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CONTINGENT VALUATION PAYMENT CARDS: HOW MANY CELLS?

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Abstract

The dichotomous choice approach to contingent valuation is extremely popular, but obtains very little information from each respondent and is therefore inefficient. Multiple-bounded dichotomous choice approaches are more efficient in theory, but theoretical gains are not always obtained in practice. The multiple-bounded dichotomous choice approach also yields internally inconsistent responses. Payment cards are another approach to improve contingent valuation efficiency. At the extremes, dichotomous choice is a two cell payment card, while open-ended CVM has an infinite number of cells.

This paper reports a split sample test of the impacts on benefit estimates and efficiency arising from differences in the numbers of divisions on the payment card. Don't know responses were explicitly included to test for changes in uncertainty because of differences in cell numbers. Prior expectations were for increased cell numbers to improve efficiency, but that efficiency gains would eventually be offset by increased frequency of don't know responses and response variance as cell numbers increased. Contrary to prior expectations, parameter estimates, standard errors and benefit measures were largely invariant to cell numbers.

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1. Introduction

Contingent valuation studies may take a variety of formats, including open-ended, dichotomous choice, multiple-bounded dichotomous choice, iterative bidding, and payment cards. Recently, the dichotomous choice approach has gained a high level of popularity, but it comes at the cost of efficiency. Approaches that obtain more information from each respondent than the single-bounded dichotomous choice approach can be much cheaper to apply because fewer survey responses are necessary to obtain any pre-determined level of accuracy. The payment card approach offers one method for increasing efficiency over dichotomous choice, however it may also introduce a number of biases. For example, Schuman (1996, p.87) claims "presenting respondents with a set of values to choose from is now seldom used because of recognition that this kind of framing and anchoring is quite likely to create bias to and away from certain values". More specifically, inappropriate choice of bid range and distribution may introduce information and truncation biases, although recent research provides mechanisms for circumventing these problems (Rowe *et al.*, 1996).

One potential source of bias is from the number of divisions, or cells, on the payment card. At the extremes, dichotomous choice represents a two cell payment card, while open-ended CVM has an infinite number of cells. It is well known that mean WTP from dichotomous choice CVM generally exceeds that from open-ended approaches (Schulze *et al.*, 1996; Ready *et al.*, 1996; Bateman *et al.*, 1995; Boyle *et al.*, 1996; Brown *et al.*, 1996). There are several potential explanations of this discrepancy, including yea saying and anchoring in the dichotomous choice approach and strategic behaviour in the open-ended approach. Between the extremes, it is not known what impacts arise from changing the number of divisions on the payment card. This paper addresses that issue.

2. Payment Card Design Issues

Increasing the number of divisions for any given range of values narrows down the range within which each individual's WTP falls and therefore increases the efficiency of the payment card approach. However, such increases in efficiency may only be realised if people have well-formulated and certain preferences. Narrowing the interval size may increase the difficulty of answering the question because of the apparent increased visual complexity, or

because values are not sufficiently finely defined. Rowe *et al.* (1996; p.184) surmise that "maintaining the range of a payment card and increasing the number of entries to reduce the interval size may result in a presentation that is unwieldy for respondents and that assumes more precision than respondents have in the formation of their values."

The outcome from increasing the number of cells on the payment card may be more item non-response, biased responses in response to uncertainty, or more "don't know" responses. The role of stochastic benefits is emphasised by the high proportions of "don't know" responses to single-bounded dichotomous choice approaches, which have provided the impetus for several investigations of how those responses should be analysed (Ready *et al.*, 1995; Li and Mattsson, 1995; Wang, 1997).

3. Tests for Cell Number Impacts

This paper presents an empirical test of survey participants' responses to payment cards with different numbers of cells. The presence of stochastic benefits is hypothesised to result in a positive correlation between the number of "don't know" responses to the valuation question and the number of cells on the payment card. The less favourable visual impact of increased number of cells is hypothesised to increase item non-response as cell numbers increase, it could also be reflected in an increased presence of "don't know" responses.

Because there are two hypothesised reasons for an increase in "don't know" responses with additional cells, it is not possible to identify the underlying cause of this response behaviour empirically. One approach to identification of causes of changes in response behaviours is to interview survey participants to obtain expressions of their cognitive processes whilst responding to the survey (e.g. "verbal protocol analysis", Schkade and Payne, 1994). This paper provides an empirical examination of the existence of differences in don't know responses, but does not seek a formal explanation.

In the present study two different items are valued using three payment cards, each with a different number of cells, but with identical lower and upper bid ranges. Following Rowe *et al.* (1996), payment card bids are distributed exponentially. Consequently, range effects are precluded by the survey design. Centre effects are not expected with this design either because a single, common bid appears in the centre of each payment card.

The effects of changes in payment card cell numbers are tested in the following ways:

(i) Frequencies of "don't know" and non-useable responses are compared across payment card versions.

(ii) Common bid amounts are included on each card to allow for tests of significance of differences in probability of WTP particular bid amounts, allowing comparison of different points on distributions.

(iii) Differences in willingness to pay are tested by comparing confidence intervals on mean and median WTP derived by parameterisation of the response data using maximum likelihood and bootstrap estimation methods. These "end value" tests have limited power, as they could show no significant differences in mean and/or median WTP while there are real differences in underlying responses and WTP distributions for the different payment cards.

(iv) A chi-square test is used to test for differences between distributions as a whole.

(v) Efficiency changes between versions are evaluated using three goodness of fit measures.

4. Case Study

Potential items for valuation were identified in discussions with groups of students at Lincoln University. Three student facilities were initially identified as being potentially valuable to students. These were: high quality study space, video tapes of lectures made available in the University library, and a shuttle bus service between the campus and Christchurch City. The shuttle bus service was dropped from the survey subsequent to pre-testing that showed that very few students would actually utilise it. The video and study room facilities were included in the same questionnaire and were introduced in the following ways.

Videotapes:

> *Students spend a great deal of time sitting in lecture theatres. This is often inconvenient, especially if it clashes with family, work, or leisure commitments. Many students ask friends to take notes for them, but this is rarely a satisfactory arrangement, either because of the different ways people interpret class experiences or because of student inability to understand each other's notes.*

One approach to dealing with this difficulty would be to place videotapes of all lectures in the library and allow them to be borrowed for free, just like other videotapes in the library collection.

Private study rooms:

Some students find studying difficult in the shared workspaces available for most undergraduates. Issues arise from noise, visual distractions, odours, insecure storage, and limited computer access.

Imagine that a private company has built a set of study rooms adjacent to campus. The rooms all share the following characteristics:

- *2.5 metres x 2.5 metres*
- *sound proof*
- *air conditioned/ centrally heated*
- *whiteboard*
- *bookshelf*
- *digital security lock*
- *24 hour access*
- *Pentium III 450mhz computer joined to the Lincoln University network*
- *shared use of a laser printer at 10 cents per page printed*

In each case, survey respondents were asked whether they would make use of the facility now if it were available for free. Only potential facility users then faced the CVM question for that facility. The payment scenarios were introduced as.

Videotapes:

*Now, **suppose** that the only way to pay for the expense involved in providing this videotape service would be a uniform tuition fee increase for all students.*

***Imagine** there were a binding referendum amongst students to decide whether a fees-funded videotape programme would be implemented. Over 50% voter support would cause the programme to be put in place.*

Please tick the box alongside the highest annual tuition fee increase at which you would vote for the proposal to increase fees to fund videotapes of all lectures.

Private study rooms:

*Now, **imagine** that you had to pay to hire a study room for a full semester.*

*Please tick the box alongside the **greatest** amount of money that **you** would be willing to pay to hire a study room for a semester.*

Provision of videotapes is contingent upon a social decision rule, and would provide a common resource. In contrast, there is no social provision rule for study rooms, they would be a privately owned facility and only those paying would obtain access. Private ownership was introduced to minimise protest response from survey participants who thought that the University should be providing these facilities already. In order to create the strongest possible incentives to focus on the **value** of the facility to the student, the provision of rooms is presented as an opportunity that students can choose to ignore.

4.1 Method

Three different payment card formats were applied. Each format had identical lowest and highest bids ($1 and $300) and allowed "don't know" and "greater than $300" responses, as well as zero bids. Application of an exponential function to the range and number of bid divisions identified bid amounts, which then were rounded in a manner that allowed for as many common bid amounts as possible between the formats (Rowe *et al*., 1996). Bid amounts are reported in Table 1. The smallest version of the card contained 9 response categories (including zero and don't know), with the intermediate size card having 13 response categories and the large card 18 response categories. Differences in cell numbers are more significant than indicated by the number of categories because 5 categories are the same in each case, with zero and $1 anchoring the bottom end of each card and $300, more than $300, and don't know anchoring the other end. Efficiency will not be affected by the total number of cells, but by the number of cells in the region between $1 and $300. These were 5, 9 and 14 for the three versions. The middle response category in each case was $29[1].

[1] Because the large version had 18 response categories, there were two middle responses ($17 and $27). If centre effects were operating, then this would result in a slight reduction in bids for the large version relative to the other versions.

Table 1
Bid Divisions on the Three Payment Card Versions

Payment Card Version		
Large	Medium	Small
0	0	0
$1	$1	$1
$1.50		
$2.50	$2.50	$2.50
$ 4		
	$5	
$6		
$9	$9	$9
$ 12		
	$13	
$17		
$27	$27	$27
$39		
	$45	
$59		
$90	$90	$90
$140		
	$160	
$200		
$300	$300	$300
>$300	>$300	>$300
Don't know	Don't know	Don't know

Shaded cells indicate response categories common to all three versions

Validity of zero bids was tested by a probe question. Answers indicating protest responses (e.g. university fees are too high already) were deemed to be "invalid zeros", while those indicating the facility had no value to them were deemed to be "valid zeros". Invalid zero bids were excluded from analysis.

The survey was administered in classes on Lincoln University campus from late May to early September 1999. Large classes were targeted for administrative convenience. Other selection criteria included class level, attempts were made to get a range of undergraduate classes from first year to third year level, and willingness of the lecturer to participate[2]. The three versions of the survey were distributed evenly throughout each class. Distribution was made in blocks of five questionnaires of each version to minimise the chance of neighbours perceiving differences in questionnaires, but to ensure that seating allocation did not influence the final

[2] Lecturer approval and mutually convenient times for survey administration were obtained beforehand.

results[3]. The results are not representative of all students on Lincoln University campus, but this is irrelevant for the primary purpose of the research, which is to identify impacts of differences in payment card format.

The survey was given a brief oral introduction concurrent with display of overhead transparencies that identified the voluntary nature of the survey and guaranteed anonymity. Students who had completed the survey in other classes were asked not to do it again. The survey was then distributed, completed and collected. Median completion time was six minutes. While the survey was being collected participants were told of its hypothetical nature and its role in research, although the specific purpose was not identified. Participants were given the opportunity to obtain study results. Because of the context it was not possible to identify precise response rates, but spot checks indicated these to be in the range of 95% to 100% of those attending the class who had not been surveyed previously.

5. Results

A total of 738 completed surveys was obtained. However, not all of these were useable because some students who returned surveys would not use the facilities even if they were provided free of charge. Study rooms would be used by more respondents than video facilities would be, with 551 respondents (75%) indicating they would use the videotapes if they were available for free and 617 respondents (84%) stating they would use the study rooms if they were available for free. Of these respondents, who would theoretically be willing to pay something for the use of these facilities, 438 (79.5%) provided useable responses on the payment card for videotape facilities and 537 (87.0%) did likewise for the study room. Response data are summarised in Table 2.

[3] In small classes, blocks of more than five may have caused versions to be unevenly distributed between the front and the back of the class. The changes in student type between these locations could have influenced willingness to pay for the target facilities.

Table 2
Summary Survey Response Data

	Videotapes				Study rooms			
	Small Version	Medium Version	Large Version	Total	Small Version	Medium Version	Large Version	Total
Returned	236	258	244	738	236	258	244	738
Would use if free of charge	180	199	172	551	188	223	206	617
Useable WTP response	142	162	134	438	163	199	175	537
Don't know WTP	15	9	6	30	10	7	9	26
Other non-useable response	23	28	32	83	15	17	22	54
Total non-useable	38	37	38	113	25	23	33	81
% of users providing useable WTP responses	78.9%	81.4%	77.9%	79.5%	86.7%	89.2%	85.0%	87.0%

5.1 Frequency of Don't Know and Non-Useable Responses

Chi-square tests were undertaken for differences in frequency of "don't know" responses and total non-useable responses from the populations of respondents who would use the facilities if they were available free of charge. Test results are reported in Table 3. There is no significant difference in don't know and non-useable response frequencies across the payment card versions. This result suggests that respondents did not find greater difficulty in answering when cards had more cells on them. However, it does not mean that the quality of responses is unchanged between versions.

Table 3
Chi-square Test Results for Non-Useable Response Categories

Facility	Comparison	Chi-square	d.f.	Probability
Video tapes	Useable vs non-useable	0.753	2	.686
	Don't know vs others	4.525	2	.104
Study rooms	Useable vs non-useable	2.866	2	.239
	Don't know vs others	1.220	2	.543

5.2 Comparison of Common Bid Amounts and Bid Distributions

The inclusion of common bid amounts provides the opportunity to apply a chi-square test of differences in frequency of WTP for those amounts across the different versions. Results are reported in Table 4. There are only minor differences in rates of WTP between the versions. There are differences at the $2.50 and $9 bid levels for the videotape facility and at $2.50 for the study rooms. However, there is no pattern to these differences indicative of any relationship between the number of cells on the payment card and WTP frequency.

Table 4
WTP for Common Bid Amounts

% Willing to pay each dollar amount		Small Version	Medium Version	Large Version	Chi-square	Probability of Chi-square
Video tapes	$1	95.74	96.27	91.79	3.37	.185
	$2.50	85.82	83.85	73.13	8.42	.015
	$9	65.96	51.55	61.19	6.78	.034
	$27	41.13	34.16	30.60	3.49	.175
	$90	12.06	11.80	10.45	0.20	.903
	$300	00.71	00.62	00.75	*	*
Study rooms	$1	93.86	93.97	94.29	0.03	.985
	$2.50	81.60	89.45	88.57	5.54	.063
	$9	74.23	71.36	75.43	0.85	.654
	$27	53.99	58.29	56.00	0.68	.712
	$90	22.70	21.61	17.14	1.85	.398
	$300	4.91	1.51	1.71	*	*

* Numbers of respondents who were WTP this amount were too low for reliable calculation of the chi-squared statistic

5.3 Comparison of Mean and Median Willingness to Pay

Estimates of mean and median willingness to pay are reported in Table 5. The estimates were derived using maximum likelihood estimation to fit a log-logistic distribution to the data (Cameron and Huppert, 1989). The measures of goodness of fit used for dichotomous choice contingent valuation, such as McFadden's R^2, are not applicable to payment card models (Kanninen and Khawaja, 1995). Consequently, the Wald test proposed by Harpman and Welsh (1999) for use with the double-bounded logit model is used. The Wald statistic tests the improvement of the fitted model over a model that includes only a constant term. The Wald statistic has a chi-square distribution, with one degree of freedom for all tests in Table 5. The fitted models are all of very high significance.

Table 5
Maximum Likelihood Model Results

Log-logistic model		Constant (t-score)	Money (t-score)	Wald statistic	Median	Mean	95% Range: Median	95% Range: Mean
Video tapes	Small	3.116 (11.12)	-1.1125 (-11.41)	130.19	$16.46	$149	$12.43 ~ $21.53	$67 ~ ∞
	Medium	2.742 (9.89)	-1.0882 (-11.71)	137.09	$12.43	$142	$9.53 ~ $15.89	$57 ~ ∞
	Large	2.219 (9.68)	-0.9654 (-10.82)	117.12	$9.96	∞	$7.26 ~ $13.78	$103 ~ ∞
	Pooled	2.667 (18.03)	-1.0471 (-19.94)	397.53	$12.77	$272	$10.90 ~ $15.07	$103 ~ ∞
Study rooms	Small	3.134 (13.13)	-0.9685 (-12.49)	155.95	$25.44	∞	$18.95 ~ $33.36	$264 ~ ∞
	Medium	3.507 (15.59)	-1.0587 (-14.89)	221.75	$27.45	$470	$21.64 ~ $34.66	$150 ~ ∞
	Large	3.472 (14.98)	-1.0802 (-14.47)	582.63	$24.89	$313	$19.63 ~ $31.78	$122 ~ ∞
	Pooled	3.376 (25.30)	-1.0364 (-24.23)	586.84	$25.98	$716	$22.55 ~ $33.06	$251 ~ ∞

Estimated confidence intervals are the result of 1000 bootstrap replications of the estimation procedure in each case. They show no significant differences in either mean or median willingness to pay.

5.4 Comparison of Response Functions

A likelihood ratio test is used to test the hypothesis of equality of the estimated response functions reported in Table 5 (Welsh and Poe, 1998). The test statistic is approximately chi-square distributed, with the number of restrictions determining degrees of freedom. The statistic is:

$$LR = 2*[\Sigma LL_u - LL_R]$$

where the LL_u are the log-likelihood values for independent versions and LL_R is the log-likelihood value for the pooled model which imposes equality of coefficients.

Four tests are possible for each facility, one comparing all three versions with the total pooled sample and a further three that compare each pair of versions with the appropriate pooled sample. Results of these tests are reported in Table 6. There are no significant differences for

the study room tests. However, the large and small videotape versions showed strong differences.

Table 6
Likelihood Ratio Test Results

Facility	Test	$-\Sigma LL_U$	$-LL_R$	Chi-square	d.f.	Prob-ability
Video tapes	Large vs Medium vs Small	988.64	992.65	8.02	4	.091
	Large vs Medium	744.47	745.78	2.62	2	. 27
	Large vs Small	617.07	620.78	7.42	2	.02
	Medium vs Small	615.75	616.89	2.28	2	.32
Study rooms	Large vs Medium vs Small	1241.83	1242.77	1.88	4	.76
	Large vs Medium	942.16	942.36	0.40	2	.82
	Large vs Small	775.38	776.07	1.38	2	.50
	Medium vs Small	766.13	766.66	1.06	2	.59

5.5 Comparative Efficiency

Efficiency effects are expected to manifest themselves as small coefficients in the variance-covariance matrix, larger asymptotic t-scores on estimated coefficients, and narrower bounds on confidence intervals for estimates of central tendency (Hanemann *et al.*, 1991). The prior expectation is that efficiency will increase with more divisions on the payment card.

Table 7 reports the estimated variance-covariance matrices for each of the three versions of the model estimated for each facility. The only differences in variance-covariance matrix elements are those for the large version of the videotape facility, which are smaller than for the small and medium versions. However, asymptotic t-scores and 95% confidence interval estimates for the means and medians are practically invariant to version (Table 5). In these two cases, efficiency effects of additional payment card cells appear to be negligible.

Table 7
Estimated Variance-Covariance Matrices

Facility	Version	Variance-Covariance Matrix	
Video tapes	Small	0.79×10^{-1}	-0.23×10^{-1}
		-0.23×10^{-1}	9.51×10^{-3}
	Medium	0.77×10^{-1}	-0.23×10^{-1}
		-0.23×10^{-1}	8.64×10^{-3}
	Large	0.53×10^{-1}	-0.16×10^{-1}
		-0.16×10^{-1}	7.96×10^{-3}
Study rooms	Small	0.57×10^{-1}	-0.15×10^{-1}
		-0.15×10^{-1}	6.01×10^{-3}
	Medium	0.51×10^{-1}	-0.13×10^{-1}
		-0.13×10^{-1}	5.05×10^{-3}
	Large	0.54×10^{-1}	-0.14×10^{-1}
		-0.14×10^{-1}	5.57×10^{-3}

6. Discussion and Conclusions

The data obtained here are not representative of all students on the Lincoln University campus, but can provide indicators of value for the facilities examined. Less than 4% of students would hire study rooms if they were available for $500 per semester. Using a 10% discount rate, rooms would need to cost less than $10,000 to be viable at this fee level. Table 8 reports the frequency of support for increasing student fees to pay for provision of video tapes of lectures. Note that these frequencies (and the median) are different from those that would be derived from the results reported in Table 5 for the pooled model. The difference arises because Table 8 incorporates those students who have no interest in the facility at all. Hence, while the estimated median in Table 5 is $12.77, it is derived only for those students who would, in theory, be willing to pay. The $8.73 median in Table 8 includes all students. The results of Table 8 indicate that a majority vote would not approve provision of video tapes if it increased student fees by more than about $8 per year. Consequently, this practice could only pay for itself if it were to cost less than about $30,000 per year to operate.

Table 8
Support For and Revenue From Video Tape Policy

Cost	Proportion of students supporting the video tape policy	Total revenue (assuming 3600 students)
$0	0.7466	$ 0
$5	0.6082	$18,000
$6	0.5752	$21,600
$7	0.5454	$25,200
$8	0.5183	$28,800
$8.73	0.5001	$31,428
$9	0.4937	$32,400
$10	0.4712	$36,000
$20	0.3216	$72,000
$50	0.1615	$180,000
$100	0.0868	$360,000
$200	0.0444	$720,000
$500	0.0176	$1,800,000

Increasing the number of cells on a payment card is expected to increase efficiency except in those cases where respondents find it more difficult to answer the contingent valuation question because of the increased number of payment card cells. This study found no significant difference on any test for the study room case. Responses were not significantly different between payment card versions, nor was there any efficiency gain from an increase in the number of cells. In both cases, frequency of "don't know" responses was invariant to number of payment card cells.

The only instance in which a possible small improvement in efficiency was observed was between the small and large versions in the video tape case, based on the evidence of coefficient t-scores and variance-covariance matrices. However, higher t-scores and lower variance in the large payment card case did not translate into narrower confidence intervals on estimated measures of central tendency. The fitted response distributions for these two cases also differed significantly. Estimated median willingness to pay declined markedly between the small and large payment cards for video tapes. While this difference was not significant at the 95% confidence level applied here, it could be for larger samples. The direction of change is consistent with observed discrepancies between open-ended and dichotomous choice responses.

The lack of, or minimal, improvements in efficiency from increasing cell numbers indicates that respondents did behave differently because of the number of cells on the payment cards. The uniformity of "don't know" response rates indicates that differences in responses are qualitative, not quantitative and are suggestive of an increase in the variance of responses as cell numbers increase. In the study room case, that behavioural response did not have any significant effect on estimated bid distributions or measures of central tendency. Bid distributions did change for the video case, in which event the cards with fewer cells are likely to be more reliable than cards with more cells. In the absence of evidence that additional cells provide efficiency benefits, use of small payment cards, which are likely to place a smaller cognitive burden on respondents and therefore to reduce response variance, is recommended.

These results are far from conclusive and need to be reinforced with further research. In particular, it would be instructive to compare results obtained from payment card studies with those obtained from the dominantly utilised dichotomous choice approach. It would also be highly desirable to verify the validity of the payment card approach, and variants within that approach, by testing it against simulated and actual market responses.

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