confidence intervals are very broad with this model. It is not possible to say unambiguously for any age group that the marginal rate of substitution is less than negative one.

Table 6
Model E Expected Marginal Rates of Substitution

Age	Health, Environment	Education, Environment	Support, Environment	Health, Education	Health, Support	Education, Support
20	0.74 [0.44~1.88]	1.07 [2.4~0.61]	-1.13 [-0.53~-3.25]	0.69 [1.31~0.46]	-0.65 [-0.45~-1.07]	-0.95 [-0.46~-1.70]
30	0.89 [0.46~4.01]	1.10 [3.6~0.49]	-1.12 [-0.32~-6.12]	0.81 [2.06~0.50]	-0.80 [-0.51~-1.63]	-0.98 [-0.34~-2.34]
40	1.13 [8.7~-5.6]	1.14 [5.7~-2.5]	-1.09 [7.0~-10.8]	1.00 [3.95~0.51]	-1.04 [-0.58~-3.50]	-1.04 [-0.13~-4.34]
50	1.56 [15.8~-12.6]	1.21 [8.4~-4.9]	-1.05 [12.4~-14.9]	1.29 [10.2~-6.5]	-1.48 [4.5~-10.9]	-1.15 [4.9~-11.6]
60	2.48 [20.6~-17.0]	1.37 [8.1~-5.7]	-0.96 [10.3~-10.7]	1.81 [19.3~-15.9]	-2.59 [22.8~-26.6]	-1.43 [18.5~-21.0]
70	6.13 [21.8~-22.4]	1.99 [8.2~-6.3]	-0.59 [6.6~-5.2]	3.08 [23.8~-21.4]	-10.31 [33.4~-34.7]	-3.35 [18.4~-16.8]

[3] Health: $0.64 = 1/$1.56, Education: $0.85 = 1/$1.18

Model B provides the opportunity to identify differences between people born in New Zealand and others (Table 7). Within origin groups, relative willingness to spend on Health and Education rather than on the Environment increases with age. This result is consistent with earlier models. New Zealand born respondents place a higher relative value on the environment than do those who are born overseas, with overseas born 70 year olds obtaining negative net benefits from additional environmental spending.

Table 7
Model B Expected Marginal Rates of Substitution

Age	Origin	Health, Environment	Education, Environment	Health, Education
30	NZ Born	0.91	0.69	1.32
	Not NZ Born	1.60	1.21	1.32
50	NZ Born	1.36	1.03	1.32
	Not NZ Born	3.84	2.91	1.32
70	NZ Born	2.69	2.04	1.32
	Not NZ Born	-9.71	-7.34	1.32

6. Logarithmic Model

In principle, a logarithmic model has the ability to identify the full vector of β's.

Let $V = \beta_1\log(X_1+k) + \beta_2\log(X_2+k) + \beta_3\log(X_3+k) + \beta_4\log(X_4+k) + \beta_5\log(TAX+4k)$

(6.1)

and $TAX = X_1+X_2+X_3+X_4$

Then

$$V = \beta_1\log(X_1+k) + \beta_2\log(X_2+k) + \beta_3\log(X_3+k) + \beta_4\log(X_4+k) + \beta_5\log(X_1+X_2+X_3+X_4+4k)$$

The levels of the (changes in) variables in the choice questions are [–50, 0, 50]. Since logarithms do not exist for numbers less than or equal to zero, the independent variables must be transformed. This has been done by adding k to each attribute change level so the attribute changes become [k-50, k, k+50]. Clearly, k must be greater than 50.

Then, $$MU(X_i) = \frac{\partial V}{\partial X_i} = \frac{\beta_i}{(X_i + k)}$$

$$MU(Money) = -MU(Tax) = -\frac{\partial V}{\partial TAX} = -\frac{\beta_5}{(TAX + 4k)}$$

$$MRS_{Money, X_i} = \frac{-\beta_i (TAX + 4k)}{\beta_5 (X_i + k)}$$

At initial conditions:

$X_i = TAX = 0$,

$$\therefore \quad MRS_{Money, X_i} = \frac{-4\beta_i}{\beta_5}$$

Policy 1

Under Policy 1, when spending on one item (X_j) is reduced to allow increased spending on another (X_i) with a balanced budget ($dX_j = -dX_i$), the change in utility is:

$$dV = \frac{\beta_i}{(X_i + k)} dX_i + \frac{\beta_j}{(X_j + k)} dX_j$$

$dX_j = -dX_i$

$$\Rightarrow \quad \frac{dV}{dX_i} = \frac{\beta_i}{(X_i + k)} - \frac{\beta_j}{(X_j + k)}$$

At initial conditions $X_i = X_j = 0$

$$\Rightarrow \quad \frac{dV}{dX_i} = \frac{(\beta_i - \beta_j)}{k}$$

Transferring spending from j to i will increase welfare as long as $\beta_i > \beta_j$ (Alternatively, $\beta_i/\beta_j > 1$).

Since $X_j = -X_i$, optimal reallocation occurs when:

$$\frac{dV}{dX_i} = \frac{\beta_i}{(X_i + k)} - \frac{\beta_j}{(k - X_i)} = 0$$

$$\Rightarrow \qquad X_i^* = k\frac{\left(\frac{\beta_i}{\beta_j} - 1\right)}{\left(1 + \frac{\beta_i}{\beta_j}\right)} = k\frac{(\beta_i - \beta_j)}{(\beta_i + \beta_j)}$$

Policy 2

Taxes are raised to fund increased spending on item i.

$$\frac{dV}{dX_i} = \frac{\partial V}{\partial X_i} + \frac{\partial V}{\partial TAX}\frac{dTAX}{dX_i}$$

As before, $dTAX = dX_i$

$$\frac{dV}{dX_i} = \frac{\beta_i}{(X_i + k)} + \frac{\beta_5}{(TAX + 4k)}$$

At initial conditions $X_i = 0$

$$\Rightarrow \qquad \frac{dV}{dX_i} = \frac{\beta_i}{k} + \frac{\beta_5}{4k}$$

This will be positive and spending should be increased on item i if $-\beta_5/\beta_i < 4$. **(6.2)**

This result is unsurprising given the earlier result: $MRS_{Money,X_i} = \frac{-4\beta_i}{\beta_5}$

For an optimum, $dV/dX_i = 0$, i.e.

$$\frac{\beta_i}{(X_i + k)} = \frac{-\beta_5}{\left(X_i + 4k + \sum_{j \neq i} X_j\right)}$$

When X_i is the only variable being changed $\sum_{j \neq i} X_j = 0$

and:

$$X_i^* = -k\left[1 + \frac{3}{\left(1 + \frac{\beta_5}{\beta_i}\right)}\right]$$

Policy 3

When tax changes fund spending changes for multiple items, the following equation must be solved for all i (4 equations in 4 unknowns) to identify optimal spending on all items.

$$X_i^* = -\left[k + \frac{\left(3k + \sum_{j \neq i} X_j\right)}{\left(1 + \frac{\beta_5}{\beta_i}\right)}\right]$$

6.1 Results

The logarithmic model requires selection of k. This was undertaken by searching over a range of values to maximise the fit of the model. Three different logarithmic models were estimated:

Model G: $U = \beta_1 \log(X_1+k) + \beta_2 \log(X_2+k) + \beta_3 \log(X_3+k) + \beta_4 \log(X_4+k)$

Model H: $U = \beta_1 \log(X_1+k) + \beta_2 \log(X_2+k) + \beta_3 \log(X_3+k) + \beta_4 \log(X_4+k) + \beta_5 \log(TAX+4k)$

Model I: $U = \beta_1 \log(X_1+k) + \beta_2 \log(X_2+k) + \beta_3 \log(X_3+k) + \beta_5 \log(TAX+4k)$

In each case, McFadden's R^2 continues to improve as k increases until the point where the models fail to converge (Table 8). The onset of convergence failure occurs at different points for the three models. Goodness of fit is almost identical for the three models at any given level of k.

Table 8
Estimation of k

k	McFadden's R^2		
	Model G	**Model H**	**Model I**
200	.09401	.09425	.09416
300	.09476	.09517	.09515
330	.09488	.09531	.09528
400	FTC	.09556	.09546
500	FTC	FTC	FTC

FTC: Failed to converge

The constant (k) has been set at 330 to allow comparison of the three models. Results for the logarithmic models are reported in Table 9.

Table 9
Logarithmic Models

Multinomial logit models (asymptotic t-scores in parentheses)	**Model G**	**Model H**	**Model I**
Ln(HEALTH)	3.5706 (10.26)	6.7849 (1.72)	5.8684 (11.53)
Ln(EDUCATION)	2.7300 (7.84)	5.9253 (1.50)	5.0127 (9.69)
Ln(INCOME SUPPORT)	-2.2476 (-6.94)	0.9054 (0.23)	
Ln(ENVIRONMENT)	2.2344 (6.60)	5.4349 (1.38)	4.5227 (8.93)
Ln(TAX)		-12.9283 (-0.82)	-9.2405 (-6.97)
McFadden's R^2	.0949	.0953	.0953

Model H is the preferred model because it identifies marginal utilities for all four expenditure items as well as for taxes. However, coefficients are uniformly non-significant in Model H. This problem appears to arise because 60% of the variance in TAX is explained by the other independent variables. Consequently, Model H is not retained for further analysis. Estimated coefficients in Models G and I are always very highly significant. Model G implies that additional taxes have no impact on utility, which is clearly at odds with expectations. Model I constrains marginal utility of Income Support expenditures to equal zero. In other words, it assumes that the public sees no benefits from additional spending on Income Support, just the implications of additional taxes.

Table 10
Relative Benefits of Spending: Logarithmic Models

	$\beta_i - \beta_j$		MRS_{ji}	
i,j	**Model G**	*Model I*	**Model G**	**Model I**
Health, Education	0.85 [-0.0001 ~ 1.69]	0.86* [0.13 ~ 1.72]	-1.31¶ [-1.77 ~ -1.00]	-1.17¶ [-1.39 ~ -1.00]
Health, Support	5.82* [4.83 ~ 6.80]		1.59 [1.17 ~ 2.25]	
Health, Environment	1.34* [0.47 ~ 2.19]	1.35* [0.60 ~ 2.20]	-1.60¶ [-2.29 ~ -1.18]	-1.30¶ [-1.57~ -1.10]
Education, Support	4.97* [3.97 ~ 5.96]		1.21¶ [0.84 ~ 1.69]	
Education, Environment	0.49 [-0.38 ~ 1.37]	0.49 [-0.26 ~ 1.38]	-1.22 [-1.75 ~ -0.86]	-1.11 [-1.34 ~ -0.92]
Environment, Support	4.48* [3.49 ~ 5.46]		0.99¶ [0.67 ~ 1.47]	

MRS = $-MU(X_i)/MU(X_j)$
Numbers in square brackets [ ] are 95% confidence intervals
* Significantly different from zero at the 95% confidence level
¶ Significantly different from negative one at the 95% confidence level

The coefficient differences in Table 10 are not sensitive to the model specification and marginal rates of substitution are similar across the two models. These models yield the same hierarchy of marginal utilities as the linear models (Table 5).

Policy 1: Logarithmic utility function

The coefficient differences in Table 10 indicate that utility would be increased if spending were transferred between individual items as indicated in Table 11. In each case the tax take is unaltered, as is expenditure on items other than the two identified. In both models differences in benefits from spending on Education or Environment are not statistically significant.

Table 11
Two Item Reallocations, Model I

From	To	Optimal amount to reallocate
Education	Health	$26 million
Environment	Health	$43 million
Environment	Education	$17 million
Income Support	Health	unidentified
Income Support	Education	unidentified
Income Support	Environment	unidentified

Policy 2: Logarithmic utility function

Coefficient ratios identified in Table 12 are used to measure the utility of an increase in spending on particular items, funded by an increase in taxes.

Table 12
Coefficient Ratios, Model I

Coefficient ratio	Expected value	95% confidence interval
$-\beta_{TAX}/\beta_{HEALTH}$	1.57	1.25 ~ 1.88
$-\beta_{TAX}/\beta_{EDUCATION}$	1.84	1.49 ~ 2.20
$-\beta_{TAX}/\beta_{ENVIRONMENT}$	2.04	1.66 ~ 2.44

Because each of the ratios in Table 12 is less than 4, an independent increase in spending on each item would increase utility (Equation 6.2, page 19).

Model I provides the opportunity to derive the utility maximising level of spending for each item, with spending on all other items remaining unchanged.

Recall, $$X_i^* = -k\left[1+\frac{3}{\left(1+\frac{\beta_5}{\beta_i}\right)}\right]$$

From the Model I coefficient ratios in Table 12 it can be deduced that optimal changes in levels of spending on each item, when spending on other sectors is held constant, are as shown in Table 13.

Table 13
Optimal Partial Changes in Item Spending

	Expected ($ million)	**95% confidence interval**
Health	+$1,393	$796 ~ $3,630
Education	+$844	$495 ~ $1,690
Environment	+$619	$358 ~ $1,170

Care must be applied in using the results in Table 13. The optimal changes in single-item spending are well beyond the changes investigated in the choice experiment, where spending on individual items could vary only within a range of ±$50 million from the status quo. These results do, however, support small increases of taxes to fund additional spending on these three items and indicate that further investigation of larger changes is warranted.

Policy 3: Logarithmic utility function

Equation 6.2 identifies the utility maximising level of any expenditure item, given the level of all other expenditure items. The global optimum (Policy 3) is found by simultaneously solving for all expenditure items in 6.3.

$$X_i^* = -\left[k + \frac{\left(3k + \sum_{j \neq i} X_j\right)}{\left(1 + \frac{\beta_5}{\beta_i}\right)} \right] \qquad \textbf{(6.3)}$$

Simultaneous solution of 6.3 indicates that spending on Income Support should be decreased and taxes increased substantially (by over 100 billion dollars) to fund additional spending on Health, Education and Environment. These solutions are extreme extrapolations beyond the data with little relevance to policy, so they are not reported here.

Model I can be used to investigate specific policy initiatives, however. Suppose that spending on Income Support were to be reduced – what should happen to the savings? There are two broad options, reduction in taxation, or dispersal amongst the other expenditure items. Maximisation of the utility function (Equation 6.1) with the additional constraint that total taxes equal zero indicates the optimal dispersal solutions in Table 14.

Table 14
Optimal Tax-Neutral Reallocation with Reduction in Income Support Expenditure

	Change in Expenditure ($ million)				
Income Support	**0 (status quo)**	**-$100**	**-$150**	**-$200**	**-$300**
Health	+$47	+$85	+$104	+$123	+$161
Education	-$8	+$25	+$41	+$57	+$90
Environment	-$39	-$10	+$5	+$19	+$49
Tax	0	0	0	0	0

The optimal reallocations in Table 14 reflect the marginal utility rankings. Under unaltered allocation to Income Support it is desirable to shift expenditure from relatively low marginal utility items to Health, resulting in less spending on Education and Environment. Once Income Support expenditure is decreased a significant amount it is no longer optimal to reduce spending on Education and Environment. However, the relatively high marginal utility of Health means that it will always receive the bulk of any expenditure reallocation.

7. Discussion

Mathematical modelling has been used to show how, on aggregate, respondents are willing to trade off budget allocations between sectors. This modelling exercise indicates that people obtain negative utility from allocating money to income support, consistent with the stated desire to cut spending on superannuation and income support in Question 9. Older respondents are not as averse to spending on income support, but are still generally in favour of cuts in spending on this item. Spending on the other three items (health, education, environment) yields positive benefits. Respondents see significantly more benefits (at the 95% confidence level) from spending on health, than on education or the environment. Spending on education is expected to provide more benefits than spending on the environment, although this difference is not significant at the 95% confidence level. There is a marginally significant effect that indicates that people born in New Zealand are more in favour of spending on the environment than is the case for people not born in New Zealand. Willingness to spend on health is not affected by respondent age, but willingness to spend on education and the environment both decline with age.

Kemp and Willetts (1995b) found “Items which appear to be regarded as particularly good value relative to their costs … include the police, the Department of Conservation, public hospitals and schools. Those regarded as particularly poor value compared to their costs are the New Zealand Symphony Orchestra, Unemployment Benefits, Domestic Purpose Benefits, and defence.” [p.29]. The highest marginal value ratings are achieved by health, education and police (Kemp & Willetts, 1995a; Kemp, 1998; Kemp & Burt, 2001). The present study addresses a much narrower range of government services than these earlier studies, but indicates similar perceptions about the value of government services. The macro-budget allocation exercise indicates a preference for large reductions in spending on superannuation and income support. The major beneficiaries of budget reallocation would be health and conservation, with education and crime prevention gaining smaller amounts and the smallest amount would go to defence. Similarly, the choice experiment indicates preferences for reduced spending on income support, with the community signalling a strong desire to spend more on health, and being willing to support additional spending on education and the environment, but education and environment spending provide lower marginal benefits than health spending. These studies all indicate a strong community preference for spending on health, education and the environment rather than on social security.

Because of high correlations the logarithmic model did not resolve the identification problem inherent in the linear and polynomial models. Logarithmic utility function results mirror those of the linear model, indicating efficiency benefits from transferring budget from income support to health, education and environment, with the bulk of reallocated funds going to health spending. The logarithmic utility function model has the ability to account for costs of service provision and illustrates that the community is willing to increase taxes to increase spending on health, education, and the environment.

The environmental budget allocation exercise provides little guidance on which aspects of environmental spending would provide the greatest benefits at the margin. For most items the modal response was no change in current spending. However, more than 50% of respondents indicated they preferred increased spending on pest & weed control, air quality and fresh waters.

The choice experiment approach to identification of efficient budget allocation is novel. This application has been successful in that marginal rates of substitution between individual budget categories have been estimated within relatively narrow confidence intervals. The model has been less successful at measuring the marginal utility of spending on particular items. In theory, this can be done using the logarithmic utility function, but high correlations meant this did not occur in practice. This problem may be surmountable by including additional spending items in the choice sets or increasing the number of attributes in the experimental design. In particular, the income support item is probably too poorly defined, it incorporates a large number of specific budget items. Disaggregation of income support may remove the high correlation between taxes and income support that precluded inclusion of both variables in the models. An alternative solution may rest in utilisation of alternative functional forms.

A criterion validity test of community preferences is not possible because there is no objective measure against which stated preferences can be assessed. Consequently, less powerful indicators of model validity are required. In this case there are several indicators of convergent validity. The results obtained in the macro-budget allocation question and the choice experiment are in agreement. Further, the results obtained here concur with the extensive evidence presented by Kemp and associates. This weight of evidence suggests that the community would prefer less government spending on income support and increased spending on health and education. It also indicates that increased environmental spending is likely to be advantageous.

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