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Testing the convergent validity of the contingent valuation and travel cost methods

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Abstract

The validity of the contingent valuation method has been of interest since the method's inception in the early 1960s. At issue is whether responses to hypothetical questions provide a means of capturing the preferences for non-market or unpriced goods such as health care. In this study estimates of the welfare benefits from improved access to mammographic screening using the contingent valuation and travel cost methods are compared in order to test their convergent validity. It is based on a hybrid mail and telephone survey (n=458) of women in 19 different rural Australian towns. In the first part of the survey, women were asked about their recent screening behaviour and this was used to construct a travel cost model of the demand for mammographic screening. In the second part, women were asked if they were "willing to pay" one of eight bids to have a mobile screening unit visit their town. Estimates of the compensating variation associated with the decrease in access costs resulting from the introduction of mobile screening units were derived using statistical analysis of the discrete response data and confidence intervals estimated through a bootstrap procedure. The convergent validity was tested by comparing estimates of the average compensating variation from both methods under a range of assumptions regarding the value of time and the allocation of costs.

I. Introduction

The validity of the contingent valuation method (CVM) has been of interest since the method's inception in the early 1960s. At issue, is whether responses to hypothetical questions provide a means of capturing the preferences for unpriced goods such as health care. Three types of validity are generally distinguished in the contingent valuation literature: content, criterion and convergent validity (Mitchell and Carson 1989, p. 190). *Content validity* addresses whether the measure covers all aspects of a theoretical construct. In this case, the theoretical construct is the maximum amount of money that a respondent is willing to pay if a market existed for the good under evaluation. Checking the content validity involves undertaking a subjective assessment of the survey instrument to see if it is conducive to respondents revealing their true preferences. *Criterion validity* concerns how the measure under investigation relates to a criteria which is closer to the theoretical construct than the measure whose validity is being assessed. This normally involves a comparison with preferences revealed through actual or simulated market transactions. *Convergent validity* relates to whether the measure under consideration relates to other measures in a way that is predicted by theory. This often involves examining whether welfare measures from a contingent valuation experiment converge with those from indirect techniques such as the travel cost method (TCM) (Bishop, Champ and Mullarkey 1995, p. 642). As these methods are calculated with a similar degree of error, there are no grounds for regarding measures of welfare based on the TCM to be more accurate than those based on the CVM (Mitchell and Carson 1989, p.204). In the case of the TCM, errors arise because of the unobserved nature of travel costs. However, in the absence of a criterion with which to validate the CVM (e.g. a simulated market experiment), comparisons with indirect methods provide one of the strongest tests of validity for the contingent valuation method.

Testing the convergent validity by comparing the CVM and the TCM has a long tradition in environmental economics dating back to the first contingent valuation study when Davis compared his contingent valuation results with a travel cost study that he conducted on the same population (Knetch and Davis 1966, 140–142). Since then, this approach has been widely used to assess the validity of both methods (e.g. Sellar Stoll and Chavas 1985; Smith, Desvousges and Fisher 1986; Loomis, Creel and Park 1991). Surprisingly, there have been few attempts to examine the convergent validity of these methods in quantifying the benefits of health care goods and services.[1]

This study tests the convergent validity of the CVM and the TCM by using both techniques to measure the benefits of improving access to mammographic screening through the use of mobile units in rural areas of New South Wales, Australia. It is divided into 5 sections. Section 2 provides an overview of breast cancer screening in Australia and the nature of the welfare gain from using mobile screening units. Section 3 provides an overview of the empirical component of the study. The results are then presented in section 4 and discussed in section 5.

II Background

Mammographic Screening in Australia

In 1991, the most recent year for which data are available, 2,513 women died from breast cancer in Australia. In an attempt to reduce the mortality rate the National Program for the Early Detection of Breast Cancer (NPEDBC) was introduced to provide mammograms "free of charge" to all women aged between 40 and 79 years (with the program primarily targeting women aged between 50-69 years). The NPEDBC supplements existing facilities through the introduction of an additional 100 screening facilities to provide mammograms for an estimated 550 000 to 860 000

[1] Interestingly, one of the few previous studies that tested convergent validity also involved breast cancer screening, see Hill (1988) .

women each year (NPEDBC Monitoring and Evaluation Reference Group 1994). One of the principal aims of the NPEDBC is to "ensure equitable access for all women aged 50–69 years to the Program" (p.ES1). In rural areas this can be achieved by adopting one of two modes of service delivery: (i) "service to the client"; and (ii) "client to the service". The first approach involves the use of mobile screening units in towns too small to have fixed screening units. The alternative is to place fixed units only in major regional towns and require women in smaller towns to travel in order to have a mammogram.

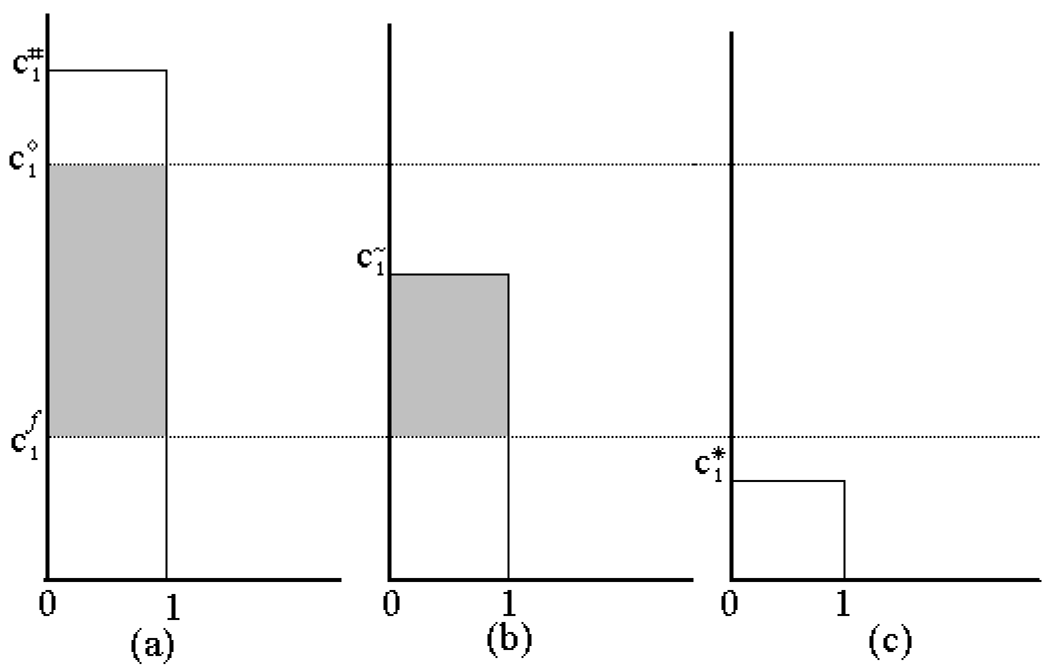
Benefits of Improving Access to Mammographic Screening

If a mobile unit visits a rural town without a permanent screening facility, women in the area benefit from having to travel a lesser distance to have a mammogram. Clarke (1998) derives welfare measures for the reduction in time and travel costs associated with the introduction of mobile screening units. The total cost of travelling to a screening unit is $c_1 = p_1 + wt_1$, where p_1 is "out-of-pocket" travel expenses (e.g. cost of petrol), w is the value of time, and t_1 the total time required to be screened. Both p_1 and t_1 are in turn functions of the distance that women must travel to have a mammogram. It is useful at this point to briefly review the measures of welfare change associated with a decrease in access costs. The benefits can be divided into two parts:

(i) Use benefits: Consider a town in which a woman must incur a cost of c_1^0 to have a mammogram at a permanent facility (fixed site) located outside her town. When a mobile screening unit visits the town her access cost is reduced to c_1^f. Given the binary nature of the screening decision (i.e. to have a single mammogram or remain unscreened) the population of women eligible for screening can be divided into three groups which are illustrated in figures 1(a) to 1(c). Each figure represents a woman with a different WTP for a mammogram (denoted by $c_1^{\#}$, $c_1^{\sim}$ and c_1^{*}). Figure 1(a) represents a woman who is prepared to travel to a permanent facility, because her WTP is greater than the cost of travelling to that site ($c_1^0 < c_1^{\#}$). Her welfare gain, if a mobile unit visits her town of residence is the reduction in access costs (i.e. c_1^f -c_1^0). Figure 1(b) represents a woman who chooses not to have a mammogram at the permanent facility ($c_1^0 > c_1^{\sim}$), but has a mammogram at the mobile unit. For this woman, the welfare benefit associated with the reduction in access costs from c_1^0 to c_1^f is the difference between the final access cost and her WTP for a mammogram (i.e. $c_1^f - c_1^{\sim}$). The final figure (1(c)) represents a woman who chooses not to have a mammogram even when the access costs are reduced (i.e. $c_1^f > c_1^{*}$). She gains no use benefit from the visit of a mobile screening unit.

(ii) Non-use benefits: Individuals may also be concerned about the access of others and these altruistic values may be reflected in their WTP. Becker (1974) sets out the altruistic relationships that can exist within the family, showing that individuals not only maximize their monetary income, but also a social income which includes the monetary value of the relevant characteristics of others who are part of their social group. In this way, a woman who lives in the same town as her mother may place a higher value on screening, because it reduces the access cost to both of them. Altruism also extends beyond the family, when individuals have concern for the welfare of members outside their social group (Culyer, 1972). For example, a woman that has had a double mastectomy following the detection of breast cancer gains no *use* benefits from the visit of a mobile unit, but may have strong preferences on whether others should have improved access to mammographic screening.

Figure 1. The welfare benefits from a visit by a mobile screening unit



The degree to which altruism should be taken into account when undertaking cost-benefit has been the subject of considerable recent debate. Milgrom (1993) argues that altruistic benefits should be given a zero weight in cost-benefit analysis, but Jones-Lee (1991) demonstrates that this view is justified only when altruism is *non-paternalistic* (i.e focused on all aspects of wellbeing). In contrast, if altruism is paternalistic in that it stems from concern about one aspect of wellbeing rather than general welfare (e.g. concern about other people's access to health care) it should be taken into account. Harberger (1984) illustrates how this form of altruism can be incorporated into cost-benefit calculations.

III Estimating the benefits of using mobile screening units

This study was based on a survey of women from 19 randomly selected towns in rural New South Wales. These towns represented all but one of the towns involved in the *Cancer Action in Rural Towns* (CART) Project which was a randomized control trial of a two year community-wide intervention to promote behavioral change relating to skin, breast, cervical and lung cancer (CART Project Team 1993). The survey was conducted post intervention on a sample of 458 women randomly selected from these towns.

The study used a hybrid mail–telephone survey in which women were contacted by mail and provided with a sheet containing background information on mammgraphic screening, the contingent valuation scenario and a willingness to pay (WTP) question (see Appendix A). The telephone survey was conducted between one and three weeks later. The survey was divided into three sections. The first section collected background information on the respondent, including her date of birth, occupation and whether she knew anyone who had been diagnosed as having breast cancer in the last five years. In the second section women were asked a series of questions on their screening behaviour including: (i) how many times they had had a mammogram in the last five years; (ii) the year in which they were last screened; (iii) their reasons for having a mammogram; (iv) the type of facility used; (v) the name of the town where they had the mammogram; and (vii) whether it was the sole reason for their travel; (viii) had they received advice from a GP or nurse to have a mammogram in the previous two years. The final section provided respondents with the contingent valuation scenario and asked whether they were willing to pay a randomly selected amount from $5–$300 (i.e. $5, $20, $50, $75, $100, $150, $200, $300) for the visit of a mobile unit. The amount offered in the telephone survey matched that stated on the information sheet previously sent to them.

Contingent valuation equation

The WTP for a visit by a mobile screening unit was estimated using single-bounded (SB) model based on responses to the amount initially offered in the WTP question. Other approaches to estimating WTP are reported in Clarke (forthcoming). To estimate the WTP for a visit by a mobile unit, a utility function must be specified to represent a woman's decision on whether to accept the offered bid:

$$V_j = (z_j, y_j, S) = W_j(z_j, y_j, S) + e_j \qquad (1.)$$

where W_j is a "universal" utility function, z_j denotes whether the individual accepts the bid (i.e. $z_1 = 1$ represents acceptance and $z_0 = 0$ represents rejection), y is income and S is a vector of other characteristics of the consumer and e_j are errors due to some components of the utility function being unobservable to the researcher. The respondent accepts a given bid (B) when:

$$W_1(1, y - B, S) + e_1 \geq W_0(0, y, S) + e_0 \qquad (2.)$$

Equ.(2.) can be rewritten as $\Delta W(y, B, S) = W_0(1, y - B, S) - W_1(0, y, S) \leq e_1 - e_0$ which emphasizes that it is the difference in utility that determines choice. To operationalize the model, the researcher must specify the utility function and a particular cdf for the error term. For simplicity we apply a probit model based on a linear utility function $\Delta W(B, S) = (a_1 - a_0) - bB + (g_1 - g_0)S + h$, where b is the coefficient on the bid B and $h = e_1 - e_0$ is a normally distributed error term.[2] An advantage of the CVM is that it can be used to value both the use and non-use benefits of improving access to mammographic screening.

Travel cost equation

The travel cost approach provides an alternative to the CVM in estimating the *use* benefits from improving access to mammographic screening. The model employed in this study is similar to that reported in Clarke (1998) in that it calculates an access cost variable c_1 by combining medical costs, travel costs and the opportunity cost of time. The latter two are a function of travel distance that is estimated by measuring the shortest road distance between their town of residence and the town where she had her mammogram.

The decision to have a mammogram within the recommended screening interval of two years is then modeled using utility function in Eq (2.) under the assumption that $z_1 = 1$ represents being screened and $z_0 = 0$ represents not being screened (within the

[2] It is important to recognize that the linear model is simply a special case of the more general Box-Cox utility function $W_j = a_j + b_j \left[\frac{y^l - 1}{l}\right] + g_j S$. An extension of this study is to apply the more flexible functional form.

recommended screening interval of two years). One difference with the dichotomous choice contingent valuation experiments is that unlike a *Bid,* the access costs cannot be observed for women who choose not to have a mammogram. To overcome this problem a method commonly employed in labour economics is used to fill in the missing data. This involves the use of a two-stage procedure (Wales and Woodland, 1980). The first stage consists of specifying an equation for c_1 estimated using the sub-set of individuals who have attended a screening clinic. The reduced form equation is:

$$c_1 = \Pi_0 + \Pi_1 S + \Pi_2 X + n \qquad (3.)$$

where X is a vector of exogenous variables not included in the random utility function; Π_0, Π_1 and Π_3 are the reduced form coefficients for the constant term, S and X respectively; ν is an error term. After estimating the parameters of Eq. (3.) the *predicted* access costs ($\hat{c}_1$) are calculated for all individuals in the sample and used in a probit model of the decision to have a mammogram. The use of predicted access costs introduces an additional source of random variation and so an adjustment procedure must be applied to the asymptotic co-variance matrix for a two-equation OLS-Probit model (Maddala 1983, p.245).

The two areas of greatest imprecision in measuring access costs are the monetary valuation of time and the allocation of costs when a woman is undertaking multiple activities when having a mammogram (i.e. joint production). On way of reflecting the uncertainty surrounding these costs is to adopt a range of assumptions and examine the sensitivity of the results rather than estimate a single travel cost model. Firstly, three different values were adopted for the value of time: (i) 100 per cent of the marginal wage (i.e. $14.70); (ii) 150 per cent of the marginal wage ($22.05); (iii) 50 per cent of the marginal wage ($7.35). The wages rates were based on the average hourly earnings of Australian women (ABS, 1996) Secondly, two assumptions were adopted regarding the allocation of joint costs for women engaged in joint production: (ii) attributing 50 per cent of c_1 to mammographic screening ; (iii) attributing 100 per cent of the c_1 to mammographic screening. The combined effect of these factors yield six potential combinations of assumptions (see Table 1). Each of these combinations forms the basis of a travel cost model that is used to estimate the *use* benefits of screening in section IV below.

Table 1. Assumptions regarding the value of time and the allocation of costs for women undertaking joint production

	Assumptions regarding the nature of joint production	
Assumptions regarding the value of time	Attribute 100 per cent of the access costs to mammographic screening (JC=100 %)	Attribute 50 per cent of their access cost to mammographic screening (JC=50 %)
Value of time is equal to the full marginal wage (VT=100 per cent)	Model 1	Model 2
Assume the value of time is equal to 50 per cent of the marginal wage (VT= 50 per cent)	Model 3	Model 4
Assume the value of time is equal to 150 per cent of the marginal wage (VT=100 per cent)	Model 5	Model 6

IV Results

Summary statistics and variables used in the contingent valuation and travel cost models are reported in table 2. The estimated parameters for the CVM and the TCM are presented in table 3. For the sake of brevity only the significant variables are reported. In the contingent valuation equation the variables had signs consistent with expectations. The probability of accepting the bid increases if the respondent intends to use a mobile unit and if she is resident in a town at greater distance from a fixed site. The coefficient on the Bid variable is highly significant with an asymptotic *t*- ratio in excess of 8. Table 3 also shows the significant variables for travel cost models 1 to 6. The only variables which were found to be significant in addition to the *access costs* were *GP advice* and having been *screened before*. The travel cost model appears to be robust, in that, the same coefficients remained significant under a wide range of assumptions regarding the allocation of joint costs and the value of time.

Evaluating the welfare benefits of screening

In order to calculate the benefits of a visit by a mobile screening unit, the cdf for each model must be integrated over the positive range of WTP. If numerical integration is applied, the usual practice is to truncate the distribution at a finite value. In this study, the cdf is truncated at the highest bid in the contingent valuation experiment and the highest access cost in the travel cost model and the mean WTP is reported in Table 3. There is a need to determine the statistical precision of these estimates of WTP, because the parameter estimates used to calculate welfare measures are based on random variables, and so the confidence intervals should be calculated. One method of calculating confidence intervals is the Duffield and Patterson (1991) approach based on bootstrapping. Their method can be broken down into a series of stages. Firstly, the predicted probabilities of a positive response are calculated using the estimated probit equation. Secondly, a new dependent variable is created by randomly drawing from a binomial distribution for each individual using their predicted probability of a positive response. The model is then re-estimated with the new dependent variable. The procedure is repeated a large number of times and the welfare estimates are calculated at each replication. A $(1-j)$ confidence interval is then obtained by ranking the calculated WTPs and dropping the $j/2$ values from each tail.

Variable	Description	Mean(S.D.)
Contingent valuation model (n=372)		
Bid	The initial bid offered	105.88(87.09)
Distance	The distance to the nearest fixed site	125.99(72.62)
Intended use	Equals one if the respondent stated she would use a mobile unit if it visited, 0 otherwise	0.81
Age	Respondent's age	56.58(9.44)
Married	Equals one if respondent is married, 0 else	0.72
Travel cost models (n=319)		
Access cost	Access costs consisted of three components: Total *out of pocket* medical costs is equal $10.40 if a women had a mammogram at a private clinic ; $0 otherwise (data supplied by Australian Health Insurance Commission); Travel costs equal to $0.50 per km (NRMA, 1996); Value of time equal to $14.70 per hour (ABS, 1996)	
Model 1	Access cost including women engaged in joint production (VT=100 per cent; JC=100 per cent).	$70.98(69.36)
Model 2	Access cost including women engaged in joint production (VT=100 per cent; JC=50 per cent).	$62.38(66.86)
Model 3	Access cost including women engaged in joint production (VT=50 per cent; JC=100 per cent).	$62.33(60.84)
Model 9	Access cost including women engaged in joint production (VT=50 per cent; JC=50 per cent).	$53.73(58.51)
Model 11	Access cost including women engaged in joint production (VT=150 per cent; JC=100 per cent).	$79.63(77.25)
Model 13	Access cost including women engaged in joint production (VT=150 per cent; JC=50 per cent).	$71.03(75.25)
GP Advice	Equals one if she had received advice from a GP or nurse to have a mammogram, 0 otherwise	0.19
Screened before	Equals on if she had been screened three or four years before the current survey, 0 otherwise	0.53

Table 2. Variable descriptions and summary statistics

Variables	Contingent valuation method(n=372)	Travel cost models (n=319)					
		Model 1 (VT=100%; JC=100%)	Model 2 (VT=100%; JC=50%)	Model 3 (VT=50%; JC=100%)	Model 4 (VT=50%; JC=50%)	Model 5 (VT=150%; JC=100%)	Model 6 (VT=150%; JC=50%)
Constant	0.909 (1.660)						
Bid	-0.008 (8.286)[b]						
Distance	0.002 (1.916)[d]						
Intended use	0.466 (2.598)[b]						
Married	0.277 (1.666)[d]						
Age	-0.015 (1.875)[d]						
Constant		-0.068(0.484)	-0.115(1.022)	-0.068(0.480)	-0.076(0.544)	-0.069(0.487)	-0.133(1.025)
Travel cost		-0.003(2.363)[b]	-0.003(2.093)[c]	-0.003(2.367)[b]	-0.003(2.341)[b]	-0.003(2.360)[b]	-0.003(2.090)[c]
GP Advice		0.509(2.444)[b]	0.5140(2.497)[b]	0.509(2.446)[b]	0.510(2.456)[b]	0.508(2.443)[b]	0.514(2.495)[b]
Screened before		0.849(5.365)[b]	0.880(5.595)[b]	0.849(5.364)[b]	0.854(5.403)[b]	0.849(5.365)[b]	0.880(5.595)[b]
LLF(β) Full model	-204.21	-191.35	-192.10	-191.34	-192.43	-191.36	-192.11
LLF(0) Intercept only	-256.94	-214.44	-214.44	-214.44	-214.44	-214.44	-214.44
LRI	0.21	0.11	0.11	0.11	0.11	0.11	0.11
Mean WTP	$132.03	$76.89	$64.02	$64.42	$60.22	$83.10	$72.68

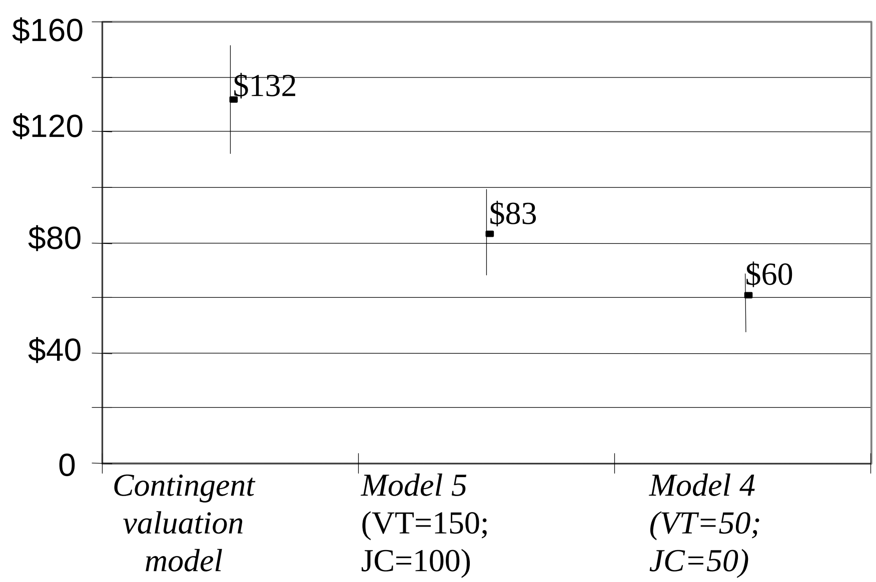
[a] Asymptotic *t*-ratios are reported in parentheses; [b] Significant at 1 per cent level; [c] Significant at 5 per cent level; [d] Significant at 10 per cent level

Table 2: Final specifications for contingent valuation and travel cost models

Testing the convergent validity

To conduct a statistical test of the convergent validity between the travel cost and contingent valuation methods, estimates of the mean WTP must be compared. Figure 2 is divided into two parts: the left-hand side shows the predicted mean WTP for the contingent valuation model of $132.03 and the 95 per cent confidence interval (95 % C.I $112.4–$151.1). The right had side reports mean WTP and confidence interval for travel cost models 4 and 5. These were selected from table 3, because they produced the highest and lowest mean WTP and so provided a range for all 6 models. The highest predicted mean WTP was $83.10 in model 5, (C.I $99.06–$68.53). In contrast, the lowest predicted mean WTP was $60.22 (C.I $72.10-$49.67) which was estimated using model 4. These results show that the confidence intervals for the mean WTP estimated contingent valuation method is significantly higher than either of the travel cost models, because the confidence intervals do not overlap.

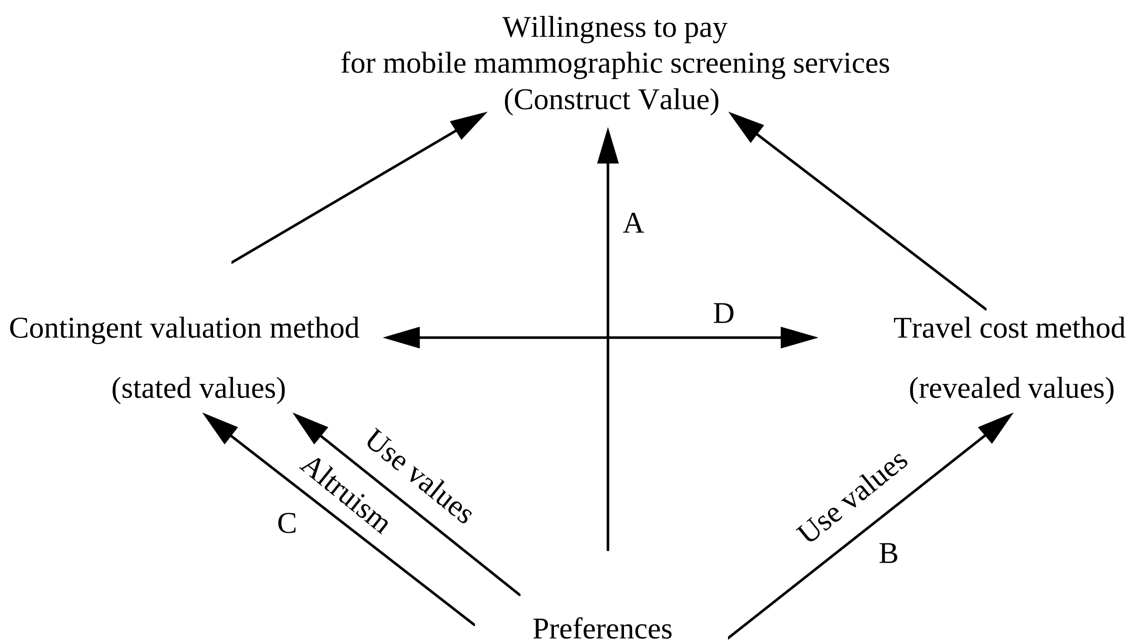
Figure 2. Comparison between the contingent valuation and travel cost estimates of mean WTP (95 per cent confidence intervals)



V Discussion

In order to summarize the conclusions of this study, a simple framework developed by Bjornstad and Kahn (1996) is adapted to set out the relationship between its major elements. This framework has four dimensions illustrated in figure 3. At the bottom of the figure are individual preferences which, within a welfare economic framework, are the source of all value. These preferences (ray A) are reflected in the maximum amount of money that an individual is willing to pay for mobile mammographic screening services. As Mitchell and Carson (1989, p.190) note: “This construct is, in the nature of things, unobservable; all we can do is to obtain imperfect measures of that entity.” The two techniques that have been used to estimate willingness to pay are the TCM (ray B) and the CVM (ray C) with, the main focus of the study has been on exploring the relationship between revealed and stated values (ray D).

Figure 3. The relationship between the main elements of the study



In this study, the contingent valuation experiment was compared with several travel cost models to test the convergent validity of both approaches. Both of these methods had a common data source: a survey of 458 women in 19 rural towns. On the basis of this comparison, the CVM produces a higher predicated mean WTP that those estimated using the TCM. The highest predicted mean WTP estimated using the TCM was $83.10 (C.I. $99.06–$68.53), which is significantly less than comparative estimates produced by the CVM. Whereas, the mean WTP using the CVM was $132.03 (95 % C.I $112.4–$151.1).

There are number of possible explanations for this divergence. First, the travel cost model may not have captured all the costs associated with travel. For example, women might place a higher value on their time than has been assumed in the travel cost model. Second, some respondents in the contingent valuation survey might be engaging in strategic behaviour by overstating their WTP. Third, respondents may hold altruistic values that are reflected in their contingent valuation responses, but not in their observed behaviour. There are strong grounds for suspecting altruism is a motivation behind some of the responses, because 47 per cent of women who did not intend to use the mobile screening unit gave positive WTP responses. It is an open question as to what degree each of these factors contributed to the systematic difference between these two methods.

Appendix A: Information Sheet

Breast Cancer Screening Survey

Background information

To help you answer our questions we have provided you with some background information on breast cancer screening. Could you read the information below and answer the two questions (see over the page). These questions are similar to the questions you will be asked in our phone survey.

What is a mammogram?

A mammogram is a breast x-ray. It detects breast cancer, including those cancers too small to be felt. In the past, only women who had breast lumps or a family history of breast cancer had mammograms. It is now recommended that **all** women aged between 50-69 years have a mammogram every two years.

What is breast cancer screening?

Both the Federal and State governments have combined to setup the *NSW program for Mammographic screening*. The program aims to make mammograms available to all women over 50 years of age. Women between 40-49 years may also have a mammogram if they request it. This program involves the setting up mammographic screening units in larger towns and cities and the use of mobile screening clinics to provide mammograms in country towns. Mammograms are provided free of charge.

What is a mobile breast cancer screening service?

Mammographs can be provided through a mobile screening service that has all the x-ray equipment on board a special van. It uses staff who are experienced and specially trained in breast cancer screening. The mobile units usually visit towns for two months a year to allow women to have access to breast cancer screening.

P.T.O

Questions

We are interested in your attitudes and opinions on how breast cancer screening should be provided in **«Town»**. **There are no right or wrong answers to these questions.**

Would you use a mobile screening service to have a mammogram if it visited «Town»?

Yes ☐
No ☐
(✓ the box that applies)

To provide a breast cancer screening service in town like **«Town»** will cost the government money. Such health programs are normally funded through higher taxes. **It is important to find out if the community wants to pay for a service such as mobile breast cancer screening.**

Would you be prepared to pay **extra** tax to have a mobile breast cancer a screening unit located in **«Town»** ? If you don't currently pay tax think of the payment as an increase in rates to the local council to provide the service. **If there was no mobile screening service women «Town» would still be able to use the existing services in places such as «Substitute site»**.

Would you be prepared to pay $«Bid1» to have mobile breast cancer screening unit visit «Town» ?

Yes ☐
No ☐
(✓ the box that applies)

Do not send your answers to us.
We will ask you these questions again over the phone.

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