Using Choice Modeling to Value Ecosystem Services on Arable Land

Yuki Takatsuka
Lincoln University, NZ

Ross Cullen
Lincoln University, NZ

Matthew Wilson
University of Vermont, USA

Steve Wratten
Lincoln University, NZ

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Introduction

- Ecosystem services
  - Regulating services
  - Supporting services
  - Provisioning services
  - Cultural services

- Agricultural Land
  - Profit maximization Vs. Welfare Maximization

New Zealand Arable Land
Profit Maximization…….?

Nitrogenous fertilizer

→ Leaching to streams and lakes

→ - Effecting on nature and human health

- Greenhouse gas emissions

Soil erosion, soil retention

Landscape (scenic Views)

Values of ES

- Costanza et al. (1997)

- Patterson and Cole (1999)

  New Zealand & Waikato studies

  only 5 ES out of 16 have positive values in arable land

Objectives

-More accurately measure values of non-market ES on NZ arable land.

-Estimate values of

-gas regulation (greenhouse gas emissions),

-waste treatment (nitrogen leaching),

-soil retention,

-recreation (scenic views)

using CVM and choice modeling.

CVM and Choice Modeling

Random Utility Model(RUM):

- Both the CVM and the Choice Model utilize RUM.
- The utility for the choice of the alternative i for each individual is given by:

(1) $U_i(q_i, z)$

q_i=attributes of alternative i
z=individual characteristics

We typically consider an indirect utility function, which expresses utility as a function of income and prices:

(2) $$U^i = v^i(p^i, q^i, m, z) + \varepsilon^i ,$$

If $U^i > U^j$, then

$$\Pr(i) = \Pr\{ U^i > U^j \}$$

$$= \Pr\{ v^i(p^i, q^i, m, z) + \varepsilon^i > v^j(p^j, q^j, m, z) + \varepsilon^j \}$$

(3) $$= \Pr\{ \varepsilon^j - \varepsilon^i < v^i(p^i, q^i, m, z) - v^j(p^j, q^j, m, z) \}$$

Assuming $\varepsilon = \varepsilon^j - \varepsilon^i$ is logistically distributed.
the probability of choosing alternative i is:

$$\Pr(i) = \exp(v_i) / \Sigma^J_{j=1} \exp(v_j)$$

To estimate the welfare impacts, i.e., willingness-to-pay, the following formula is used:

(6) $v^i (p^i,q^i,m-CV,z)+\varepsilon^i= v^j (p^j,q^j,m,z)+\varepsilon^j,$

we restrict equation (6) to only two choice levels (one is status quo) in an attribute:

(7) $CV=(1/a) [\ln \exp(v^{i0})- \ln \exp(v^{i1})],$

(8) $CV=(1/a) [\exp(v^{i0})- \exp(v^{i1})]$

And thus the welfare measure can be determined by calculation:

(9) $CV=(1/a) [v^{i0}- v^{i1}]$

Survey Experiment Methodology

- Data Collection
  - -Mail Survey
  - -November 2004
  - -3000 people selected from NZ electoral roll
    - 1500 from Canterbury & 1500 from the rest of NZ
    - 480 CVM; 1020 Choice Modeling
  - -Pre-survey and post-reminder cards

A Survey on New Zealand Farming and the Environment

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Te Whare Wānaka O Aoraki

Response Rate

- CVM

  35 % in both regions

- Choice Modeling

  39 % in Canterbury, 34 % in rest of NZ

- Overall Effective Response Rate

  36 %

Format for the Surveys

1. Questions about the environment in NZ

2. Questions about NZ farming

3. Questions about alternative scenarios for cropping farm (WTP questions)

4. Questions about respondent's demographics

ES Attributes on Arable Land

Attributes	Levels	Definitions
Greenhouse Gas Emissions	Big Reduction	50% reduction from the current emission level
	Small Reduction	20% reduction from the current emission level
	No Change	maintain current emission level
Nitrate Leaching	Big Reduction	50% reduction in nitrate leaching to streams
	Small Reduction	20% reduction in nitrate leaching to streams
	No Change	maintain current nitrate leaching to streams
Soil Quality	Small Change	soil organic matter and structure are retained over 25 years
	No Change	maintain current slow rate of soil degradation
Scenic Views	More Variety	more trees, hedgerows and birds and a greater variety of crops on cropping farms
	No change	maintain the current cropping farm landscape
Cost to Household	10; 30; 60; 100	annual payment to a regional council for the next 5 years (NZ$)

CVM Survey Question

Please tick the option that you prefer:

	Option A	Option B
Greenhouse Gas Emission	Big Reduction	No Change
Nitrate Leaching	No Change	No Change
Soil	No Change	No Change
Scenic Views	No Change	No Change
Cost to Household ($ per year for next 5 years)	$60	$0

Option A ☐ Option B ☐

Question about Ideal Policy

Ideal Greenhouse Gas Emission	Big reduction ☐	Small reduction ☐	No change ☐
Ideal Nitrate Leaching	Big reduction ☐	Small reduction ☐	No change ☐
Ideal Soil	Small change ☐	No change ☐	
Ideal Scenic Views	More variety ☐	No change ☐	
Amount Your Household is Willing to Pay ($ per year for next 5 years)	$_____		

Choice Modeling Question

Please tick the option that you most prefer:

	Option A	Option B	Option C
Greenhouse Gas Emission	Big reduction	No change	No change
Nitrate Leaching	Big reduction	Small reduction	No change
Soil	No change	No change	No change
Scenic Views	More variety	No change	No change
Cost to Household ($ per year for next 5 years)	$100	$10	$0

Option A ☐ Option B ☐ Option C ☐

Choice Modeling Questions

- Multiple Questions
- $2^2 x 3^2 x 4$ factorial designs
- D-efficient design, excluding unrealistic case
- Question about ideal policy

Effect Codes – Choice Modeling

Attributes	Variables	
Green House Gas Emissions	GGS	1 if small reduction ; 0 if big reduction ; -1 if no change
	GGB	1 if big reduction; 0 if small reduction; -1 if no change
Nitrate Leaching	NLS	1 if small reduction ; 0 if big reduction ; -1 if no change
	NLB	1 if big reduction; 0 if small reduction; -1 if no change
Soil Quality	SOIL	1 if small change; -1 if no change
Scenic Views	SV	1 if more variety; -1 if no change
Cost to Household	COST	NZ$10; $30; $60; $100

Result: Result : Descriptive Statistics

	CHOICE-Canterbury		CHOICE-RestNz		CVM-Canterbury		CVM-RestNZ	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
AGE	52.02	15.85	53.69	15.59	51.71	15.98	49.25	15.54
GENDER	0.57	0.50	0.56	0.52	0.49	0.50	0.42	0.49
EDU	4.00	1.57	3.97	1.64	4.05	1.67	4.20	1.66
INC	55.81	33.09	60.51	35.20	53.38	32.86	51.08	32.85
URB	0.74	0.44	0.68	0.47	0.73	0.44	0.76	0.51

	CHOICE-Canterbury		CHOICE-RestNz		CVM-Canterbury		CVM-RestNZ	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
ENVIS	4.33	0.79	4.35	0.96	4.30	0.93	4.34	0.88
AIR	4.87	0.91	4.96	0.83	4.88	0.84	4.90	0.92
FWAT	4.43	1.02	4.27	1.01	4.44	0.91	4.17	1.03
GWAT	4.60	1.14	4.17	1.20	4.65	1.21	4.14	1.18
CWAT	4.46	1.05	4.48	1.04	4.45	1.10	4.41	1.04
SOIL	4.42	1.07	4.17	1.17	4.42	1.22	4.39	0.92
PEST	4.36	2.39	4.34	1.44	4.21	1.64	4.34	1.49
GG	4.09	1.41	4.05	1.31	4.02	1.45	3.82	1.45

Result: Binomial Logit - CVM

	Canterbury				Rest of NZ			
	Coeff.	Std.Err.	t-ratio	P-value	Coeff.	Std.Err.	t-ratio	P-value
ONE	0.628 **	0.295	2.128	0.033	1.324 **	0.313	4.232	2.32E-05
COST	-0.003	0.005	-0.645	0.519	-0.015 **	0.005	-2.928	0.003
Number of observation	151.000				154.000			
Log likelihood function	-100.364				-95.928			
Log likelihood function (0)	-100.572				-100.371			
Chi-squared	0.416				8.885			
Significances	0.518				0.003			
McFadden	0.002				0.044			
Ben/Lerman	0.528				0.568			
Akaike I.C.	1.356				1.272			

* Siginificant at the 0.10 level
** Siginificant 0.05 level

Result: Conditional Logit – Choice Modeling with ASC

	Canterbury				Rest of NZ			
	Coeff.	Std.Err.	t-ratio	P-value	Coeff.	Std.Err.	t-ratio	P-value
COST	-0.011 **	0.002	-5.889	4E-08	-0.013 **	0.002	-6.565	5.22E-11
GGS	0.084 **	0.046	1.824	0.068	0.176 **	0.049	3.552	0.00038
GGB	0.479 **	0.055	8.638	3E-15	0.309 **	0.059	5.262	1.42E-07
NLS	0.222 **	0.052	4.246	2E-05	0.118 **	0.056	2.091	3.65E-02
NLB	0.358 **	0.051	6.992	3E-12	0.456 **	0.056	8.168	2.89E-15
SOIL	0.233 **	0.040	5.782	7E-09	0.194 **	0.043	4.493	7.01E-06
SV	0.088 **	0.034	2.559	0.010	0.072 **	0.036	2.006	0.045
A_01	0.132	0.207	0.637	0.524	0.602 **	0.224	2.687	0.007
A_02	0.145	0.131	1.102	0.270	0.479 **	0.142	3.374	0.001
Number of observation	2075.000				1809.000			
Chi-squared	190.352				163.220			
Log-likelihood	-2006.260				-1717.536			
R-squared Adj.	0.043				0.043			

* Significant at the 0.10 level

** Significant at the 0.05 level

Result: Conditional Logit – Choice Modeling without ASC

	Canterbury				Rest of NZ			
	Coeff.	Std.Err.	t-ratio	P-value	Coeff.	Std.Err.	t-ratio	P-value
COST	-0.011 **	0.001	-9.421	3E-15	-0.012 **	0.001	-9.350	2.89E-15
GGS	0.088 **	0.046	1.906	0.057	0.191 **	0.050	3.862	0.00011
GGB	0.513 **	0.046	11.213	3E-15	0.421 **	0.049	8.593	2.89E-15
NLS	0.250 **	0.048	5.207	2E-07	0.194 **	0.052	3.712	2.06E-04
NLB	0.370 **	0.050	7.418	1E-13	0.497 **	0.055	9.116	2.89E-15
SOIL	0.252 **	0.035	7.197	6E-13	0.261 **	0.038	6.870	6.43E-12
SV	0.105 **	0.032	3.316	0.001	0.121 **	0.033	3.628	0.00029
Number of observation	2075.000				1809.000			
Chi-squared								
Log-likelihood	-2007.174				-1723.427			
R-squared Adj.	0.043				0.040			

* Significant at the 0.10 level

** Significant at the 0.05 level

Result: WTP

	GG- 20% reduction	GG-50% reduction	NL-20% reduction	NL 50% reduction	SOIL-change	SV-variety
CVM						
Canterbury		192.51				
Rest of NZ		86.03				
CHOICE (With ASC)						
Canterbury	60.52	97.36	74.95	87.73	43.49	16.43
Rest of NZ	50.72	60.96	53.10	79.03	29.81	11.08
CHOICE (Without ASC)						
Canterbury	62.42	100.91	78.77	89.70	45.68	18.99
Rest of NZ	67.89	87.27	74.80	100.40	44.13	20.50

GG - Greenhouse gas emissions
NL - Nitrate leaching
SOIL - Soil quality
SV - Scenic Views

Ideal Policy: Choice Modeling Survey

- Big reduction of greenhouse gas emissions

  -57% respondents in both areas

- Big reduction of nitrate leaching

  -63% in Canterbury; 69% in rest of NZ

- Maintaining of soil quality from the current condition

  -88% in both areas

- More variety of scenic views

  -56% in Canterbury; 54% in rest of NZ

Ideal Policy: Choice Modeling Survey

Canterbury

	GG	*%*		*NL*	*%*		*SOIL*	*%*		*SV*	*%*
No Change	414	0.07	No Change	297	0.05	No Change	708	0.12	No Change	2592	0.44
Small Change	2160	0.36	Small Change	1932	0.32	**Small Change**	5265	**0.88**	**More Variety**	3366	**0.56**
Big Change	3450	**0.57**	**Big Change**	3801	**0.63**						
Total	6024	1		6030	1		5973	1		5958	1

Rest of NZ

	GG	*%*		*NL*	*%*		*SOIL*	*%*		*SV*	*%*
No Change	321	0.06	No Change	204	0.04	No Change	696	0.13	No Change	2354	0.46
Small Change	1935	0.37	Small Change	1410	0.27	**Small Change**	4500	**0.87**	**More Variety**	2764	**0.54**
Big Change	2991	**0.57**	**Big Change**	3621	**0.69**						
Total	5247	1.00		5235	1.00		5196	1.00		5118	1.00

WTP: Ideal Policy

	GG- 20% reduction	GG-50% reduction	NL-20% reduction	NL 50% reduction	SOIL-change	SV-variety	**Stated Ideal**	**Estimated Ideal**
CVM								
Canterbury		192.51					48.89	
Rest of NZ		86.03					59.08	
CHOICE (With ASC)								
Canterbury	60.52	97.36	74.95	87.73	43.49	16.43	**63.04**	**245.02**
Rest of NZ	50.72	60.96	53.10	79.03	29.81	11.08	**55.25**	**209.92**
CHOICE (Without ASC)								
Canterbury	62.42	100.91	78.77	89.70	45.68	18.99	**63.04**	**255.28**
Rest of NZ	67.89	87.27	74.80	100.40	44.13	20.50	**55.25**	**254.78**

GG - Greenhouse gas emissions
NL - Nitrate leaching
SOIL - Soil quality
SV - Scenic Views

Summary

- CVM > Choice Modeling

  embedding issues?

- Estimated WTP > Stated WTP for Ideal policy in the Choice Modeling

  -Assumption valid?

  -WTP derived by the Choice modeling does not reflect true WTP?

Summary

- The choice modeling study found that:

  -Greenhouse Gas emission reduction is the most valuable ES in Canterbury.

  -Nitrate leaching reduction is the most valuable ES in rest of NZ

  -Maintaining soil quality is higher value for Canterbury than for rest of NZ

  - More variety of Scenic views has some positive values in both areas; they may be a significant component of the total social benefit.

cullenr@lincoln.ac.nz

takatsuy@lincoln.zc.nz