Valuing the benefits of health care in monetary terms with particular reference to mammographic screening

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Except where otherwise indicated, the work in this thesis is my own, and is based on original research performed at the Australian National University.

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Abstract

In recent years there has been renewed interest in using cost–benefit analysis as a means of evaluating health care goods and services. Under this approach, both a project's benefits and costs are measured in monetary terms. The major challenge for researchers wishing to apply this approach is to develop valid and reliable methods by which to measure the benefits of health care.

This thesis examines two different methods that can be used to value health care in monetary terms: (i) the travel cost method, which indirectly estimates the benefits by observing demand at different distances from a health care facility; and (ii) the contingent valuation method, which estimates the benefits directly by asking individuals to state their preferences for health care. Both of these methods are consistent with the theoretically correct definition of benefits, which measures them in terms of an individual's willingness to pay.

In this study both methods are used to value the same type of health care—mobile mammographic screening services in rural areas of Australia. Applying these methods to the same health care program not only highlights the strengths and weaknesses of each method, but also facilitates their cross-validation in a health care context.

To explore how the travel cost method can be applied in the evaluation of a health service, it is used to estimate the benefits from increased access to mammographic screening services in 10 rural towns in New South Wales. This empirical work was based on a survey of 901 women conducted in 1993–4. The results suggest that the welfare gain associated with such a program depends on a town's distance from the nearest fixed screening unit. The average willingness to pay per individual ranged from $1.46 per visit (if she lived in a town that was 15km from a fixed screening unit) to $48.20 (if she lived in a town that was 160km from a fixed screening unit). These estimates formed the basis of an indicative cost–benefit analysis to determine which towns should have access to these units.

A second survey was conducted in order to explore how the contingent valuation method can be used in the evaluation of the same service. This involved the use of a dichotomous choice contingent valuation survey of 458 women in 19 rural towns. Each woman was asked whether she was "willing to pay" one of eight pre-specified bids (ranging from $5 to $300). The amount was selected at random from these eight bids. Depending on her response to this question she was then offered a higher or lower amount in a follow-up question. Estimates of the mean willingness to pay based on these data range from $107 to $150.81 per visit.

The final issue examined is the validity of the contingent valuation method. Validity is tested using three different approaches. First, a detailed assessment of the survey instrument was undertaken to see if it was conducive to respondents revealing their true preferences. Second, the theoretical validity was assessed. Finally, welfare estimates from the contingent valuation experiment are compared with those from a travel cost model as a means of cross-validating these methods. Based on this comparison, the contingent valuation method was shown to produce higher estimates of the welfare gain. The thesis concludes with a discussion of how these findings can contribute to the further development of these methods in the evaluation of health care.

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Chapter 1

Introduction

> Value is the most invisible and impalpable of ghosts, it comes and goes unthought of, while the visible and dense matter remains as it was.
> (W. Stanley Jevons 1884, p.80)

In 1884, Jevons gave a clear warning of the difficulties one faces when trying to quantify value. More than a century later, economists are still struggling with this elusive concept. No more so, than when trying to quantify the benefits of health care. In this field two different approaches have emerged in the last 30 years. One approach measures the value of health care in monetary terms and the other in units that reflect changes in health status, such as quality adjusted life years (QALYs).

One of the first attempts at valuing the benefits of health care was undertaken by Weisbrod (1961) who used the human capital approach to estimate the value of several public health programs. The underlying tenent of the human capital approach is that the benefits of health care result from its ability to improve the productive capacity of society. Under this approach, the value of saving a life is equivalent to the future earnings of the individual whose life is saved (Mooney 1977, p. 55). Although initially popular, the limitations of the human capital approach soon became evident– the main one being that it cannot be used to quantify the benefits of health care that do not improve a society's productive capacity. No value is placed on treating conditions that cause pain and suffering, but have no affect on lifetime earnings. The method also has some disturbing ethical implications because it values the loss of a poor person's life less than a rich person's life and places no value on the life of someone who has retired from the labour force. Dissatisfaction with the human capital approach lead to the development of two quite distinct research programs.

Initially, health economists tended to move away from the monetary valuation of health care altogether. This move coincided with the development of alternative methods of evaluation such as cost-effectiveness analysis (CEA), which measures health benefits in physical units such as "life years saved". CEA facilitates the comparison of different health care interventions by estimating the cost of achieving a one unit change in health outcome. However, the potential applications are limited because the output measure (life years saved) does not reflect changes in morbidity. To overcome this shortcoming, QALYs were developed in the 1970s (Zeckhauser and Shepard 1976). Economic evaluations that measure output in terms of QALYs are normally referred to as cost-utility analyses (CUA). Both of these methods avoid valuing health care in monetary terms by shifting the valuation problem from the researcher onto the decision maker—after a CEA or CUA has been conducted, the decision maker must still determine whether an intervention that costs $X per life year/QALY saved is worth funding. In doing so, they must make an implicit judgement regarding the value of an extra year of life/QALY.

The other research program that has emerged within the discipline of health economics in the past few years is to retain the emphasis on monetary valuation, but to make its measurement consistent with the principles of welfare economics. Under a welfare economic framework, value is defined in terms of individual preferences and is considered to be reflected in the amount an individual is willing to sacrifice in order to obtain a good or service. As Pauly (1995, p.102) notes:

> In welfare economic theory, there is only one accepted way to measure the benefits an individual gets from a program. Benefit is defined as *the individual's maximum willingness to pay for the program* when supplied with information as complete as it can be, given the scientific knowledge available at the time. {italics in original}

It should be recognised at the outset that health care has several characteristics that set it apart from most other goods and services. Firstly, health care has the potential to have an enormous impact on an individual in that it can determine whether she[1] lives or dies. Secondly, it is often used to treat conditions over which an individual has no control. Finally, there is a significant information asymmetry between the providers of health care and patients. For all of these reasons, there is substantial government intervention in the health care market in most developed and many

[1] The focus of the empirical work conducted in this thesis concerns the evaluation of mammographic screening services. Since this health care service is used exclusively by women, the female pronoun is used.

developing countries. Although this intervention takes many forms it normally results in the consumer facing a zero or nominal price for health care goods and services.

In the case of private goods that are traded in markets, people reveal their preferences through their actions. That is, an individual's demand curve can be used to infer her willingness to pay. When a health care good or service is sold at a nominal price, it is impossible to observe its demand curve and hence obtain a measure of its benefits. This problem is not unique to health care. It also arises when valuing environmental commodities such as national parks, which generally have a nominal entry fee (Bockstael, McConnell and Strand 1991, p.227). Environmental economists have developed two approaches to overcome this problem: (i) the travel cost method (TCM)—which indirectly estimates the benefits of a national park by observing the demand at different distances from the park; and (ii) the contingent valuation method (CVM)—which attempts to directly estimate the benefits by asking individuals their willingness to pay (WTP) to gain access to the park.

The central concern of this thesis is to examine how these two methods can be used in the evaluation of health care. This study has three main objectives. The first objective is to provide an overview of the theoretical issues that are germane to application of these methods in the evaluation of health care. The second objective is to apply both methods in an attempt to measure the benefits of using mobile mammographic screening services in rural areas of Australia. The third objective is to test the validity of these methods in a health care context. The plan of the study is set out below:

Chapter two provides an overview of the two approaches that can be used to value health care. The benefits of health care can be quantified either by valuing the health outcomes that health care produces, or by directly valuing the health care goods themselves. The chapter systematically explores both approaches within the framework of a household production model.

Chapter three examines money measures of price changes when goods must be purchased or consumed in discrete quantities. These are often referred to as indivisible goods. Indivisibility often characterises the acquisition of information. In this respect it is relevant to mammographic screening, because like most medical screening tests, its output comprises information on a patient's disease status.

Chapter four is intended to provide some background material on mammographic screening. The chapter is divided into three parts. The first part outlines the outcomes of a mammogram and the structure of Australia's mammographic screening program. The second part is concerned with the valuation of mammographic screening in monetary terms. In this section, a simple model is developed where the outcomes of a mammogram are represented by four potential states. Since it is not known with certainty which of these states a particular test will produce, welfare measures that take risk into account are derived. The final part returns to the household production model and examines the modifications which are necessary to model the demand for mammographic screening.

Chapter five discusses the potential role of revealed preference methods in the evaluation of health care. Although these methods have been used extensively in the valuation of the health effects associated with improvements in the environment and the introduction of safety equipment, they have rarely been used to value health care. After briefly reviewing some of applications in these related fields, this chapter focuses on the potential for using the TCM to value health care goods and services.

Chapter six provides a practical application of the TCM in the form of an indicative cost benefit analysis of the use of mobile mammographic screening units in rural areas of Australia. The empirical work is based on a survey conducted in 1993–4 on 10 randomly selected rural New South Wales towns. The welfare benefits associated with the introduction of mobile units are estimated and compared with the cost of provision for each of the 10 towns.

Chapters seven and eight focus on the use of the CVM in the valuation of health care. After reviewing several recent studies, chapter seven examines a number of issues that have been largely overlooked in the existing health care contingent valuation literature. These include the important role of information in the valuation of health care, possible motivations for contingent valuation responses, and statistical issues that arise when trying to elicit measures of the willingness to pay though contingent valuation surveys. An empirical application in the form of a contingent valuation experiment is presented in chapter eight. This application parallels the travel cost study undertaken in chapter six in that it again attempts to quantify the benefits associated with using mobile screening units in rural New South Wales towns. The welfare benefits associated with a hypothetical program to use mobile screening units in these towns is estimated.

The final issue, which is examined in chapter nine, is the validity of these methods. The main focus of this chapter is on the CVM, because economists tend to be sceptical of stated preference methods. The validity of this method is examined using three different approaches. First, a detailed assessment of the survey instrument is undertaken to see if it is conducive to the respondent revealing their true preferences. Secondly, the theoretical validity is assessed. Finally, welfare estimates from the contingent valuation experiment are compared with those from a travel cost model as a means of cross-validating the use of these methods in health care.

The main conclusions are summarised in Chapter 10

Chapter 2

Methods for evaluating health and health care

> There is however a special difficulty in estimating the whole of the utility of commodities some supply of which is necessary for life. If any attempt is made to do it, the best plan is perhaps to take that necessary supply for granted, and estimate the total utility only on that part of the commodity which is in excess of this amount... (Alfred Marshall 1920, p.110).

2.1 Introduction

One of the first questions that must be addressed before attempting to undertake any applied work is, what are we trying to value? Initially, this seems like a trivial question but this not so, because there are two domains in which value can be measured. It can be reflected either in the preferences for health care goods and services or in the preferences for a change in health status. Both domains are examined in this chapter within the framework of the household production model (HPM).

The remainder of this section provides background information on the origins of both these approaches. Section 2.2 outlines a two-commodity HPM. In order to derive the results in this section, two simplifying assumptions about the nature of household production are made: (i) non-joint production of commodities; and (ii) constant returns to scale. Section 2.3 shows how this model can be applied to value health and health care. The purpose of section 2.4 is to clarify a point over which there has been some confusion in the literature—whether health can be represented as a single commodity. Section 2.5 then relaxes the two key assumptions invoked in section 2.2. The implications for evaluation are then discussed in section 2.6 and a summary is provided in the final section.

2.1.1 Background

Adopting a welfare economic framework to value changes in health dates back to Schelling (1968), but it was Mishan (1971) who had the greatest influence on the monetary valuation of health (Tolley, Kenkel and Fabian 1994, p.4). The primary purpose of Mishan's work was to provide estimates of the costs and benefits arising from "changes in the incidence of death, disablement, or disease caused by the operation of new projects or developments" (Mishan 1971, p.687). His focus was very much on the valuation of life and limb (or changes in mortality and morbidity) and hence it lies within the domain of valuing health. Mishan's approach has largely been ignored by those health economists who prefer to value health in nonmonetary terms by using measures such as QALYs.

In recent years there has been renewed interest in valuing the benefits of health care in monetary terms. This has come from two different quarters. First, economists who have applied Mishan's approach in other fields (e.g. environmental economics) have sought to apply these methods in the evaluation of health care. For example, the morbidity associated with a disease could be represented by different symptoms such as coughing or nausea. The benefits of relieving each symptom could then be measured. The value of a drug that cures the disease could be estimated by adding up the total value of the health benefits. A comprehensive overview of this approach is contained in a recent book by Tolley, Kenkel and Fabian (1994).

The second approach involves the direct valuation of health care and, unlike the previous approach, it has been developed within the confines of health economics.[1] The valuation of health care goods and services as opposed to measuring the benefits in terms of the health outcomes represents a significant departure not only from the nonmonetary valuation of health outcomes (i.e. QALYs), but also from the monetary valuation of health discussed above.

[1] Studies that have adopted this approach include Johannesson, Jönsson and Borgquist (1991) and Donaldson (1990).

2.2 A household production model of health care

The household production approach developed by Becker (1965) to model consumer choice provides a theoretical framework for valuing health and health care. Becker's approach to consumer theory draws a distinction between commodities and market goods. The household is viewed as combining market goods and their own time to produce commodities and it is these commodities that are the ultimate source of utility. The main advantage of this approach over traditional demand theory is that it separates the factors determining the process of production from those influencing consumer tastes.

The HPM has had great influence on health economics through the seminal work of Grossman (1972). The "Grossman model", as it has become known, regards health as: (i) a consumption commodity because "good health" is a direct source of utility; and (ii) an investment since improved health enables more market activities to be undertaken in the future. Grossman's full model will not be presented here, because the primary purpose of this chapter is to distinguish between the valuation of health and health care. For this reason a simplified HPM is developed in the following sections.

2.2.1 A single period household production model

It is assumed that an individual is endowed with a stock of health (H^s) which depreciates at a rate of δ. At the beginning of each period the individual must decide how much health to produce, but must always maintain their stock of health above a critical level (H^c) in order to survive. To abstract from intertemporal issues we focus on a single time period in which the individual starts with an initial stock of health $H_t^s = H_{t-1}^s - \delta H_{t-1}^s$. The individual must then decide what quantity of health (H_t) and another commodity (Z_t) to produce during this period. At the end of period t their stock of health depreciates by δH_t^s. The rate of depreciation is assumed to be exogenous and is known with certainty.

Although this is a very simple model, it allows us to explore several important aspects of the HPM relevant to the measurement of welfare change.

The individual's decision over the optimum commodity bundle of H_t and Z_t can be divided into two stages: (i) a lower stage where market goods are combined with time to produce a feasible set of commodities; and (ii) an upper stage where the commodity bundle that maximises the individual's utility is chosen from this feasible set. The process of optimisation involved in each stage is discussed in turn.

In the lower stage, the individual combines market and non-market goods to produce commodities. If there are *n* goods[2], let x_j^H denote the quantity of the *j*th good used in the production of health and denote the corresponding input vector as: $X^H = (x_1^H,...,x_n^H)$. The input vector X^H will consist of any factor that influences health status (i.e. for goods that have no influence on health $x_j^H = 0$). Typically, this input vector includes health care and "health creating" market goods (e.g. safety equipment) and non-market goods such as time. An individual's ability to produce health can also be affected by the environment in which they live. The health production function denoted by $H_t = f^H(X^H)$ is governed by the underlying technology available to the individual. We assume that this production function is strictly concave and is increasing in all its arguments. Similarly, denote an input vector $X^Z = (x_1^Z,...,x_n^Z)$ and define the production function for the other commodity to be $Z_t = f^Z(X^Z)$. The total quantity of each good consumed is represented by x_j (i.e. $x_j = x_j^H + x_j^Z$) and the vector of goods that the individual consumes by X where $X = X^H + X^Z$.

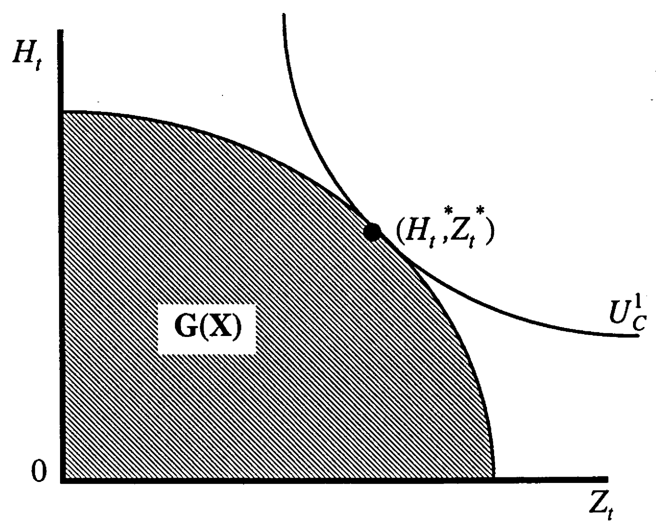
Associated with every goods vector X is a feasible set of commodities, G(X), that can be produced. A typical feasible set is depicted in figure 2.1. Along the boundaries of this set is the "production possibility frontier", which represents the maximum amount of Z_t and H_t produced for a given quantity of inputs. In

[2] Since all production is assumed to take place within a single period the subscript *t* has been suppressed on the input x_j.

order to maximise utility, the consumer must choose a point along this frontier. The exact point will be influenced by the relationship between the individual's current stock of health H_t^s, the rate of depreciation δ and the level of health that is critical for survival H^c. In particular, if $H_{t+1}^s - H^c \leq \delta H_t^s$ then a minimum quantity of health (denoted by H_t^c) must be produced in the current period in order for the individual to survive. This level of health production is *essential* in the sense that the utility function is undefined for quantities of health below H_t^c. Alternatively, if $H_{t+1}^s - H^c > \delta H_t^s$, then the individual can choose not to produce health in the current period (i.e. H_t =0) without affecting their survival. The exact quantity of health chosen beyond H_t^c is governed by the individual's preference for H_t relative to Z_t (i.e. the marginal rate of substitution between health and the other commodity) and the marginal rate of transformation between the two commodities.

In figure 2.1 the consumer chooses the commodity bundle (H_t*, Z_t *) since the highest available indifference curve (U_C^1) just touches the production possibility frontier at this point.

Figure 2.1. Choice in the household production model



In order to operationalise the HPM, the input demand curves for goods and commodity outputs must be derived. Associated with X will be a vector of prices $P = (p_1,...,p_n)$. In the first stage of the household production process we define a cost function which represents the minimum cost of achieving a level of output for a given level of prices:

$$C(P, H_t, Z_t) = \min \sum_{j=1}^{n} p_j x_j \qquad (2.1.)$$

In general, the budget constraint in commodity space is non-linear. As a first step to deriving the commodity demand functions, the shadow prices (s_H and s_z) must be derived from the cost function:

$$s_H(P,H_t,Z_t) = \frac{\partial C(P,H_t,Z_t)}{\partial H_t} \qquad s_Z(P,H_t,Z_t) = \frac{\partial C(P,H_t,Z_t)}{\partial Z_t} \qquad (2.2.)$$

Unlike the standard utility maximisation problem, s_H and s_Z are not exogenous to the consumer, but vary with the input prices and the chosen combination of commodities. In order for the problem to be tractable it is normally assumed that *household technology exhibits constant returns to scale and no joint production.* Pollak and Wachter (1975) demonstrate that under these conditions, the shadow prices are independent of the quantities of commodities chosen.

In order to complete the exposition of the basic model, we assume that both of these conditions hold, hence $s_H(P,H_t,Z_t) = s_H(P)$ and $s_Z(P,H_t,Z_t) = s_Z(P)$. The implications of relaxing these assumptions are discussed in section 2.5 below.

At any point on the production possibility frontier, the marginal rate of transformation between the two commodities is the ratio of $s_Z(P)$ to $s_H(P)$. More formally, the commodity demands can be derived from the upper stage maximisation problem:

$$\begin{aligned} &\max U_C(H_t, Z_t) \\ &s.t.\, s_H(P)H_t + s_Z(P)Z_t = y \end{aligned} \qquad (2.3.)$$

where y is the consumer's total income and $U_C(.)$ denotes utility in commodity space. To simplify the exposition, y is assumed to be exogenous. Eq. (2.3) yields Marshallian commodity demand functions:

$$H_t^m = m^H(s_H, s_Z, y) \qquad Z_t^m = m^Z(s_H, s_Z, y) \qquad (2.4.)$$

These demand functions display all the properties of traditional demand functions. As Grossman (1972, p.225) notes the "most fundamental law in economics is the law of the downward-sloping demand curve, the quantity of health demanded should be negatively correlated with its shadow price."

The dual of the utility maximisation problem in Eq. (2.3.) is expenditure minimisation subject to the attainment of a minimum level of utility:

$$\begin{aligned} &\min s_H(P)H_t + s_Z(P)Z_t \\ &s.t\ U_C(H_t, Z_t) \geq \overline{U}_C \end{aligned} \qquad (2.5.)$$

By differentiating the resulting expenditure function with respect to the shadow prices the Hicksian (compensated) demand curves can be derived for both commodities:

$$H_t^h = c^H(s_H, s_Z, \overline{U}_C) \qquad Z_t^h = c^H(s_H, s_Z, \overline{U}_C) \qquad (2.6.)$$

The demand functions for different inputs can also be derived since the utility function used to select the optimal commodity vector may also be defined over goods space. In figure 2.1 the optimal bundle (H_t*,Z_t*) is produced by an input vector X. The Marshallian demand for goods can be derived by attaching the utility associated with the optimal commodity bundle with the input vector X (Pollak and Wachter 1975). The Marshallian demand functions can be derived by:

$$\max U_G(X)$$
$$s.t. \sum_{k=1}^{n} p_k x_k = y \tag{2.7.}$$

where $U_G(.)$ is utility in goods space. This yields input demand functions for each good.

$$x_j^m = m^i(P, y) \tag{2.8.}$$

Using the dual of Eq. (2.7.) the Hicksian demand for goods can also be derived:

$$x_j^c = c^i(P, \overline{U}_G) \tag{2.9.}$$

2.3 Valuing health and health care

The separation of health and health care in the HPM suggests that there are two different approaches that can be used to value a health care good or service. Either the benefits associated with its consumption can be quantified by valuing the health outcomes it produces (i.e. measuring the welfare change in commodity space), or it can be valued by directly observing the input demand function (i.e. measuring welfare change using the derived demand for the health creating good).

2.3.1 Valuing health

Health (H_t) is a non-market commodity which an individual cannot purchase directly. Instead it must be produced by consuming health creating inputs, like health care. Its valuation differs from the welfare measurement of price changes. Mishan (1971, pp 228-229) highlights this issue:

> In the market place, the price of the good... is fixed by the producer, and the buyer or seller determines the amount by reference to his subjective preferences. Where, however, the amount of a... good is fixed for each person—as may be the case with a change in risk—a person's subjective preference can only be determined by the price he will accept or offer for it; in short, his CV.

This suggests that the welfare change associated with an improvement or decline in health (which Mishan refers to above as a "change in risk") must be defined in terms of a quantity change rather than a price change, because health is not a traded good.

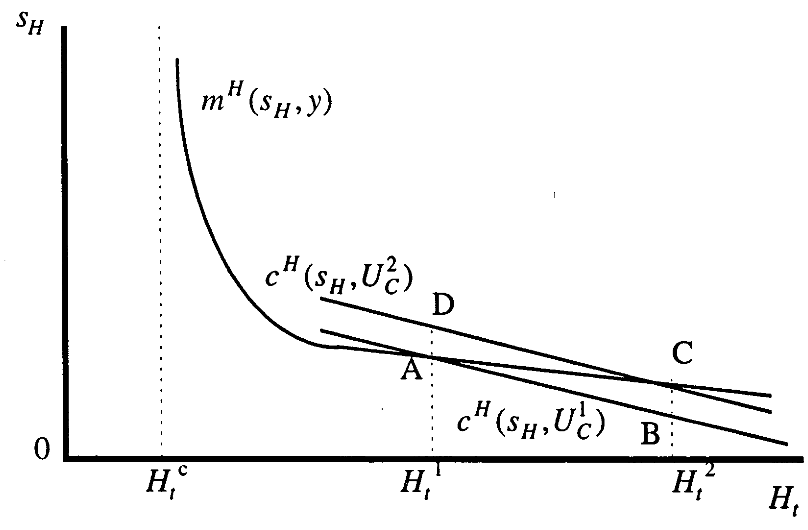
The compensating variation (CV) associated with an improvement in health from H_t^1 to H_t^2 in period t can be defined using the expenditure function:

$$CV_q = e(s_H, H_t^1, U_C^1) - e(s_H, H_t^2, U_C^1) \qquad (2.10.)$$

In Eq. (2.10), CV_q represents the maximum amount of money that must be taken from the individual—that is, her willingness to pay (WTP), so that she remains at her initial level of utility (U_C^1). If the health change was reversed (i.e. a decline from H_t^2 to H_t^1) then the CV is the minimum amount of compensation she requires to leave her as well off as before the reduction. Here the CV measures the willingness to accept (WTA) compensation for a decline in health (Johansson 1995, p.35). Alternatively, the equivalent variation (EV) for the same change in health can be defined using the final level of utility (rather than the initial level as in Eq. (2.10.)).

The relationship between the various measures of welfare can be illustrated using the Hicksian and Marshallian commodity demand functions for health. Figure 2.2. illustrates three measures of welfare change associated with a change in health from H_t^1 to H_t^2. The ordinary Marshallian consumer surplus (CS) is the area under $m(s_H, y)$ between the two health states (i.e. $ACH_t^2H_t^1$). The CV for the same change will be $ABH_t^2H_t^1$ (i.e. the area under Hicksian demand curve $c(s_H, U_C^1)$). The EV for the same change in health will be the area under $c(s_H, U_C^2)$ or $DCH_t^2H_t^1$.

Figure 2.2. The welfare benefits associated with an improvement in health



The size of the benefit (or loss) associated with a change in H_t depends on the proximity of the change to H_t^c. If it is essential to produce a certain level of health in the current period to survive (i.e. H_t^c >0) then the marginal valuation of health (represented by it's shadow price s_H) will approach $\propto$ as the quantity of H_t approaches H_t^c. Welfare measures cannot be used to value a change that results in an individual's certain loss of life. Alternatively, if the individual can survive the current period without producing health, then $m^H(s_H,y)$ will intersect the vertical axis at a finite shadow price. In this case any change in health (i.e. above $H_t = 0$) produces finite measures of welfare change.

In practice, two techniques can be used to value changes in health status. The first involves observing the value of health implied by revealed preference. The other method involves asking consumers to express preferences for a change in their health.

The revealed preference approach applies the HPM to derive the Marshallian demand function for H_t (Eq. (2.4.)). The alternative approach is to use survey methods to value changes in health. The most developed survey method is the contingent valuation method (CVM), in which respondents are asked their "willingness to pay" or "willingness to accept" contingent on a market existing for the good or service. Typically, individuals are asked what they would be willing to pay to improve their health from H_t^1 to H_t^2 (i.e. a measure of the CV).

2.3.2 Valuing health care

Health care is normally combined with other market goods (e.g. a bus ticket to travel to the doctor, or an ambulance ride to hospital) and non-market goods (such as time) to produce health. All these goods represent inputs into the health production function. If health care is represented by x_1^H, the Marshallian demand (Eq. (2.8)) will be $x_1^m = m^1(p_1, \overline{P}, Y)$, where $\overline{P} = (p_2, p_3 .. p_n)$. Similarly, the Hicksian demand (Eq. (2.9)) can also be defined as $x_1^c = c^1(p_1, \overline{P}, U_G)$. In the general case, x_1 may also produce Z_t, but health care goods—unlike some other inputs (such as the time)— cannot normally be divided between multiple uses. Consequently, in the following example we assume that $x_1^Z = 0$. The demand curves for x_1 can be used to calculate the welfare benefit (or loss) from a price change and in some instances it can be used to infer the value of change in health.

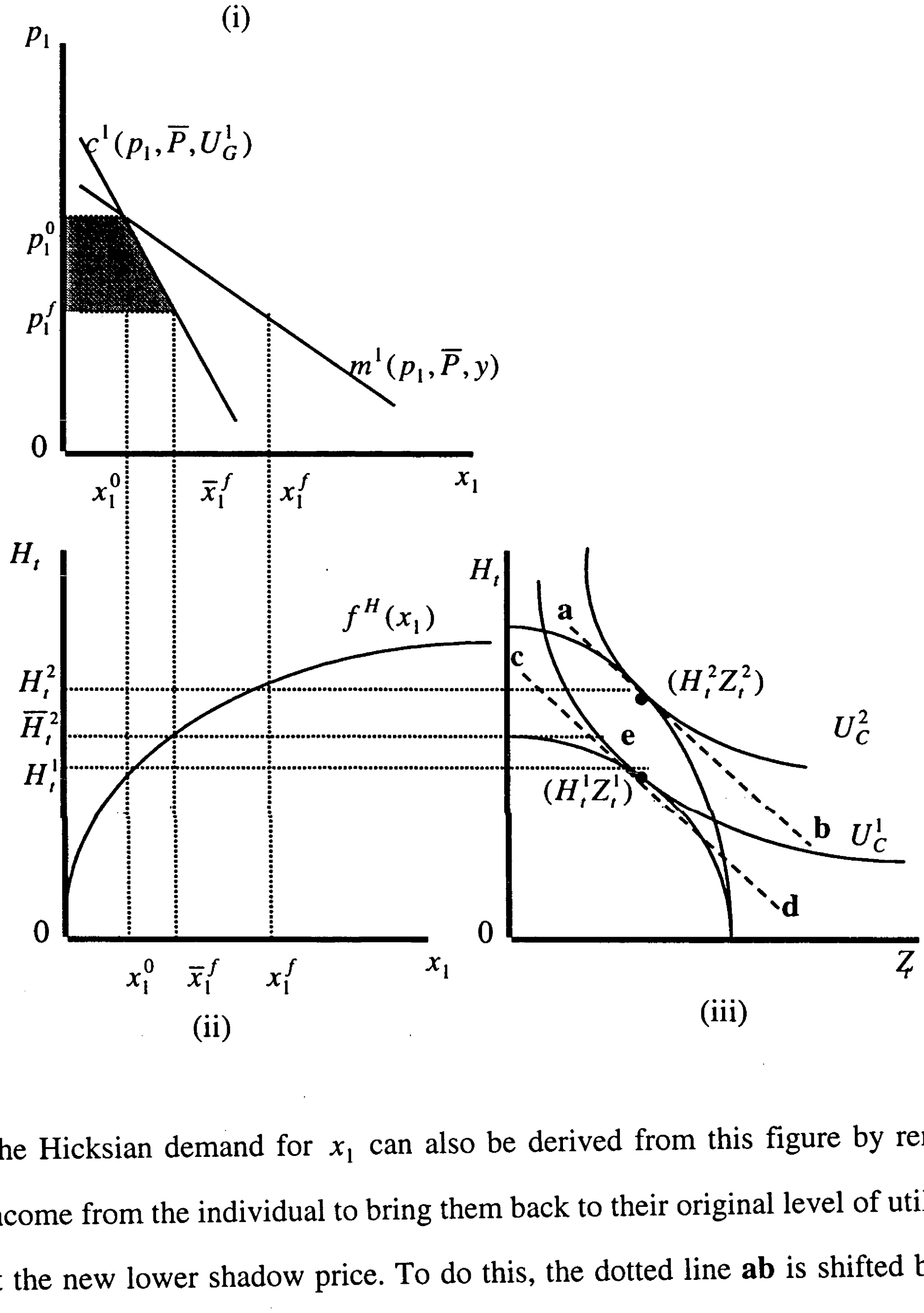
(i) Welfare measurement of a price change

The effect of a change in the price of health care is graphically illustrated in figure 2.3. In the first diagram (figure 2.3(i)), the Marshallian demand for the good is $m^1(p_1, \overline{P}, y)$ and the Hicksian demand associated the initial utility (U_G^1) is $c^1(p_1, \overline{P}, U_G^1)$. The second (figure 2.3(ii)), illustrates the health production function $f^H(x_1)$ and the third (figure 2.3(iii)), represents commodity space (H_t, Z_t).

If the price of x_1 declines from p_1^0 to p_1^f, the individual will purchase a greater quantity of health care (i.e. increase consumption from x_1^0 to x_1^f). The effect that this has on H_t is illustrated in figure 2.3(ii). The increase in health care inputs from x_1^0 to x_1^f results in an increase in the production of health (i.e. H_t^1 to H_t^2).

This in turn has an impact on the feasible production set G(X) illustrated in figure 2.3 (iii). Since x_1 only enters the health production function, the production possibility frontier shifts upward rather than outward. The combination of these factors results in a change in the optimal bundle of commodities from (H_t^1, Z_t^1) to (H_t^2, Z_t^2). As the commodity bundle (H_t^2, Z_t^2) is on a higher indifference curve (U_C^2), a decline in price leads to a welfare gain. Providing health is not a giffen good the individual will increase their consumption of H_t following a decline in the price of a necessary input. The quantity of Z_t can rise or decline depending on whether it is a substitute or complement to H_t. The dotted line, **ab,** represents the marginal rate of transformation of H_t into Z_t and it's slope is equal to $-s_H(P)/s_Z(P)$.

Figure 2.3. The welfare benefits associated with a reduction in the price of health



The Hicksian demand for x_1 can also be derived from this figure by removing income from the individual to bring them back to their original level of utility U_C^1 at the new lower shadow price. To do this, the dotted line **ab** is shifted back to the point at which it just touches U_C^1 (i.e. point **e** on the dotted line **cd**). At this lower level of utility, the consumer demands less health ($\overline{H}_t^1$) and consequently less health care ($\overline{x}_1^f$). The CV associated with the decline in price is:

$$CV_p = e(p_1^0, U_G^1) - e(p_1^f, U_G^1) = \int_{p_1^0}^{p_1^f} x_1^c \, dx_1^c \qquad (2.11.)$$

The area between the initial and final prices to the left of $c^1(p_1, \overline{P}, U_G^1)$ represents the welfare gain from the price fall (represented by the shaded area in figure 2.3(i)).

The derived demand curve for health care $c^1(p_1, \overline{P}, U_G^1)$ could also be used to estimate the value of the change in health when the following three conditions are met: (i) x_1 is necessary[3] for the production of H_t; (ii) x_1 does not produce Z_t: (iii) the change in health (H_t^1 to H_t^2) does not encompass H_t^c. The intuition behind these conditions is as follows. Firstly, if x_1 is necessary for the production of H_t the marginal value of the change in health will be reflected in $c^1(p_1, \overline{P}, U_G^1)$. Secondly, if x_1 does not produce Z_t the marginal value the individual places on other commodities will not be reflected in $c^1(p_1, \overline{P}, U_G^1)$. Finally the change in H_t brought about by a change in x_1 must be non-essential for survival. If a health care is "life saving" an individual cannot place a monetary value on the health change and hence it is not possible to integrate under $c^1(p_1, \overline{P}, U_G^1)$. Even if the first two conditions are not met, the input demands still represent the marginal value an individual places on different quantities of the health care good x_1, but these values cannot use to make inferences about the value of the change in health.

2.4 Measurement of output and welfare in the HPM

An important assumption underlying the valuation of health in the previous section is that health can be represented by H_t. This notion that health is a single commodity "output" has gained widespread acceptance, since it also ties in closely with the view that health status can be measured using QALYs, which are another unidimensional measure of health. However, the use of such a broadly defined concept should be closely examined, since a commodity must represent

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[3] A good is defined as necessary if it is impossible to produce an output without using a particular input. For example, if there were two goods (x_1, x_2) used in the production of H_t, then x_1 is necessary if $f^H(0, x_2)=0$ (Gravelle and Rees 1992, p. 181).

the output of production processes and not a measure of utility (i.e. numbers representing preference ordering) (Pollak and Wachter 1975). The measurement of the two most important health outputs—changes in mortality and changes in morbidity are considered below:

Mortality

An individual's risk of mortality is usually measured as the probability of dying over a fixed period of time (Cropper and Freeman 1991). The effect that health care or other market goods, such as safety equipment has on mortality can be represented by changes in this probability (i.e. a change in risk). This is an objective measure in that it represents the individual's chance of survival and not the individual's preferences. It can therefore be regarded as a commodity "output" within a household production framework.

Morbidity

Morbidity has been defined as "a departure from a physical state of well-being, resulting from disease or injury, of which the individual is aware" (U.S. Public Health Service as cited in Cropper and Freeman 1991, p.168). Morbidity, unlike mortality, has many dimensions. For example, a cancer patient's "quality of life" will be governed by a range of factors including physical symptoms such as pain, body temperature, tenderness, discomfort, stiffness and swelling in the treated area (Hall et. al. 1992). Such patients might also experience psychological morbidity and anxiety stemming from a fear of death. It is difficult to measure many of these symptoms, even in physical terms. Although some symptoms can be measured on an objective cardinal scale (e.g. body temperature) other symptoms such as pain cannot be objectively measured. However, for illustrative purposes let us assume that morbidity can be represented by a series of symptom scores measured on different scales $(H_t^A, H_t^B, H_t^C ... etc)$. If health is to be represented by a single commodity these scales must be combined into a single index (H_t). A vector of weights $(w_1, w_2 w_3 ...)$ can be used to represent the individual's *valuation* of different aspects of her health:

$$H_t = w_1 H_t^A + w_2 H_t^B + w_3 H_t^C \tag{2.12.}$$

However, the resulting index is a measure of utility rather than a commodity, because it represents her preferences for different symptoms.

It is therefore not surprising that the focus of most quality of life research has been on developing *subjective* measures of health status, such as QALYs. These generally rely on techniques such as the *standard gamble* or *time-trade-off approach* to weight different health states. Responses to standard gamble questions depend not only on physical health, but also on the utility gained from that health. Even the *visual analogue scale* involves a value judgement on the relative importance of one health state over another (Mooney 1986).[4]

2.5 Extensions to the household production model

The HPM introduced in section 2.2 makes two important assumptions regarding the nature of production technology within the household: (i) there is no joint production; (ii) there are constant returns to scale. The implications of relaxing either of these assumptions is addressed below.

2.5.1 Joint production and the household production model

The previous section suggests that morbidity must be represented by a series of narrowly defined symptoms. This has important implications for the evaluation of health care, because the existence of multiple health commodities increases the likelihood that household production involves one of the following forms of joint production:

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[4] Johannesson (1996) attempts to reconcile the cost–utility and cost–benefit approaches by introducing the concept of willingness to pay for a QALY(pp. 202–210). The problem with this approach is that QALYs are a measure of preference for health and so the WTP is a measure of preference for QALY preferences. This is an ill-defined concept in neo-classical welfare economics.

(i) *Production indivisibility* arises when there are more commodities than goods. For example, if health care produces two health outcomes, H_A and H_B, and both commodities are produced in fixed proportions (i.e. $H_t^A = ax_1^H$ and $H_t^B = bx_1^H$, where a and b are the marginal rates of transformation. Indivisibilities in production occur if the input vector contains only one necessary good $X^H = (x_1^H, 0, \ldots, 0)$, because the feasible set is a ray from the origin in commodity space and a given quantity of x_1^H will produce fixed quantities of H_t^A and H_t^B. Points along the production possibility frontier will be consistent with an infinite variety of marginal rates of substitution since the consumer cannot choose to trade-off one commodity for another (Hori 1975);

(ii) *Interdependent production functions:* even if the number of goods is equal to the number of commodities, joint production can still occur if the different production functions are linearly dependent (Dickie and Gerking 1991);

iii) *Inputs confer utility:* if health care is a direct source of utility as well as producing other commodities. Mooney (1996) terms this "process utility".

In section 2.2., the derivation of commodity demand functions, represented by Eqs. (2.4.) and (2.6.), depend on the shadow price (or marginal cost) being independent of the quantities of commodities chosen. However, if there is joint production, the marginal costs will also depend on the commodity bundle consumed (i.e. $s_H(P, H_t, Z_t)$ and $s_Z(P, H_t, Z_t)$). This has important implications for welfare measurement. Bockstael and McConnell (1983) show that Marshallian commodity demands (Eq. (2.4.)) do not exist, because it is impossible to uniquely define at each marginal cost a level of demand for which the income constraint holds. However, the presence of joint production does not preclude the derivation of Hicksian commodity demand functions (Eq. (2.6.)) as the income constraint is not required to hold along the compensated demand curve. Even if the commodity outputs are jointly produced, the Marshallian input demand functions for goods can still be derived (Eq.(2.8.)). Hence, revealed preference methods can be used to value health care treatments even if they cannot be used to value aspects of the individual's health (i.e. symptoms).

2.5.2 Non-constant returns to scale

In section 2.2, the cost function is assumed to be linear homogeneous in Z_t and H_t, which is predicated on the assumption of constant returns to scale. This assumption should be relaxed, because most health production processes are governed by biological relationships that are subject to decreasing returns and sometimes natural limits. The later can result in production having an upper bound; that is, increases in scale beyond a certain point result in no increases in output. In some instances, higher quantities of health care are harmful. For example, paracetamol, a common pain-relieving drug, is effective in small does (e.g. one or two tablets), but leads to kidney failure and even death if 20 or more tablets are consumed at one time. The difficulty of incorporating non-constant returns to scale into the HPM is that we face a similar problem to that of joint production which means that the shadow prices are not only a function of input prices, but of the commodity bundle consumed. For this reason, only the Hicksian commodity demand functions can be estimated unless the entire cost function is known (Bockstael and McConnell 1983).

2.6 Implications for valuing the benefits of health care

The discussion in the previous section suggests that valuation of health using revealed preference methods faces formidable obstacles, because joint production and non-constant returns to scale are pervasive in the production of health. However, these features which are prevalent in commodity space do not affect the valuation of health care inputs in goods space. It is therefore quite possible to observe the demand for a health care good which reflects the combined value of all its outputs while being unable to observe the marginal value of a particular health commodity. However, all is not lost for those wanting to measure the value of health commodities, because Hicksian commodity demand functions still exist, and so it is still possible to apply stated preference methods.

Consider the case of indivisibility in production outlined above. What options are open to a researcher trying to evaluate this drug? One option is to use the CVM to elicit preferences for the alleviation of each symptom by asking individuals their maximum WTP for a change in H_t^A combined with a change in H_t^B.[5] The other option is to use stated or revealed preference methods to directly value the drug. This involves either observing the Marshallian demand for the drug or asking the individual her WTP for the drug. The merits of both these options are discussed below.

2.6.1 Valuing health care by valuing its outputs

The health outputs approach measures the benefits of a health care program by valuing its outputs. This approach can be divided into a series of stages. In the first stage, all the relevant outputs of a program need to be identified. In the second stage the effects of treatment are quantified in terms of these outputs. In the third stage, the value of a change in each output must be elicited. Finally, the value of all outputs must be combined.

Up to this point, this chapter has primarily been concerned with technical issues surrounding the valuation of health and health care. There is a more fundamental question that also needs to be addressed. Namely, can an individual value changes in health commodities? As Dolan (1997) highlights, the valuation of health is predicated on the notion that an individual possesses a unique set of consistent preferences over health commodities. This assumption is not only germane to the monetary valuation of health, but to any method that requires an individual to express preferences for health outcomes such as QALYs or conjoint analysis.

A potential difficulty that arises when trying to value health is that most individuals are not familiar with the notion of expressing values directly for health-related commodities and so it may be difficult for them to form preferences even if they are able to value the good or service that produces these commodities. This problem is not unique to health, but arises whenever we attempt to disassemble a good into constituent commodity outputs. As Johansson (1995, p.77) notes we face the same problem when valuing a recreation trip:

> ... even if you know your WTP for a charter trip to the Bahamas, it may be difficult to specify the WTP for the weather, the WTP for the hotel, and so on; it is the package not a number of sub-components, that you buy.

Although it is possible to speculate on whether people have a consistent and complete set of preferences for health commodities, this issue ultimately can be resolved only through empirical testing.

2.6.2 Valuing health care directly

The alternative approach is to value health care directly either by observing the demand for health care inputs or by asking respondents what they would be willing to pay for a health care good. This is a much more holistic approach in that it requires respondents to weigh up their preferences for the various commodities and transform them into a single value.

Unlike health symptoms, health care is exchanged in markets, but in many developed countries the government subsidises care so that the user is charged a zero or nominal price. This generates its own problems, because a single point on the demand curve does not convey enough information to facilitate the calculation of the benefits associated with its consumption. This problem is quite different from that encountered when valuing health, because the cause is not an absence of (shadow) prices, but insufficient variation in the observed price to enable the researcher to value care.

There are two approaches to overcoming this problem. The first is to use other necessary inputs in the HPM to derive values for a zero-priced health care good.

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[5] As studies reported in Tolley et. al. (1994) show the benefits of simultaneously relieving multiple symptoms may differ from the sum of the benefits associated with relieving each symptom on its own.

The travel cost method discussed in chapters five and six is a prime example of this approach. The second alternative is to construct a hypothetical market for health care using the CVM. The objective of both these approaches is to measure the consumer's WTP for health care.

In the previous section it was suggested that it is likely to be more difficult for an individual to form preferences for commodities than for goods. However, this does not mean that it is easy for the individual to value any type of good. There are some features of health care that make especially difficult to value. The rest of this section is devoted to examining this issue.

Underlying the direct valuation of health care is the assumption that the individual is aware of all the health commodities that are produced (e.g. H_t^A, H_t^B etc) and is able to weigh up the relative importance of each of these commodities using a unidimentional metric that reflects their combined value (i.e. money). As Vatn and Bromley (1995, p.5) argue, an individual's ability to undertake such a task is likely to depend on her experience in valuing the good in question:

> ...this computational process is difficult for most goods. Long experience is required to for it to work quickly – and well. Children sent to the bakery for their first bread purchase would not find the process simple. Adults are reminded of this when they undertake the purchase of an automobile.

The notion that preferences are not inherited, but instead are a learned behaviour is an interesting one. They are suggesting that the reason why adults can easily evaluate their preferences for common private goods such as bread is that they can ascertain its attributes (e.g. colour, freshness, texture) and have experience in measuring the relative importance of these attributes in monetary terms. Such skills are built up through a "trial and error" learning process over a long period of time and cannot necessarily be transferred to goods with which they have less experience in purchasing (e.g. automobiles). This does not mean that adults cannot value such a good, but they must undertake "preference research" by gathering information on the choices available to them before making a decision.

Why do people find it difficult to value unfamiliar goods? Vatn and Bromley (1995) suggest that the process of determining preferences can break down for three reasons. Firstly, people find it cognitively difficult to observe and weigh up the attributes of unfamiliar goods. Secondly, health care contains potentially disparate attributes that cannot be mapped onto a single dimension. Finally, the value of one attribute may depend on another and so the value of the good may be different from the sum of its parts.

If this view of preference formation is correct, what implications does it have for the valuation of health care? It has long been recognised that health care is a good with special characteristics, as Arrow (1963, p.948) states in his seminal article on the welfare economics of medical care:

> The most obvious distinguishing characteristic of an individual's demand for medical services is that it is not steady in origin as, for example, food and clothing, but *irregular and unpredictable.* Medical services, *apart from preventative services,* afford satisfaction only in the event of illness, a departure from the normal state of affairs. *It is hard, indeed, to think of another commodity of significance in the average budget of which this is true.*{emphasis added}

What impact does the irregular and unpredictable nature of the demand for curative health care have on preference formation? These characteristics are likely mean that it is difficult for many individuals to express or reveal preferences, because they are often deigned the opportunity to engage in "trial and error" leaning for many types of health care. It may even be a more difficult task than forming preferences for infrequently purchased private goods such as automobiles, because illness often denies an individual the opportunity to undertake preference research; this is especially true for acute conditions. However, not all curative care falls into this category. For example, an individual might regularly suffer from migraines and therefore have a clearly defined set of preferences for different drug treatments even though the occurrence of this condition is unpredictable.

Interestingly, Arrow draws a clear distinction between demand for preventative and demand for curative heath care. The demand for the former is motivated by a desire to reduce the probability of experiencing deleterious health states in the future. Given that consumption of preventative services is not unpredictable, individuals might find it easier to form preferences—especially when a regular pattern of consumption is involved (e.g. taking anti-hypertensive tablets once a day or annual cancer screening tests).

2.7 Summary and conclusions

There is a fundamental difference between valuing health and health care. Health is not a traded good, and so we are restricted to valuing quantity changes. Whereas, when valuing changes in health care the situation is quite different, because health care goods are traded. Thus, we can potentially measure the welfare changes associated with either price or quantity changes. In practice, institutional restrictions mean that health care is often sold at a zero price which creates difficulties for the measurement of value, but this problem is very different from that encountered when trying to value non-traded commodities such as health.

Under the HPM, the valuation of health and health care are linked, because health care is an input into the production of health. Under some conditions, the demand for health care or other health-enhancing products can be used to value health. However, these conditions are fairly restrictive. In particular, there must be constant returns to scale and no joint production. If these conditions are not met, the HPM breaks down and revealed preferences cannot be used to value changes in health. In contrast, there is no problem with using stated preference methods as these are not subject to the above conditions.

The final section examines the processes by which individuals form preferences for health and health care. Although little empirical work has been conducted in this area it would seem likely that the more experience an individual has in purchasing a good the easier it is for them to form preferences. In this regard, individuals are likely to find it easier to value health care goods and services that are purchased on a regular basis than to value changes in health commodities. This particularly true when they have had experience in sacrificing the consumption of other market and non-market goods (e.g. time) in order to consume health care. It is for this reason that the empirical work on mammographic screening services undertaken in later chapters adopts the approach of directly valuing health care.

Chapter 3

Welfare measures for binary and indivisible goods[1]

> ... a given piece of information is by definition an indivisible commodity and the classical problems of allocation in the presence of indivisibilities appear here.(Kenneth Arrow 1962, p.170)

3.1 Introduction

It has long been recognised that some goods must be produced or consumed in discrete quantities. Samuelson (1947, p.241) touches on the subject when he discusses "the problem as to whether a commodity should be produced at all".[2] Welfare economists have also been interested in this type of good. Little (1957) devotes an entire chapter to the issue of "Indivisibilities and Consumers' Surplus" in his *Critique of Welfare Economics*. He considers a good to be indivisible if "the amount of a thing bought or produced can only be varied in jumps"(p.166). Perhaps not surprisingly, he draws a very negative conclusion regarding the prospects for measuring welfare change when goods are indivisible: "There is the obvious fact that areas under demand curves cannot be measured"(p.179). However, this was by no means the final word on the subject.

Mäler (1974) returned to the issue and derived welfare measures for the special case of goods that are demanded in just one quantity (i.e. a binary good). Far from being unable to measure welfare change, Mäler demonstrates that in the case of a decline in the price of such a good, the compensating variation (CV) is the area to the left of the ordinary demand curve. He also notes in passing that this result holds for a price rise.

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[1] Some of the material contained in this chapter was included in Clarke and Butler (1995). The work that appears here is substantially my own work.

[2] Samuelson also makes some interesting remarks about the use of stated preference methods to value this type of good: "In these cases involving finite decisions we must *ask* consumers... whether a given abundance of fewer commodities is preferred to an alternative scarcity of a greater range of commodities. At this point there will inevitably arise questions concerning the rationality of individual

In commenting on this result, Small and Rosen (1981, p.114) highlight what they believe to be an error in Mäler's work:

> [If a] good... must be purchased in a given quantity or not at all... [then] for a *fall* in price of such a good, the compensating variation is given by the area to the left of the ordinary demand curve. However, R. Willig has pointed out to us that Mäler is incorrect in stating that the result also holds when the individual is consuming the good and the prices *rises* above the... critical price.{Emphasis in original}

The first objective of this chapter is to examine Mäler's original result and to explore whether Willig is correct in stating that it does not apply in the case of a price rise. The second objective is to provide a general overview of indivisible goods and the statistical techniques that can be used to model consumption when it is restricted to discrete quantities.

What relevance do these welfare measures have for the evaluation of mammographic screening? The answer to this question lies in the quotation that heads this chapter. Medical screening tests such as mammograms provide the patient with information on whether they have a particular disease and so indivisibilities that arise in the acquisition of information have an impact on the measurement of welfare change.

The remainder of this chapter is divided into seven sections. Section 3.2 discusses indivisibility in general. Section 3.3 illustrates how indivisibility can be represented through indifference schedules. Section 3.4 derives the Hicksian and Marshallian demand for a binary good. Section 3.5 then provides an intuitive explanation for Mäler's original result and Willig's suggested clarification. Section 3.6 moves on from the binary good case to examine the demand and welfare measures for indivisible goods in general. Section 3.7 then re-examines indivisibility within a stochastic framework. The last section summarises the major findings.

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choice... But these questions, whatever their importance, cannot be settled by deductive analysis. " {emphasis added} (p. 241).

3.2 Definition of indivisibility

Neoclassical demand theory attempts to explain choices by constructing a set of subjective preferences and an opportunity set of feasible alternatives open to the consumer (Pudney 1989, p.17). Both of these sets are normally assumed to contain a continuum of different quantities that allow the consumer to make infinitesimal adjustments to their consumption bundle in order to maximise their utility. If goods are *divisible* then such adjustments are possible, but some goods must be consumed or exchanged in discrete quantities. These can be termed *indivisible* goods.

On the face of it, indivisible goods would appear to be quite common, as most goods are sold in integer quantities. However, it is probably a much less pervasive phenomenon than it would first appear if we adopt the approach of working with the characteristics of a good rather than with the goods themselves (Lancaster 1966). If the consumer has preferences for a divisible characteristic she might be able to maximise her utility by renting or sharing the good. In this way she is able to satisfy her preferences for a continuous characteristic even if the good is initially purchased in a discrete quantity. It is only when she is in some way prevented from doing so that such a good can be classed as being *indivisible in exchange*. This form of indivisibility is not restricted to consumer durables, but arises whenever it is impossible to make post-change adjustments along the quantity continuum (Randall and Stoll 1980).[3]

Another type of indivisibility arises when goods must be *consumed* in discrete quantities. Here, only integer quantities provide the consumer with utility. To distinguish this from the previous form of indivisibility, we term this *indivisibility in preferences*.

This classification system is summarised in table 3.1. Some medical examples of divisible and indivisible goods are also listed in table 3.1:

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[3]Randall and Stoll (1980) have suggested five factors that contribute to the impossibility of post-change adjustments: (i) situations in which the individual cannot continuously adjust holdings independently of others; (ii) indivisibilities of production; (iii) non-exclusiveness, making post-change

Table 3.1: The classification of different types of goods

Type of Good	Properties	Medical Example
Divisible	The good can be consumed in any quantity.	Dosage of some medications (e.g. aspirin)
Indivisibility in exchange	The good is exchanged in a discrete quantity and post-change adjustment is impossible.	Some operations (e.g. amputations)
Indivisibility in preferences (integer choice)	The good must be consumed an integer quantity	Blood tests

3.3 Representation of an individual's preference for indivisible goods

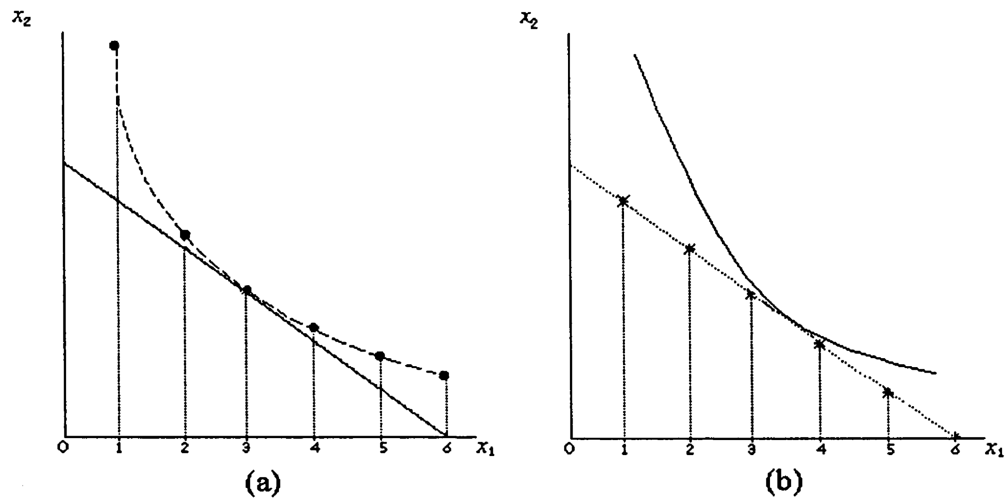
3.3.1 General case

In the case of goods that are indivisible in exchange, consumers are still able to express preferences for continuous quantities even though they are restricted to integer quantities when they trade the good. This can be represented by a budget line consisting of discrete points representing the quantities at which the good is traded. In contrast, if a good is indivisible in preferences, the indifference schedule consists of a series of isolated points. Both types of indivisibility result in a demand curve that is stepped rather than continuous, because quantity changes only occur at discrete points.[4]

adjustment infeasible; (iv) prohibitive transactions costs; and (v) institutional restrictions upon the quantity an individual can consume.

[4] In terms of figure 3.1, successive changes in the price of x_1 will rotate the budget constraint, but this will give rise to discrete changes in the quantity of x_1 demanded and hence a stepped demand curve.

Figure 3.1. Indivisibility in goods space



In figure 3.1(a), x_1 is a good which is indivisible in preferences and x_2 is an divisible good. Given her budget constraint, the individual chooses to consume three units of x_1. In figure 3.1(b), preferences for x_1 and x_2 may be infinitely varied, but x_1 can only be exchanged in integer quantities (i.e. indivisibility in exchange). In this case, the individual would prefer to consume a non-integer quantity (between three and four units), but is constrained to consume four units. Since indivisibility in preferences is relevant to the demand for information, it is the focus of the remainder of this chapter.

3.3.2 Indivisibility in preferences

Figure 3.1(a) illustrates the indifference curve for a good that is indivisible in preferences. It is composed of the integer points, although in keeping with convention, it is mapped in Euclidean space. As Boland (1987, p.84) notes:

> The preferences represented by this integer indifference map will be neither continuous nor complete *with respect to the Euclidean space* .... But from the view-point of the consumer, the non-integer points are irrelevant and thus the alleged discontinuity in the indifference map is misleading.{Emphasis in original}

What Boland is alluding to is the importance of distinguishing between indivisibility and continuity. Modern demand theory, with its foundations in set theory rather than in calculus, has separated continuity from indivisibility. Continuity is an *axiom of* *choice,* the acceptance of which leads to the existence of the utility function. Deaton and Muellbauer (1980, pp.27–28) define continuity as follows:

> For any bundle q^1, define $A(q^1)$ the "least as good as q^1 set" and $B(q^1)$ the "no better than q^1 set" by $A(q^1) = \{q|q \geq q^1\}, B(q^1) = \{q|q^1 \geq q\}$. Then $A(q^1)$ and $B(q^1)$ are closed, that is, contain their own boundaries, for any q^1 in the choice set

In essence, the axiom states that continuity is ensured if it is impossible to move from the set $A(q^1)$ to the set $B(q^1)$ without passing through a point of indifference between the two sets. An integer indifference schedule does not preclude continuity, because sets $A(q^1)$ and $B(q^1)$ have only integer elements.

Within the domain of indivisible goods, there are goods that are subject to such high diminishing marginal utility that they are consumed in only one quantity. Here, consumers must choose either to purchase a fixed quantity of the good or to go without. To distinguish these goods from the more general case we term these *binary goods.* A medical example of a binary good is a genetic screening test. If the test is perfectly accurate there is no value in ever being re-screened.

3.3.3 Modelling the decision to consume a binary good

To formalise the representation of binary goods, we assume the consumer's utility function[5] consists of two goods: (i) a binary good (x_1) that can be purchased in only one quantity; and (ii) a Hicksian bundle of composite goods (x_c) which is defined as the numeraire. There will be just two points of indifference:

$$U(x_c^0, 0) = U(x_c^1, 1) \qquad (3.1.)$$

where x_c^0 and x_c^1 are levels of x_c. If the individual does not consume x_1, she lies at the corner solution (x_c^0,0). Alternatively if she consumes x_1 she must sacrifice x_c^0- x_c^1 of x_c . The usual axiom of strict convexity of preferences is imposed, so the more

[5] Since the analysis in this chapter and subsequent chapters is largely confined to goods space the subscript "G" has been dropped from the utility function when referring to goods space.

the she has of x_c the more she must be compensated for abstaining from x_1. The individual's budget line is:

$$x_c + p_1 x_1 = y \tag{3.2.}$$

If the individual does not consume x_1, then $x_c^0 = y$. At the point at which she switches to consuming x_1 she reduces the quantity of the composite good to $x_c^1 = y - p_1$. We define the price at this point to be p_1^* or the "critical price".

Given x_1 is an indivisible good, the budget line must touch the highest attainable indifference curve at a corner solution. Unlike the continuous case, the consumer cannot make infinitesimal adjustments to her consumption bundle. In fact, the consumer's preferred rate of substitution is either be greater than, equal to, or below the rate of exchange. Each of these cases is depicted in figure 3.2 below:

(i) Rate of substitution is greater than the rate of exchange

This is represented in figure 3.2(a) in which the budget line **ac** attains its highest utility at the corner solution (x_c^0,0) on U^2. If p_1^0 is the actual price associated with the budget line **ac**, and p_1^* the critical price associated with the marginal rate of substitution between x_1 and x_c on U^2 then $p_1^* < p_1^0$.

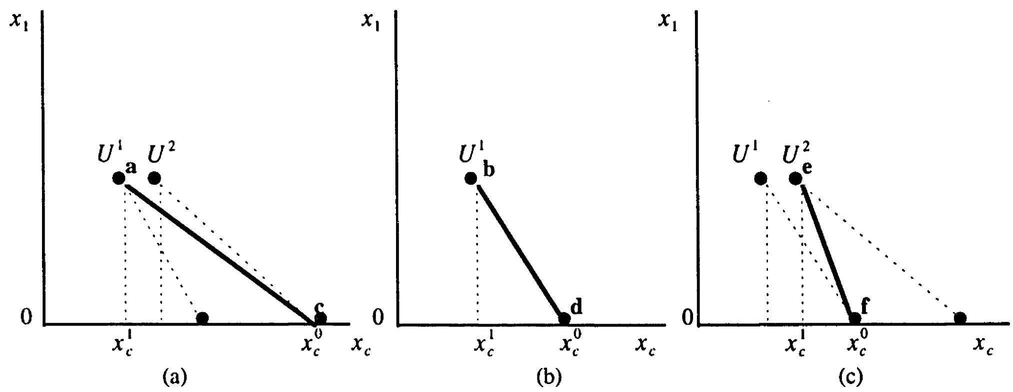
(ii) Rate of substitution equals the rate of exchange

This is represented in figure 3.2(b) in which the budget line **bd** has the same slope as the indifference schedule. In this case, the actual price equals the critical price ($p_1^* = p_1^0$).

(iii) Rate of substitution is less than the rate of exchange

This is represented in figure 3.2(c) in which the budget line **ef** attains its highest utility at the corner solution (x_c^1,1) on U^2. In this case, $p_1^* > p_1^0$.

Figure 3.2. Three prices for a binary good



3.4 Demand for Binary Goods

3.4.1 Marshallian Demand

The Marshallian demand for a binary good can be derived from:

$$\begin{aligned} &\max U(x_c, x_1) \\ &s.t \quad x_c + p_1 x_1 = y \end{aligned} \qquad (3.3.)$$

where x_1 =0,1. Mäler (1974) has shown that the demand functions have a simple form:

$$x_c(p_1, y) = \begin{cases} y - p_1 & \text{if } p_1 \le p_1^* \\ y & \text{if } p_1 > p_1^* \end{cases} \qquad (3.4.)$$

$$x_1(p_1, y) = \begin{cases} 1 & \text{if } p_1 \le p_1^* \\ 0 & \text{if } p_1 > p_1^* \end{cases}$$

If $p_1 = 0$, then the consumer is able to purchase x_1 as well as consume all of x_c. As the price rises, the consumer continues to consume x_1, but reduces her consumption of x_c. At the critical price (p_1^*), the consumer ceases to purchase x_1. Above the critical price, the consumer will only consume x_c.

3.4.2 Hicksian Demand

The Hicksian or compensated demand function is derived using the expenditure function that is obtained as a solution to the problem:

$$\begin{aligned} &\min x_c + p_1 x_1 = y \\ &s.t. \quad U(x_c, x_1) \geq \overline{U} \end{aligned} \qquad (3.5.)$$

where $\overline{U}$ is a given level of utility. The utility is usually fixed at that level associated with the initial or final prices. Consider the following price changes:

(i) Price changes above the critical price

This case is trivial as the price change has no effect on the individual. The binary good is not purchased and all income is spent on the composite good x_c.

(ii) Price changes below the critical price

The price change has no effect on the individual's consumption of the binary good, with a unit of the good being purchased regardless of the price change. However, the quantity of the composite good consumed is affected because the price change affects the amount of income y-p_1 available for purchase of x_c.

(iii)Price changes encompassing the critical price

(a) The case of a price fall

If the initial price p_1^0 is greater than the Hicksian critical price ($p_1^{\#}$), then the consumer's utility level is $U^1 = U(y,0)$. The consumption of the binary good is unaffected until price falls to the critical price, at which point $U(y,0) = U(y - p_1^{\#},1)$. Further reductions in price below the critical price will require a compensating reduction in income such that the individual's utility is maintained at that level.

For any further price falls, the consumer will be maintained at the same level of utility $U(y - p_1^{\#},1)$. Hence, the Hicksian demand can be summarised as follows:

$$x_c = \begin{cases} y - p_1^{\#} & \text{if } p_1 \leq p_1^{\#} \\ y & \text{if } p_1 > p_1^{\#} \end{cases}$$

(3.6.)

$$x_1 = \begin{cases} 1 & \text{if } p_1 \leq p_1^{\#} \\ 0 & \text{if } p_1 > p_1^{\#} \end{cases}$$

The expenditure functions also take on a simple form. There will be two expenditure functions, conditional on x_1=0 and x_1=1:

$$e(p_1,U^2) = \left\{ \begin{matrix} e^0 = y & \text{if} \quad p_1 > p_1^{\#} \\ e^1 = y - p_1^{\#} + p_1 & \text{if} \quad p_1 \leq p_1^{\#} \end{matrix} \right\} \qquad (3.7.)$$

The relationship between the Marshallian and the Hicksian critical prices must be considered. Specifically, is it the case that $p_1^* = p_1^{\#}$? For a price fall this will be so because, in deriving the Hicksian demand function, a compensating change in income will not be required for price falls above the critical price. Hence, the individual's utility remains at *U(y,0)*. The critical price at which the consumer is indifferent between consuming or not consuming x_1 will be the same in both the Marshallian and Hicksian frameworks.

The compensating change in income required in the Hicksian framework for a fall in price from p_1^0 to p_1^1 is illustrated by the shaded area in figure 3.3(a) above p_1^1 and below $p_1^{\#}$. This is also illustrated in terms of the associated expenditure function in figure 3.3(b). For prices above $p_1^{\#}$, the minimum expenditure required to obtain the initial utility level ($U^1 = U(y,0)$) is e^0 denoted by **cb**. As the price falls below $p_1^{\#}$, e^1 falls by an equivalent amount, because the compensating reduction in income is required to equal ($p_1^{\#}$ - p_1^1). This expenditure function is denoted by **ab**.

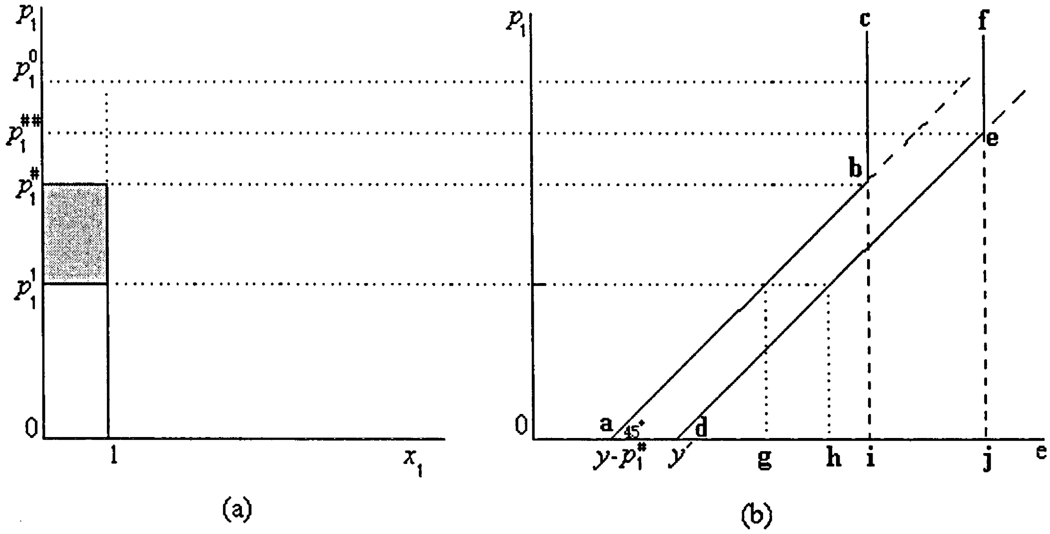
(b) The case of a price rise.

In the case of a price rise from below the critical price, the consumer will require a compensating increase in income as the price rises. In particular, we now consider the case where the consumer's initial position is at the lower price p_1^1 and the price rises above the Marshallian critical price p_1^* to p_1^0. The consumer's initial level of utility is now ($U^2 = U(y - p_1^1, 1)$) and the Hicksian critical price will be that which yields $U(y - p_1^1, 1) = U(y' - p_1^{\#\#}, 1) = U(y', 0)$, where y' is money income after compensation ($y' = y + p_1^{\#\#} - p_1^1$). The individual's final utility level after the price rise will be greater than that for the Marshallian case. Section 3.5 provides an intuitive explanation of why $p_1^{\#\#} > p_1^{\#}$ (i.e. why the Hicksian critical price is higher than in the case of a price fall (see figure 3.3(a)). The new expenditure functions associated with the price rise are:

$$e(p_1, U^2) = \begin{Bmatrix} e^2 = y + p_1^{\#\#} - p_1^1 & \text{if } p_1 > p_1^{\#\#} \\ e^3 = y - p_1^1 + p_1 & \text{if } p_1 \leq p_1^{\#\#} \end{Bmatrix} \qquad (3.8.)$$

These expenditure functions are also illustrated in figure 3.3(b). Above $p_1^{\#\#}$ the e^2 is denoted by **fe** and in the range from p_1^1 to $p_1^{\#\#}$ expenditure function must rise to compensate for the higher price. Over this range e^3 is denoted by **de**.

Figure 3.3. The demand and expenditure functions for a binary good



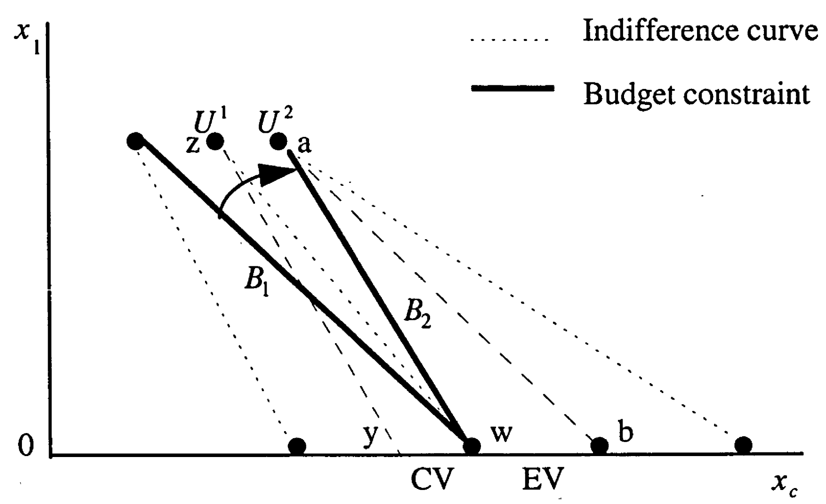
3.5 Welfare measures for binary goods

In the case of a price fall, the CV can be measured either as the area under the Hicksian demand curve ($p_1^{\#} - p_1^1$) or as the difference between the two conditional expenditure functions e^0 and e^1 at the initial and final prices represented by the interval **gi** on the x-axis. In the case of a price rise, the CV will be ($p_1^{\#\#} - p_1^1$) or the differences in the conditional expenditure functions e^2 and e^3 represented by the interval **hj** on the x-axis. The question of why $p_1^{\#\#} > p_1^{\#}$ remains. One way to explain intuitively the rise in the critical price is to use the indifference curves presented in section 3.3.3.

(i)The case of a price fall

The case of a price fall for a binary good is illustrated in figure 3.4, where the consumer faces an initial price p_1^0, which is above the critical price p_1^*. At the initial price the budget line B_1 will have slope of $\frac{1}{p_1^0}$ and the consumer attains her highest utility at **w** on U^1. To illustrate the effects of a price fall, the budget line will rotate clockwise past point **z**, when p_1^0 falls below p_1^*, to a new budget line B_2 associated with the final price p_1^1. This price fall raises the consumer onto a higher indifference curve (U^2) and results in her purchasing x_1. The CV associated with the price fall is graphically illustrated by shifting the budget line B_2, associated with the final prices, back to the point where it touches the initial level of utility denoted by indifference curve U^1 (this is illustrated by the dashed line **zy**). The CV is represented by **yw**, that is the distance between this line and the original endowment of x_c as illustrated on the x-axis. In this special case, CV is equal to the Marshallian consumer surplus(CS). The equivalent variation (EV) is derived by shifting the initial budget line B_1 forward until it touches the final level of utility U^2 illustrated by the line **ab**. The EV is equal to the interval **wb** on the x-axis. Clearly, EV is greater than the CV and the CS.

Figure 3.4. The welfare effects of a price fall



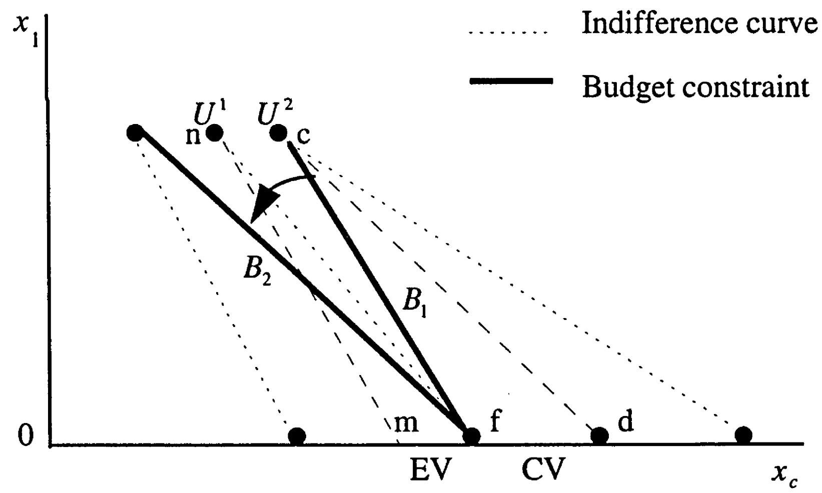
The case of a price rise

The reverse case, that of a price rise, is illustrated in figure 3.5 where the initial price p_1^1 is below the critical price p_1^* The initial price p_1^1 is represented by the budget line

B_1 which just touches U^2. As p_1 increases, the budget line rotates anti-clockwise. The individual will continue to consume x_1 until the price reaches the critical price p_1^*, associated with indifference curve U^1. If the price rises above p_1^* the consumer will remain on U^1, by forgoing any of x_1.

To derive the CV, the budget line B_2 must be shifted back to the point where it just touches the initial level of utility U^2. This is represented by the line **cd**. The compensation maintains the consumer on a higher level of utility and this increases the critical price of the good (i.e. the marginal rate of substitution). The CV is given by the interval **fd** on the x-axis. The EV is estimated by shifting the initial budget line B_1 until it just touches the final level of utility U^1 illustrated by the line **mn.** The EV is given by the interval **mf** on the x-axis.

Figure 3.5. The welfare effects of price rise



It is clear from figure 3.5 that the Hicksian demand associated with the initial level of utility is greater than the Marshallian demand in the case of a *price rise*, and hence the observed CS will underestimate the welfare benefits. In contrast, the Hicksian and Marshallian demand curves are the same in the case of a price fall and so the CV can be estimated directly from the observed demand curve.

3.6 Indivisible goods in general

3.6.1 Demand for indivisible goods

In the more general case, the discrete nature of indivisible goods means that the demand curve is stepped rather than a continuous curve. The demand curve for an indivisible good (x_3) is illustrated in figure 3.6(a) below. The Hicksian and Marshallian demand is constant over discrete ranges with price jumps at the endpoints of these ranges (Hellerstein and Mendelsohn 1993, p.605). The Hicksian and Marshallian critical prices are equal only for the first unit demanded. For subsequent units, price changes will either induce: (i) changes in income, in the intra-marginal case; or (ii) changes in quantity in the inter-marginal case. Both of these will require compensation in order to maintain the consumer at a constant level of utility. The expenditure function (**abc**) associated with the initial level of utility is illustrated in figure 3.6(b); it has a constant slope equal to the level of Hicksian demand.[6]

Figure 3.6(a) illustrates the demand for an indivisible good (q=2). The Marshallian demand is represented by the unbroken line at the critical prices p_3^* and p_3^{**}. Suppose the price changes from p_3^0 to zero, and as a result utility changes from U^1 to U^2. The price fall can be divided into two parts. For the initial price fall from p_3^0 to p_3^*, the consumer's income does not change, because she is not consuming the good. Beyond p_3^*, the reduction in price increases the consumer's utility (i.e. her real income). However, unlike the divisible case, increases in quantity occur only at discrete points along the demand curve. The increase in utility also raises the Marshallian critical price above the Hicksian critical price for the second unit ($p_3^{**} >$ $p_3^{/}$).

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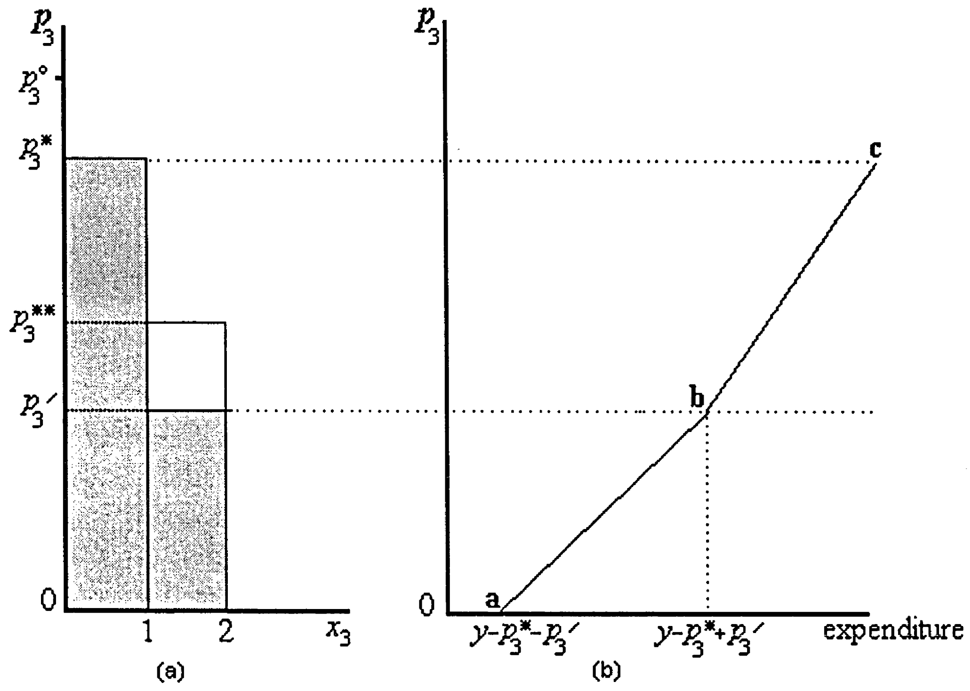
[6]This is ensured by Shephard's Lemma.

Figure 3.6. The demand and the expenditure functions for an indivisible good



3.6.2 Welfare measures for indivisible goods

The CV associated with the price reduction from P_1^0 to zero is the area under the two Hicksian critical prices (shaded area in figure 3.6.). The Marshallian CS is normally used to approximate the CV. Willig's method can be used to derive the CV and EV from the CS in the divisible good case (Willig 1976). However, this method cannot be applied directly to indivisible goods, because quantity changes occur only at discrete points along the demand schedule. Randall and Stoll (1980) have extended Willig's method from price to commodity space.

Willig's method involves estimating CV and EV by estimating the observed CS and adjusting for the income effects associated with the price change. These income effects are quantified using the income elasticity of demand. Given the exogenous nature of quantity adjustment in the indivisible goods case, the CS must be estimated by integrating not over prices, but over quantities, because income changes affect the critical price not the quantity purchased. In order to quantify these price changes, Randall and Stoll (1980) define a "relative price flexibility of income" parameter:

$$\zeta = (\partial P_1 / \partial y)(y / P_1) \quad (3.9.)$$

This represents the degree to which the critical price will change as income changes. Using Eq. (3.9.) and the procedures outlined in Willig's original paper, Randall and Stoll's bounds for CV and EV are:

$$\frac{CV - CS}{CV} \cong \frac{\zeta CS}{2Y^0} \text{ and } \frac{CS - EV}{EV} \cong \frac{\zeta CS}{2Y^0} \quad (3.10.)$$

which implies,

$$CV \cong CS - \frac{\zeta CS^2}{2Y^0} \text{ and } EV \cong CS + \frac{\zeta CS^2}{2Y^0} \quad (3.11.)$$

where, y is the initial level of income.[7] Clearly, the size of the error bounds depend on the magnitude of ζ. Randall and Stoll (1980) suggest that in the case of indivisible goods that are "especially treasured", ζ is large, leading to a divergence between EV, CV and CS. Hanemann (1991) has extended this work, arguing the magnitude of ζ depends on the availability of substitutes. If the good has few or no substitutes (such as one's own health) then ζ will be very large, suggesting that CS is a poor approximation of EV or CV.

3.7 Empirical estimation of the demand for indivisible goods using econometric models

The welfare measures in sections 3.5 and 3.6 are derived within a deterministic framework. They must be reformulated in probabilistic terms if empirical estimates are to be obtained. A variety of techniques have been developed for this purpose, including random utility models and count data models such as Poisson regression. These are briefly reviewed in the following two sections.

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[7]Randall and Stoll (1980) also derive "exact" bounds, after relaxing the assumption of constant elasticity. This relaxation is unnecessary in the indivisible case, because the price flexibility of income will be constant for each quantity change.

3.7.1 Modelling binary choice using random utility models

A *random utility model* involves specifying a utility function to represent the choices available to an individual. The underlying assumption is that an individual knows her utility function with certainty, but it is unobservable to the investigator. This introduces randomness into the model and so the individual's choice is modelled in a probabilistic fashion. The statistical properties of the model depend on assumptions made about the random component of the model (Hanemann 1984).

The general functional form of the random utility model for each individual is illustrated in Fry et. al. (1993):

$$\begin{aligned} u_j^i(z_j^i, s^i) &= W_j^i(z_j^i, s^i) + \varepsilon_j^i \\ &= \alpha_j z_j^i + \beta_j s^i + \varepsilon_j^i \end{aligned} \qquad (3.12.)$$

where $u_j^i(z_j^i, s^i)$ is the conditional utility function of consumer *i* for good *j* which is divided into a deterministic component W_j^i and a random element ε_j^i. The deterministic component represents the expected utility gained from each alternative. Eq. (3.12.) is divided into: a vector of characteristics associated each alternative (z_j); the individual's income y_j^i; and a vector of other characteristics of the individual(s^i). We define the first alternative (*j*=0) as "no choice" option (i.e. y_0^i equals the individual's full income because she does not consume good *j*). The remaining alternatives 1..*r* represent different goods. By definition $p_j \equiv y_j^i - y_o^i$.

The exact formulation of the random utility model depends on the type of binary good that is being modelled. At one extreme, the good under evaluation could be *unique* in that it has no substitutes. In this case there are only two alternatives ($z_0 = 0; z_1 = 1$):

$$\begin{aligned} &W_1^i(s^i) + \varepsilon_1^i \geq W_0^i(s^i) + \varepsilon_0^i \\ &\beta_1 s^i - \beta_0 s^i \geq \varepsilon_0^i - \varepsilon_1^i \end{aligned} \qquad (3.13.)$$

By assuming a joint probability function for $\varepsilon_0 - \varepsilon_1$ the decisions can be reformulated in probabilistic terms:

$$\pi_1^i = \Pr[\varepsilon_0^i - \varepsilon_1^i < W_1^i(1, y_1^i, S^i) - W_0^i(0, y_0^i, S^i)] \tag{3.14.}$$

where π_1^i is the probability of an individual choosing good x_1 given her income and other characteristics. The errors are commonly assumed to conform to either the normal or the extreme value distribution. The former leads to the binary probit model:

$$\pi_1^i = \Phi(W_1^i(1, y_1^i, S^i) - W_0^i(0, y_0^i, S^i))$$
$$\pi_0^i = 1 - \pi_1^i$$

and the latter results in a logit model:

$$\pi_1^i = \frac{e^{(W_1^i(1, y_1^i, S^i) - W_0^i(0, y_0^i, S^i))}}{(1 + e^{(W_1^i(1, y_1^i, S^i) - W_0^i(0, y_0^i, S^i))})}$$
$$\pi_0^i = 1 - \pi_1^i \tag{3.15.}$$

Obviously, not all goods are unique and so the random utility model must be extended into a muti-choice framework when an individual must not only decide whether to consume the good, but which good to consume.

3.7.2 Multi-choice models

The random utility model can accommodate multiple choices by including relevant characteristics (z_j) on each of the alternatives. For example, if the individual had to choose between two cancer tests that have a different sensitivity or specificity, these could be represented as attributes in z_j (see chapter four).

If the individual i faces r alternatives, the probability that first alternative is chosen is:

$$\pi_1^i = \Pr\left[W_1^i(z_1, y_1^i, s^i) + \varepsilon_1^i \geq \max_{j=0,2,\ldots,r} W_j^i(z_j, y_j^i, S^i) + \varepsilon_j^i \right]$$

To formulate such a model one must define a universal choice set representing all the *distinct* choices within the commodity group that are available to the population in question. In cases where this set is very large, a randomly drawn opportunity set can be used in order to facilitate the estimation of the model (Parsons and Kealy, 1992).

As in the binary choice case, this model is made operational by assuming an appropriate distribution for the error term. Although in theory both the probit and logit models can be extended into a multi-choice framework, the multinomial probit model is rarely used, because it requires the evaluation of a multi-dimensional integral of the normal distribution which has, until recently, imposed an insurmountable computational burden, precluding its use in applied work. Instead logit models have been developed for many multi-choice applications, because they are computationally much simpler than the mulitnomial probit model. One of the first was McFadden (1973) conditional logit model that assumed the disturbances were independent and identically distributed (iid) with a Weibull distribution. Although this assumption greatly simplifies estimation, it imposes an important restriction on preferences in the form of the independence of irrelevant alternatives (IIA). This implies the odds ratio between two alternatives is independent of any alterations in the choice set (Fry et. al. 1993). This means that introducing a new alternative leaves the relative odds of choosing an existing alternative unaltered. A partial solution to the IIA problem is to assume the errors distributed according to the generalised extreme value distribution and alternatives are grouped so that alternatives can be correlated within, but not between groups. These models are classed as nested logit models (Kling and Thomson 1996).

A special case of the multi-choice framework is when the different alternatives are perfect substitutes. In particular, if a particular group of goods have characteristics in the same proportions they are *intrinsic perfect substitutes* (Lancaster 1966) There are many medical examples of perfect substitutes—for example, a patented drug and its generic alternative. When modelling the demand for these goods, differences within the group can be disregarded so the consumption decision can be modelled using Eq. (3.13).

3.7.3 Welfare measures for a change in the price of a binary good

In order to estimate the welfare benefits, a sample of n individuals (i=1..n) must be randomly drawn from a population (consisting of N individuals). The estimated probability π_1^i for each individual in the sample may be used to forecast the population's demand by assuming each individual in the sample represents of a group of θ individuals (where $\theta = \frac{N}{n}$) in the population who share the same characteristics. The probability π_1^i can be interpreted as the proportion of the ith group that chooses the first alternative.

Consider a price change in the binary good x_1 from p_1^0 to p_1^f. The simplest case is a homogeneous binary good, because the characteristics z_j can be ignored. Assuming errors conform to a normal distribution Small and Rosen (1981) derive the CV:

$$CV_p^i = -\frac{1}{\lambda^i}\int_{\omega_1^0}^{\omega_1^f} \Phi(W_1^i - W_0^i)dW_1 \qquad (3.16.)$$

where $\omega_1^0 = W_1^i(z_1, \tilde{y}_1^i, S^i) - W_0^i(z_0, y_0^i, S^i)$; $\omega_1^f = W_1^i(z_1, \hat{y}_1^i, S^i) - W_0^i(z_0, y_0^i, S^i)$; $\tilde{y}_1^i = y_0^i - p_1^0$; $\hat{y}_1^i = y_0^i - p_1^f$ and λ^i is the marginal utility of income. It is important to note that the CV_p^i provides a measure of *individual* welfare change. This must be multiplied by θ in order to estimate the CV associated with each of the n groups in the population.

The aggregate CV will be:

$$\sum CV = \sum_{i=1}^{n} \theta CV_p^i \qquad (3.17.)$$

3.7.4 Modelling indivisible goods in general

For indivisible goods, a probability distribution defined over non-negative integers is required. One distribution commonly used is the Poisson, in which the probability density function is defined as:

$$\text{prob}(Q = m) = \frac{e^{-\omega^i} \varpi^i}{m!} \qquad (3.18.)$$

where Q is a potential integer outcome (m=1..q) and ω^i, a parameter of the Poisson distribution is equal to the mean. The functional form of ω^i is typically assumed to be:

$$\omega^i = e^{\beta S^i} \qquad (3.19.)$$

The estimated function in Eq. (3.19.) gives the probability of the individual consuming each quantity. This can be used to calculate the expected quantity consumed at each price. Issues surrounding welfare measurement using count data models are explored in Hellerstein and Mendelsohn (1993) and Haab and McConnell (1996).

3.8 Summary and conclusions

Indivisibility arises either because goods must be exchanged in discrete quantities or because consumers derive utility only from the consumption of discrete quantities of a good. To distinguish between these two types of indivisibility, the former is referred to as *indivisibility in exchange* and the latter as *indivisibility in preferences.*

Sections 3.3 to 3.6 examine goods which are indivisible in preferences. Many health care goods display this characteristic, especially those that involve the patient acquiring information on their health care status (such as medical screening). The most extreme form of indivisibility is a "binary good" which is a good that is purchased in only one quantity. In section 3.4, the Marshallian and Hicksian demand functions for binary goods were derived. These curves take on a simple form in which there is a critical price at which the consumer ceases to purchase the good.

The relationship between the Hicksian and Marshallian critical price is then explored. Interestingly, when the price falls from above to below the critical price, the Marshallian and Hicksian critical prices are equal, with the utility in the Hicksian case being maintained at the level associated with the critical price. However, when the price rises from below to above the critical price, the Hicksian critical price itself will increase and hence be greater than the Marshallian critical price. This has important implications for welfare measures, most notably that the CV equals the CS in the case of a price fall, but not a price rise. These findings are in line with Willig's clarification of Mäler's results. In section 3.5 this asymmetry is shown to rely on the assumption that the indifference schedules are strictly convex.

Section 3.6 is then devoted to a discussion of indivisible goods in general. Section 3.7 examines the statistical modelling of binary and indivisible goods. In the binary good case it is appropriate to use a random utility model. The exact form of this model depends the binary good's relationship with other goods. If the binary good is unique then it can be modelled using a binary choice regression model. However, if the good has substitutes then each of these should be included in the individual's choice set and a multinomial regression model should be used. A special case is when multiple goods are perfect substitutes, in which case a binary choice framework is again appropriate. Finally, the more general case of modelling the consumption of indivisible goods using Poisson regression is briefly examined.

Chapter 4

Estimating the benefits of mammographic screening

> Numerous issues related to screening appear tractable to economic analysis... At a minimum, some metric that makes health states and various kinds of unhealthy states commensurate is required.
> (Victor Fuchs and Joseph Newhouse 1978, p.15)

4.1 Introduction

In Australia, Western Europe and North America, breast cancer is a leading cause of death in women, particularly for those aged between 50 and 70 years. Despite extensive research, the causes of breast cancer remain largely unknown providing little scope to prevent the disease. Consequently, emphasis has been placed on its early detection and treatment. Most developed countries have implemented breast cancer screening programs in recent years.

Breast cancer screening, unlike other types of health care, does not prevent or cure the disease but provides information that enables it to be detected at an earlier stage of development than would otherwise be the case. The rationale for screening is that early detection improves an individual's probability of survival over a given time period and lowers morbidity from the disease. The most common test for detecting breast cancer in asymptotic women is a screening mammogram, which involves taking an x-ray of the breast tissue.

The purpose of this chapter is provide a backdrop for the empirical analysis undertaken in subsequent chapters, which focuses on valuing mobile mammographic screening units. A broader perspective is taken here in order to place this work in context. The next section provides a brief outline of the structure of the Australia's mammographic screening program. Section 4.3 is concerned with the value of a mammogram. It establishes that screening tests produce multiple outputs and that those outputs are subject to uncertainty. Welfare measures that take this uncertainty into account are then derived. Section 4.4 returns to the household production model (HPM) and examines what modifications are required to model the demand for mammographic screening. The final section provides a summary and conclusions.

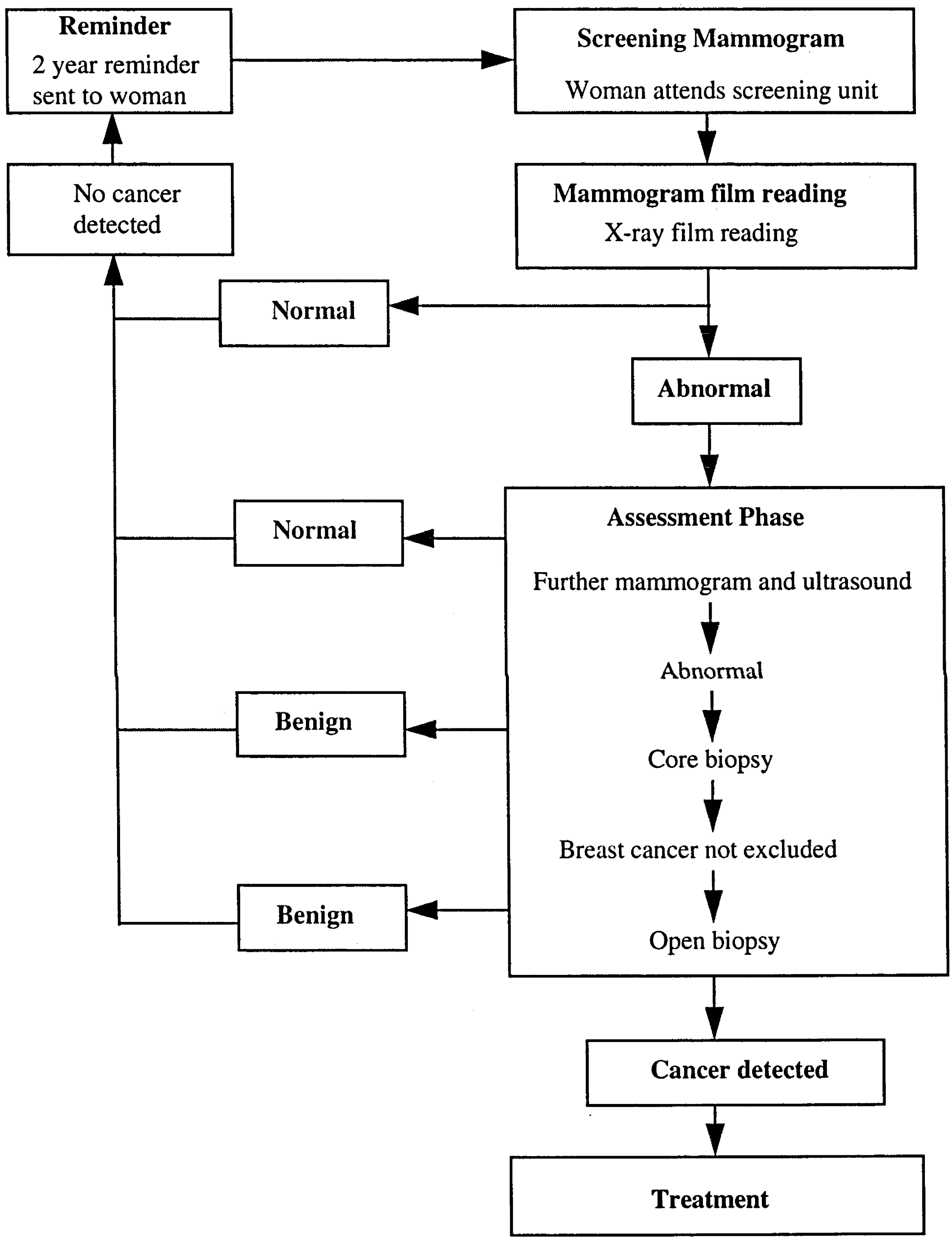
4.2 Background

Instead of relying on opportunistic screening[1], many countries have established organised programs targeted at all women within a certain age range. These programs involve an integrated process of screening and assessment. The screening and assessment pathway for Australia's *National Program for the Early Detection of Breast Cancer (NPEDBC)* is illustrated in figure 4.1. The entry point for this pathway is a screening mammogram which can return one of two possible results: (i) *abnormal*—in which case there is a suspicion of cancer; or (ii) *normal*—no cancer detected. Only women with abnormal test results enter the assessment phase of the program. Evidence from clinical trials suggests that approximately five per cent of tests produce abnormal results (Wright and Mueller 1995, p.31). In the assessment phase, women are recalled for a second mammogram and other diagnostic tests, such as an ultrasound or fine needle aspiration. If the diagnosis is still inconclusive, a more invasive open biopsy is used. Fewer than two per cent of women screened normally receive an open biopsy (NPEDBC 1994). Ultimately, between 0.5 per cent and 0.8 per cent of women screened have breast cancer (AHMAC 1990 p.56). The two endpoints for the pathway are the detection of cancer, which leads to a treatment stage or the patient is clear, in which case she should return to be re-screened in two years.

Women do not gain health benefits from the initial screening test. In order to reduce their risk of mortality from breast cancer they must proceed through the entire screening and assessment pathway and, if necessary, undertake treatment.

[1] Opportunistic screening is carried out when women present for other health matters or screening undertaken "on demand" outside a planned system of invitation or recruitment (Hussain ,1990).

Figure 4.1. The screening an assessment pathway for the early detection of breast cancer



Source: NSW Program for Mammographic Screening, Ryan (1991).

4.3 Valuing mammographic screening

Mammographic screening has been the subject of extensive economic evaluation in the last few years. Almost all of this work has involved applying either cost-effectiveness analysis (e.g. Carter et. al. 1993; Fraser and Clarke 1992) or cost-utility analysis (e.g. Hall et. al. 1992) to determine the most efficient strategies for conducting breast cancer screening. These methods focus exclusively on the health benefits of screening and overlook other benefits such as the information the test provides on cancer status (Gerard et. al. 1992). Quite apart from the health benefits, the accuracy of a mammogram could be of value, because a screening test has the capacity to reassure or generate anxiety in a patient depending on its outcome. Although these benefits (or costs) might be small relative to the health benefits of screening, it affects a much greater proportion of the screened population (Phelps 1978). Unfortunately it is difficult to incorporate such outcomes into cost-effectiveness analysis, because of the unidimensional nature of the benefits (i.e. life years saved).

Another limitation of this approach is that it only provides a ranking of different options and as such cannot be used to evaluate whether the benefits of screening outweigh the costs. Fuchs and Newhouse (1978, p.15) propose a different approach:

> Clearly one must establish the value of various states of health... To treat fully the economics of screening requires a monetary valuation of different states of the world (only then can the benefits be compared with the monetary costs of screening).

The next section takes up this suggestion by deriving money measures of the benefits of mammographic screening.

4.3.1 The outcomes of a mammogram

The results of a mammogram can be classified into one of four possible states: *true positive (TP)* when screening correctly indicates the woman has breast cancer; *false positive (FP)*, when screening returns an abnormal result, but the woman does not have breast cancer; *true negative (TN)* when the result is normal and the woman does not have cancer; *false negative*

(FN) when cancer is not detected, but the woman has cancer. These represent four mutually exclusive outcomes of any screening test. The consequences of ending up in each of these states is described below:

(a) True positives

The primary purpose of a screening mammogram is to detect breast cancer in asymptotic women as a means of reducing deaths from the disease. The efficacy of mammographic screening has been extensively researched, with at least eight major randomized controlled trials conducted in the last 30 years (Hurley and Kaldor 1992). Although not all trials have produced significant positive results, a recent meta-analysis of five international trials found a combined reduction of 37 per cent (95 per cent C.I. 21 per cent to 49 per cent) in breast cancer mortality for women aged more than 50 years (Glasziou 1992). In contrast, there is no clinical evidence to suggest that screening women aged less than 50 years reduces breast cancer mortality (Elwood, Cox and Richardson 1993; Glasziou, Woodward and Mahon 1995).

Mammographic screening can also reduce morbidity by facilitating the use of less invasive treatments. The range of treatment options available to women with breast cancer has increased dramatically in the last 20 years. The main choice is between a *mastectomy*, which involves the removal of the entire breast, and a *lumpectomy*, which removes the tumor while conserving most of the breast. Although there is no clinical evidence to suggest a difference in the rate of survival between these two methods, breast-conserving surgery can result in lower physical and psychological morbidity for many patients. Less radical surgery allows faster healing and physical recovery as well as maintaining a woman's post-treatment "body image" (Kattlove et. al. 1995). By detecting cancer at an earlier stage of development, mammographic screening has the potential to improve morbidity by giving women the option of using breast-conserving surgery (Hall et. al. 1992).

(b) True negative

Although the primary purpose of a mammogram is to reduce mortality and morbidity, it also provides women with information on their breast cancer status and thereby reduces uncertainty (Cairns and Shackley 1993). In this respect, information on cancer status can have a value independent of its capacity to influence subsequent health outcomes. A woman may value a "negative" result, because it reassures her that she is less likely to have breast cancer.

(c) False positive

For some women, a mammogram detects abnormalities which on further investigation are shown to be benign. For these women, the screening test has a negative outcome, because it leads to unnecessary further investigations and increased anxiety. Between 80 and 95 per cent of the women recalled for further assessment are diagnosed as not having breast cancer (Hurley and Kaldor 1992).

(d) False negatives

The most deleterious outcome is when the mammogram fails to detect a pre-existing cancer. In this case the test is of no benefit and could increase the risk to the patient if she delays seeking a diagnosis when symptoms ultimately develop (Forrest 1986).

Two measures commonly used to quantify the accuracy of a screening test are *sensitivity*, which is the proportion of correctly identified diseased persons, and *specificity*, which is the proportion of correctly identified disease-free persons (Cohen and Henderson 1988, p.76).[2]

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[2] Sensitivity= $\frac{TP}{TP + FN}$ Specificity= $\frac{TN}{TN + FP}$

4.3.2 The value of a mammogram

If a woman decides to have a mammogram she cannot know which the of four states (TP,TN,FP,FN) the test result will produce. In this respect, the decision is made in a risky world and is influenced by the probability and consequences of experiencing each of four states outlined above. The welfare measures derived in chapter two must be modified to take the probabilistic nature of these outcomes into account. The framework adopted here assumes that health care decisions are subject to "risk" not genuine uncertainty (Shackle 1961, p.60). That is, the future can be described by a discrete number of alternative states of the world and the probability of each state occurring can be measured.

The previous section focused on the four clinical outcomes of a screening test. Mammographic screening might also have financial consequences for the patient or third parties, such as insurance companies or the government. These may be positive or negative depending on the outcome of the test. True positives can result in cost savings if early detection leads to less-costly treatment. False positives generate additional unnecessary costs in the form of further diagnostic tests. In order to separate the health and financial consequences of screening, the discussion is divided into two parts. The first part examines money measures of the value of a screening test without reference to the cost of the different states. Financing considerations are then addressed in the second part.

(i) Valuing the health outcomes of screening

For simplicity, we assume that the outcomes of screening can be represented by the four previously defined states. Since the individual does not know which of these states the screening test will produce, she must base her decision on a comparison of the expected utility from having a mammogram with a reference utility of not being screened.

The welfare measures derived in chapter two are appropriate for a certain world where there is no risk associated with outcomes. Ordinal utility was sufficient to derive welfare measures. In a risky world, stronger assumptions are required, most notably that the individual is assumed to be able to assign cardinal utilities to each of the future states of the world. In the two previous chapters, the compensating variation (CV) and the equivalent variation (EV) were defined in terms of the expenditure function. It is appropriate at this stage to introduce the indirect utility function which provides another means of defining welfare change.

An individual's indirect utility function can obtained by substituting the demand functions back into the utility function. Recall from chapter two that utility within a two-commodity household production model was a function of health (H_t) and another commodity function (Z_t). These in turn were produced by market and non-market goods (i.e. $H_t = f^H(X^H); Z_t = f^Z(X^Z)$). In this case the indirect utility function is derived by substituting the input demand functions into their respective production functions and substituting the production functions into $U_C(H_t, Z_t)$. For simplicity, assume there are just two goods: a health care good x_1; and a good x_c that produces Z_t. The indirect utility function is then:

$$V(p_1, p_c, y) = U[f(m^1(p_1, p_c, y), f(m^2(p_1, p_c, y)] \qquad (4.1.)$$

To introduce risk into the HPM it is assumed that δ, the rate at which health depreciates each period, is stochastic so next period's health is not known with certainty ($H^S_{t+1} = H^S_t - \delta H^S_t$). Next periods stock of health (H^S_{t+1}) can now be viewed as stochastic and can be defined in terms of the number of possible states of the world. If a woman has a mammogram it would seem sensible to define these future states in terms of the four potential outcomes discussed in the previous section. If a mammogram produces a true positive outcome, then denote the indirect utility associated with this state as $V_{TP} = V(y \ , H^{TP}_{t+1})$, where y is a fixed income and H^{TP}_{t+1} is the health state associated with a true positive (the price of private goods has been suppressed). Similarly, denote the utilities associated with the other outcomes of screening as V_{TN}, V_{FP}, V_{FN}. Simpson, Chamberlain and Gravelle (1978) suggest that $V_{TP} > V_{TN} > V_{FP} > V_{FN}$ with the later two being negative. Such a ranking is plausible if one considers the consequences of ending up in each state outlined in the previous section. The greatest utility is likely to be associated with a true positive outcome since it reduces the risk of mortality and morbidity through earlier treatment. A true negative will also be of benefit because it reassures a woman she does not have cancer. A false positive is likely generate disutility because it leads to unnecessary further investigation and increased anxiety. However, the greatest disutility is likely to be associated with a false negative result, because the false test result may increase the risk of mortality from the disease. Assume also that the individual can assign a subjective probability to each outcome $\pi_{TP}, \pi_{TN}, \pi_{FP}, \pi_{FN}$. The expected utility of having a mammogram is defined as follows:

$$E_1[V] = \pi_{TP}V_{TP} + \pi_{TN}V_{TN} + \pi_{FP}V_{FP} + \pi_{FN}V_{FN} \qquad (4.2.)$$

where E is the expectations operator. In Eq. (4.2.), the utility from having a mammogram is a weighted average of the utility gained from each of the four possible outcomes.

Alternatively, if the individual does not have a mammogram then there are two possible states: either the individual has breast cancer in which case we denote the health state as H_{t+1}^{BC}; or she is free of the disease H_{t+1}^{NB}. If the associated utilities are V_{BC} and V_{NB}, the expected utility of not being screened is $E_0[V] = (\pi_{TP} + \pi_{FN})V_{BC} + (\pi_{TN} + \pi_{FP})V_{NB}$.

The change in expected utility brought about by having a mammogram is:

$$EU = E_1[V] - E_0[V] \qquad (4.3.)$$

If EU >0 the individual gains utility from being screened.

It is possible to derive a welfare measure based on the change in expected health status. The expected levels of health associated with having and not having a mammogram ($E_1[H_{t+1}^S]$ and $E_0[H_{t+1}^S]$ respectively) are given by:

$$E_1[H_{t+1}^S] = \pi_{TP}H_{t+1}^{TP} + \pi_{TN}H_{t+1}^{TN} + \pi_{FP}H_{t+1}^{FP} + \pi_{FN}H_{t+1}^{FN} \qquad (4.4.)$$

$$E_0[H^S_{t+1}] = (\pi_{TP} + \pi_{FN})H^{BC}_{t+1} + (\pi_{TN} + \pi_{FP})H^{NB}_{t+1} \quad (4.4a.)$$

Based on the change in expect health a measure of the value of a mammogram is:

$$V(y - B, E_1[H^S_{t+1}]) = V(y, E_0[H^S_{t+1}]) \quad (4.5.)$$

where B is the compensating variation. The resultant welfare measure is the additional payment (or compensation) for the change in the expected level of health. The amount B can be regarded as an individual's willingness to pay (WTP) for the expected change in health. This is not the only welfare measure that can be derived, Johansson (1995) suggests an alternative:

$$\pi_{TP}V(y - B^*, H^{TP}_{t+1}) + \pi_{TN}V(y - B^*, H^{TN}_{t+1}) + \pi_{FP}V(y - B^*, H^{FP}_{t+1}) + \pi_{FN}V(y - B^*, H^{FN}_{t+1}) = E_0[V]$$

(4.6.)

where B^* is the amount of money that she commits herself to paying regardless of the outcome of the screening test. If $E_1[V] > E_0[V]$ then B^*>0 and the amount can be regarded as a *non-contingent* CV.

Is it possible to also value individual health states (e.g. H^{TP}_{t+1} or H^{FN}_{t+1})? One possible welfare measure is the payment (or compensation) for a change in the expected level of health which results from a change in the sensitivity or specificity of the screening test. Consider the valuation of two screening tests with probabilities π^1_{TP} and π^2_{TP} in which the first test is more sensitive than the second (i.e. π^1_{TP} > π^2_{TP}). Substituting these probabilities into Eq. (4.4.) and denoting the expected health stock as $E_1(H^S_{t+1})$ and $E_1(\overline{H}^S_{t+1})$ respectively, the additional value of the first test over the second is:

$$V(y - B, E_1[H^S_{t+1}]) = V(y, E_1[\overline{H}^S_{t+1}]) \quad (4.7.)$$

Eq. (4.7.) suggests the value of a screening test depends on its accuracy and the consequences of having a true positive result relative to a false negative.[3]

How can these welfare measures be estimated in practice? The measure in Eq (4.6) should be reflected in revealed preferences for a mammogram since a woman must commit herself to "purchasing" it without knowing the result. Estimating the value of improved diagnostic accuracy (Eq (4.7.)) using revealed preference methods is more difficult, because there is often a limited range of screening tests available. The discussion on joint production outlined in chapter two is relevant to this issue, since it suggests the marginal valuation of these states requires there to be at least as many different inputs as there are outputs. This condition is rarely met in health care markets, because product quality is highly regulated to ensure a uniform standard. This means that there is likely to be little variation in the sensitivity and specificity of different screening tests. However, the existence of joint production does not preclude the use of stated preference methods (e.g. see Berwick and Weinstein 1985).

(ii) The impact of health financing arrangements on the value of screening

Up to this point, the influence of health financing arrangements on the demand for health care has only been considered briefly. In chapter two the "zero price" problem was raised. This section extends this discussion by considering the impact of health care financing on welfare measures when it alters the relative prices of other health care goods (e.g. substitutes or complements). For example, screening and the treatment of a condition once it has developed can be regarded as substitutes; hence, changes in the financing arrangements for treatment influence the demand for screening. Alternatively, assessment procedures such as the diagnostic tests undertaken after an abnormal result are complements to the screening test. These inter-relationships have two important implications for the valuation of mammographic screening.

Firstly, the welfare measures defined above dependent on the system of health financing and cannot be used in the evaluation of projects that are subject to different financing

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[3] Johansson (1995) defines a different welfare measure $\pi^1_{TP}V(y-B^*,H^{TP})=\pi^2_{TP}V(y,H^{TP})$ to quantify the gain from the

arrangements. Not only does this mean that the benefits of a screening program estimated in one country cannot be applied to another, but it also means that the program might need to be re-evaluated if health financing arrangements change.

Secondly, if third parties (e.g. health insurance companies or government) meet some or all of the costs of treatment (or assessment), the patient's marginal valuation will not reflect the true benefits (costs) of screening. As Phelps (1978, p195) notes:

> The effect of health insurance on such procedures is obvious: the costs to the patient of proceeding with subsequent medical procedures are smaller with insurance coverage. Hence the cost of a false positive is much lower to the patient than to society.

The implications for evaluation are also obvious since it means that an individual's WTP does not reflect the effect of their actions on third parties. However, this does not mean that women will always undervalue the benefits of screening since it is also possible a true positive result leads to earlier detection and this may save an insurer additional medical costs (Held and Pauly, 1990). Again these benefits are not be reflected in a the WTP for a screening mammogram.

How can these external benefits and costs be captured? This is not an easy question to answer and the exploration of this issue is beyond the scope of this thesis.[4] What can be said, is that benefits based on an individual's WTP cannot simply be aggregated with other benefits such as the cost savings from less invasive treatment that may accrue to an insurance company (or government). The reason being that an individual's WTP represents an *ex-ante* measure of welfare and cost savings are an *ex-post* measure. These cannot be combined unless several restrictive conditions are imposed.

4.4 The nature of the health production function

Having examined the valuation of a single screening test we briefly return to the HPM. A HPM of mammographic screening is illustrated in figure 4.2 and the various elements of the model are described below.

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increase in probability.

[4] Kenkel (1994, pp.48-52) provides a discussion of this issue and some useful pointers for further research in the area.

(i) Inputs

Under the household production framework, a mammogram can be viewed as an input that is combined with other market and non-market inputs (e.g. time and transport) to produce information on the individual's disease status. Under the national program, women aged between 50 and 69 years are advised to have a mammogram once every two years (NPEDBC 1994).

(ii) Outputs of mammographic screening

When the HPM is used as a pedagogical tool the health production function is normally assumed to be continuous, concave and a strictly increasing function of the quantity of health care inputs used (e.g. see Wagstaff 1986). However, there are several features of mammographic screening that alter the shape and form of the health production function. In particular, a screening test provides the patient with information on one aspect of her health status and can therefore be regarded as an indivisible good. As Doessel (1992) notes in reference to diagnostic tests in general: "the efficiency frontier consists of discrete points only and not lines joining points" (p.42). This means that women must choose to consume an integer number of mammograms and the demand and welfare theory outlined in the previous chapter applies here.

(iii) Nature of the demand for information

Mammographic screening is also likely to be subject to high diminishing marginal utility within the recommended screening interval of two years. This arises because the average sojourn time for breast cancer has been estimated to be 3.91 years for women aged 50–69 years (Paci and Duffy 1991)[5], which is almost twice the length of the recommended screening interval. Multiple *screening* tests within this interval are unlikely to detect new cancers and will only benefit patients that have been given a false negative reading on their

[5] Sojourn time is the length of time a woman spends in a pre-clinical, but a state that can be detected by a mammogram.

initial mammogram. Since the sensitivity is relatively high[6], and the incidence of breast cancer comparatively low, only a small proportion of the women whose initial screen is negative would benefit from having more than one mammogram within a two-year period. Against these benefits must be weighed the potential risk from additional exposure to radiation from a chest x-ray (Hurley and Kaldor 1992).

Two questions must be addressed before empirically estimating the demand for mammographic screening. Firstly one must determine the relevant time period over which to model demand. Secondly within the chosen interval are mammograms a binary or indivisible good? In regard to the former a sensible lower bound for the time is the current recommended screening interval of two years. If such a period is chosen a binary choice model is appropriate since most women are likely to demand only one mammogram. However, the question arises as to whether such a time period is too short, because women who use the service less frequently (e.g. once every three years) still benefit from having a mammogram. While these women will be in a random sample of the relevant population it is important to consider whether the time period chosen is representative of the underlying demand or if it is influenced by special factors such as a health promotion campaign. Such abnormal factors may mean there is high demand among these infrequent users in the period under study and so it is not representative of the underlying level of demand. If this occurs it is appropriate to model demand over a much longer period using either count data or a discrete choice panel data model.

[6] Glasziou Woodward and Mahon (1995) report the sensitivity for six major trials ranged from 68 to 88 per cent.

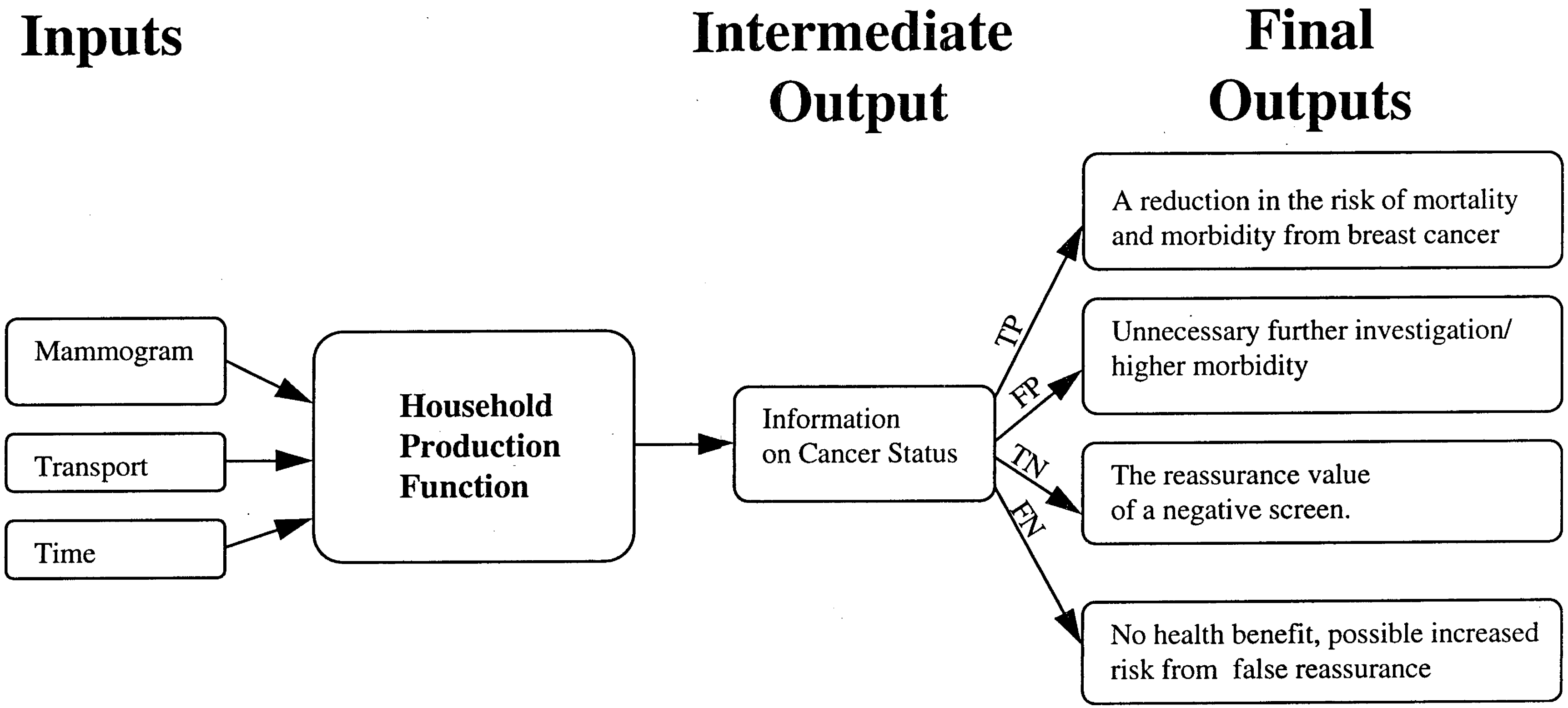

Figure 4.2. A household production model of mammographic screening

4.5 Summary

This chapter provides an overview of several interrelated issues that are relevant to the valuation of mammographic screening. First, the multiple outputs of screening in terms of the health benefits and information it provides are described in detail. Secondly, welfare measures to value those outputs are derived. These measures differ from those derived in chapter two in that they must account for the uncertainty surrounding the outcome of a screening test. Two different types of welfare measure were examined: a measure in which women must decide on the value of the test prior to knowing its outcome and a measure which values a change in the probability of achieving a specified outcome. Unlike the former, which can be measured by observing revealed preference for mammographic screening, the latter normally requires stated preference methods because the outcomes of screening are often subject to joint production. Section 4.4 discusses screening within the framework of a HPM, highlighting several aspects that are relevant to the empirical valuation of mammographic screening undertaken in chapter six.

Chapter 5

Using revealed preference methods to value health and health care

> The fact that a patient does not have to pay his GP for a consultation does not mean that consultations are costless to the patient. Visiting a surgery requires the patient to sacrifice time—travelling to and from the surgery, waiting to see the GP, and the time spent in the consultation itself... (If he travels to the surgery by car or by public transport, of if he has to take time off work, the consultation may also involve outlays of money).
> (Robert Sugden and Alan Williams 1978, p.149)

5.1. Introduction

Indirect or revealed preference methods are a class of techniques that have been developed to value non-market and unpriced goods. There has been a long tradition of using these methods in the valuation of the health benefits associated with improving the quality of the environment and the value of life, which is implied by the purchase of safety equipment. In contrast, there are very few studies that have directly valued health care goods.[1] After briefly reviewing the existing non-health care literature, this chapter concentrates on one approach that could be applied to many types of health care.

In this chapter the division between the valuation of health and health care is maintained. The first section provides some background to the methods that have been used to value changes in health risks due to improvements in the quality of the environment or through the purchase of safety equipment. This section provides several examples of recent studies that have used revealed preference methods to

[1] The lack of previous studies is highlighted in Johannesson (1996, p.73) which contains no health care applications of the revealed preference approach. His explanation is that it "is difficult to use the revealed preference approach to obtain a direct estimate of the value of health care programs, since health care is seldom bought directly on the market".

value changes in health and the value of a "statistical life".[2] Unfortunately, for reasons outlined at the end of section 5.3, it is difficult to use these values in the evaluation of health care.

A more promising revealed preference approach is the travel cost method (TCM) which is examined in detail in the remaining sections of the chapter. Section 5.4 provides an outline of the method. Section 5.5 examines how time can be valued in monetary terms. Section 5.6. provides an overview of the methods used in environmental economics and section 5.7 examines some practical issues relating to the conduct of travel cost surveys. Section 5.8 contains a summary and conclusions.

5.2 Using revealed preference to value health and statistical lives

5.2.1 Valuing the health effects from changes in environmental quality

Human health is known to be affected by exposure to pollution and toxic chemicals. For example, high levels of carbon monoxide, nitrogen dioxide, ozone or sulfur dioxide in the air have been shown to be associated with increased rates of mortality and morbidity (Chappie and Lave 1982). Since the 1950s, governments have introduced programs to improve the quality of the environment. In addition to aesthetic benefits, these programs have the capacity to improve human health. For this reason, there has been considerable research into the valuation of health benefits as a means of valuing the benefits of these programs.

Environmental health programs that reduce air pollution or remove toxic chemicals from river systems generate benefits that display the classic features of a public good: non-rivalry and non-excludability. Although these characteristics provide a justification for government intervention, they also make the evaluation of regulations designed to protect the environment difficult because organised markets in which environmental health risks are traded do not exist. The only way to value health benefits is to observe preferences for environmental quality using market

[2] There is also a large literature which estimates the value of life implied by wage-risk trade-off data in different occupations. Since this method has it foundations in hedonic price analysis (Braden Kolstad

goods whose consumption is in some way linked to an individual's exposure to environmental health risks.[3]

In order to measure the impact of the environment on health, a non-market "environmental quality" variable (denoted by α) can be added to the health production function (i.e. $H_t = f^H(X_t^H, \alpha)$). The simplest example of a linkage between private and non-market goods is where α and q_1^H are perfect substitutes. Here, the health production function takes on a linear form:

$$H_t = x_1^H + a\alpha \qquad (5.1.)$$

where a is the marginal rate at which x_1^H can be substituted for α in the production of health. Freeman (1985) has demonstrated that the marginal value (v) an individual places on a small change in α is equal to:

$$v = p_1 a \qquad (5.2.)$$

where p_1 is the price of x_1^H. Eq. (5.2.) illustrates how a one-unit increase in α (i.e. a reduction in exposure to health risks) results in a reduction of x_1^H by a providing there are no "income effects" associated with switching from the market to the non-market good. The value of the change is equal to the price of the market good multiplied by a the rate at which the market good can be substituted for α.[4]

The defensive expenditures approach has also been used to value changes in morbidity. Dickie and Gerking (1991) use this approach to value reductions in morbidity resulting from improvements in air quality. An important contribution of their study is the recognition that joint production imposes limitations on the number of commodities that can be valued (see chapter two). In order to quantify the morbidity associated with air pollution they identify key "symptoms" that afflict the exposed population. In many cases, exposure to environmental risks produces

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and Miltz 1992, p.10) rather than the HPM, it is not considered in this review.

[3] Cropper and Freeman (1991) provide an overview of this work.

multiple symptoms. For example, Dickie and Gerking list 26 symptoms associated with changes in air quality. This far exceeds the types of defensive expenditures that can be observed, resulting in joint production.

The main purpose of valuing morbidity and mortality is that it facilitates the evaluation of government policies that are designed to protect the environment. Cost-benefit analysis is often used to determine whether the health and other benefits outweigh the costs. The value of a change in health brought about by a new policy is the product of two terms:

> Value of the policy = Value per unit of health change × change in health due to policy (Tolley et. al. 1994, p.346).

The aim of the defensive expenditure approach is to estimate the value of the first term on the right hand side of this equation. The second term must be estimated from epidemiological evidence on the dose–response relationship between exposure to environmental risks and their effects on human health. In theory, the value of a change in health estimated using one set of inputs could be used to value all inputs that generate the same change in health, *if all other factors remain equal.*

An example of a unit commonly used to measure the health benefits of environmental protection is a "statistical life" which is defined as "the willingness to pay by a group of people to reduce mortality risks enough so that one life is expected to be saved, in a statistical sense" (Tolley, Kenkel and Fabian 1994, p.8). If a statistical life is worth five million dollars and a health program saves ten lives, then the benefit of the reduced mortality is 50 million dollars (i.e. $5 million × 10 lives). However, it is important to recognise that a statistical life does not represent an individual's valuation of their own life, but the implied value of an unidentified life, based on small changes in risk across the population.

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[4] For other formulations see Courant and Porter (1981) and Harrington and Porter (1987).

5.2.2. The valuation of health using safety equipment

Consumers face an array of market goods that can potentially affect their health. These can range from safety equipment, such as air-bags that are specifically designed to reduce the risk of mortality and morbidity caused by motor vehicle accidents, to common market goods such as "low fat" foods. Although there are a potentially limitless number of market goods that affect health, most studies focus on safety equipment, because it avoids many of the joint production problems discussed earlier. For example, "low fat" foods might also be purchased for their taste or texture as well for their health benefits. Empirical studies have examined the implied value of life from using safety belts (Blomquist 1979), smoke detectors (Dardis 1980) and indoor radon control (Åkerman, Johnson and Bergman 1991).

5.3 Using revealed preference methods to value health care

The evaluation of health care in developed countries normally involves goods or services that prevent or treat non-infectious diseases. Government intervention has two dimensions—the regulation of product quality and the regulation of price to ensure that consumers pay only a zero or a nominal price to receive health care.

There are two ways in which revealed preference methods can be applied in the evaluation of health care. One way is to value health care by valuing its outputs. Such an approach has been suggested by Johannesson (1996, p.73):

> ...estimates of the value per statistical life or life-year taken from revealed preference studies can be used to value lives or life-years saved in health care programs.

However, there are several disadvantages with using this approach.[5] Firstly, for the reasons given above it is difficult to extend this approach to the valuation of changes in morbidity associated with the consumption of health care. Secondly, it is impossible to value non-health related outcomes, such as the value of information or "process utility". Thirdly, the approach does not take into account the possibility that the individual's attitude to risk might differ across different types of goods (Pauly, 1995, p.115). Finally, although safety equipment and averting inputs are exchanged in markets, the market price only reflects the marginal consumer's WTP. All that can be inferred is that the market price represents the lower bound for the value of safety for those who purchase the equipment and an upper bound for those who do not purchase it.

The other approach that has largely been overlooked in the evaluation of health care is the TCM. The TCM focuses on access cost rather than price because there is likely to be much greater variations in the former. The remainder of this chapter is devoted to examining the scope for using this method in the evaluation of health care goods and services.

5.4. Travel cost model

The TCM overcomes the unpriced goods problem by focusing on the individual's outlay on other inputs that are necessary for the production of health. An individual will seek medical care if the benefit she gains is greater than her total time and travel costs.

5.4.1 The environmental travel cost model

The origins of the TCM can be traced back to a letter from Harold Hotelling written in the late 1940s in response to a US National Parks Service solicitation on ways to value the economic benefits of national parks (McConnell 1985, pp.683–4). National parks are difficult to value using conventional welfare economic analysis, because users are normally charged only nominal amounts to gain entry, and a fixed fee does not generate sufficient price variation to estimate a demand curve for the park. Without a demand curve, it is impossible to estimate the benefit recreationalists derive from using the park. Hotelling's letter contained the insight that it is possible

[5] In fairness to Johannesson it should be acknowledged that he recognises many of the shortcomings of this approach (see Johannesson 1996, p.73).

to estimate a demand curve by studying the behaviour of users at various distances from the recreation site.

Hotelling's suggestion was taken up several years later by Clawson in his work on benefits associated with the recreational use of Yosemite and the Grand Canyon National Parks (Clawson 1959). Clawson's approach involved estimating an aggregate demand curve by conducting on-site interviews at each park. Each user was then assigned to a geographic zone depending on the origin of her trip. This information was used to construct a demand curve based on the utilisation rate and the average travel cost per zone. The welfare benefits associated with the recreational use of the park are the area under this curve (McConnell 1985).

In recent years, the focus of travel cost research has shifted from zonal utilisation rates to individual demand (Willis and Garrod 1991). Individual travel cost models come in two forms: (i) a *single-site travel cost model* that focuses on the number of visits an individual makes over a fixed period of time (such as a season); and (ii) a *multi-site travel cost model* that examines the choice of site on a single occasion (Bockstael, McConnell and Strand 1991). Both of these models are outlined in section 5.6 below.

5.4.2. Applying the travel cost method to health care

The impact that travel distance has on health care utilisation has long been recognised. For example, Acton (1975) examined the influence of distance on the demand for zero-priced outpatient services in New York.[6] This type of study is often referred to as a "distance decay" study since it models the relationship between travel distance and health care utilisation (Oldroyd 1986). The travel cost method differs from the distance decay approach in that it converts physical measures of access into a money metric in order to facilitate the measurement of welfare gain (or loss) in monetary terms.

[6] Other studies that estimate the effect of distance on demand include Parkin (1979), Coffey (1983) and Henderson, McKenzie and Haiart (1988).

5.5 The valuation of time

In addition to the out-of-pocket expenses incurred while travelling to a medical facility (e.g. the cost of petrol), patients must also allocate some of their time in order to receive health care. It is generally accepted that the opportunity cost of this time is strictly positive, because the time spent on health care reduces the time available for work or leisure. However, there is little agreement on its method of valuation. Most empirical studies value time as a function of the marginal wage since the labour market is one place where time is traded for money. This is the starting point for the theoretical work presented below.

5.5.1 A general framework

The neo-classical model of labour supply assumes that an individual maximises utility by consuming goods (x_c) and leisure (non work) time (t_l) subject to an income and a time constraint. The maximisation problem is therefore:

$$\begin{aligned} &\max U\ (x_c, t_l) \\ &s.t.\ y_u + t_w w - p_c x_c \geq 0 \\ &T - t_w - t_l = 0 \end{aligned} \tag{5.3.}$$

where, y_u is unearned income; t_w is the time spent working; w is the wage rate; p_c is the price of the consumption good and T is the total time available. Unlike income, all time must be allocated to either labour or leisure and so the time constraint is an equality. The Lagrangian for this model is:

$$\ell = U(x_c, t_l) + \lambda(wt_w + y_u - p_c x_c) + \mu(T - t_w - t_l) \tag{5.4.}$$

Denoting partial derivatives by subscripts (i.e. $U_{x_c} = \frac{\partial U}{\partial x_c}$) the solution to the Lagrangian yields:

$$\frac{U_{x_c}}{U_{t_l}} = \frac{\mu}{\lambda} p_c \qquad (5.5.)$$

where, the parameter λ is the marginal utility of money and μ is the marginal value of time. In equilibrium, the "scarcity value" of time equals the marginal wage:

$$w = \frac{\mu}{\lambda} \qquad (5.6.)$$

In this simple model, only leisure time is a source of utility. It is also possible that individuals derive (dis)utility from the time they spend at work. This can be incorporated into the model by including work time (t_w) as well as leisure time in the utility function (Johnson 1966). If U_{t_w} denotes the (dis)utility associated with time spent at work Eq. (5.6.) becomes:

$$w = \frac{\mu}{\lambda} - \frac{U_{t_w}}{\lambda} \qquad (5.7.)$$

Eq. (5.7.) suggests that the marginal wage not only reflects the scarcity value of time, but also the (dis)utility of work time. This latter term has been labeled the "commodity value" of time (Chavas, Stoll and Sellar 1989). If $U_{t_w} < 0$, the wage must compensate for the disutility of undertaking work as well as the sacrifice of time. In these circumstances, the value of non-work time is *less* than the marginal wage rate, because extra compensation is not required for the sacrifice of non-work time.

Activities undertaken in non-work time can also be a source of (dis)utility. For example, Cesario (1976) argues travel time should be valued at less than the marginal wage, because the individual enjoys travel. Many environmental travel cost studies adopt this approach and value travel time at 20 to 50 per cent of the marginal wage (e.g. Cesario 1976; McConnell and Strand 1981; Smith, Desvouges and

McGivney 1983)[7]. An exception is Larson (1993), who assumes people gain utility from work and so leisure time has a value greater than the marginal wage.

5.5.2. Labour market constraints and the value of time

The other reason the value of time differs from the marginal wage is that constraints in the labour market prevent the substitution of work time for leisure. The simple labour supply model represented by Eq. (5.3.) assumes individuals have total discretion over their hours of work. Such a highly simplified labour supply model captures none of the institutional constraints that govern modern labour markets. In most labour markets, individuals must choose between a job in which they are required to work a minimum number of hours per week, or unemployment. However, even in these circumstances, there is often flexibility, as an employee in a job with fixed hours might have the opportunity to work overtime or take up a second job. Such a situation is illustrated in figure 5.1

Figure 5.1 illustrates a typical labour market situation (Bockstael, Strand and Hanemann 1987). The discrete nature of the decision to work is represented by the "hole" in the budget constraint between T and $T\text{-}h_{\min}$, with $h_{\min}$ being the minimum number of hours that the individual can work. Consider an individual with an indifference curve UU; she can gain more utility from working $h_{\min}$ hours (at point A) than being unemployed (point B). If she has discretion over her hours of work, she would move to point C on the higher indifference curve (U′U′) by working h_y hours. At point A or B the marginal rate of substitution of income for leisure does not equate with the budget line. At either point the value of time is not the marginal wage. It does not even represent the upper or lower bound since the true value depends on the (unobservable) marginal rate of substitution of income for leisure.

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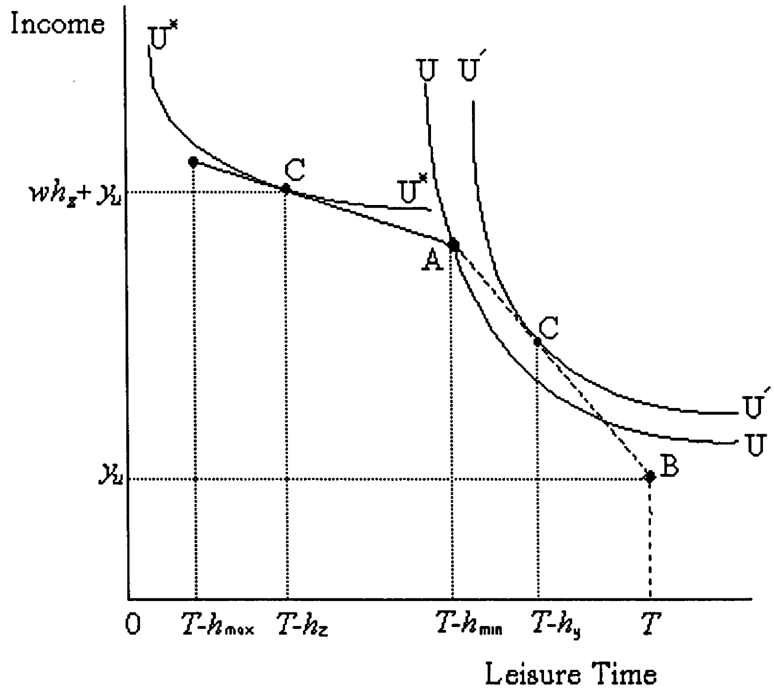
[7] This range reflects the utility an individual gains from driving to a recreation site. A patient travelling to a medical facility is more likely to experience disutility than utility so there is no basis for using these values in a health care travel cost model.

Figure 5.1. Labour market constraints and the value of time



Above h_{min}, the individual has discretion over her hours of work and so the budget line is continuous between h_{min} and h_{max}. In this range, the wage is the value of time. For example, an individual will maximise her utility at point C on the indifference curve U*U* by working h_z hours, the value of her time is the negative of the slope of the budget line, which is determined by the marginal wage of the second job or the wage paid for working overtime.

5.5.3. Health status and the value of time

Health status also places constraints on the allocation of time, because a person in poor health is likely to be unable to work and is restricted in the range of other activities they can undertake. Hence, the scarcity value of time for a seriously ill person might be quite low. The commodity value of time spent in ill health is influenced by two factors—the level of disutility experienced while spending time in a low health state and the marginal utility of money. It is safe to assume that people suffer disutility when they are in ill health, but the effect of health on the marginal utility of money is less clear. Evans and Viscusi (1991) suggest poor health has two effects on the marginal utility of money. Initially, reductions in health status are likely to lower the marginal utility of money. At the same time, people who suffer a serious illness are normally unable to work, which results in a reduction in income. This is likely to have the secondary effect of increasing the marginal utility of money. The net impact of these two effects on the marginal utility of money would be an interesting area for future research.

5.5.4 The role of time in the household production model

The role of time is central to the household production model (HPM) since it must be combined with other goods to produce non-market commodities such as health. In Becker's original formulation, time does not directly enter the utility function and so its value is constant across all activities. This implies time only has a scarcity value. The consumer's problem is to:

$$\begin{aligned} &\max U(H_t, Z_t) \\ &s.t. y_u + t_w w - p_1 x_1 - p_c x_c \geq 0 \\ &T_t - t_w - t_1 x_1 - t_c x_c = 0 \\ &H_t = f(x_1, t_1) \\ &Z_t = f(x_c, t_c) \end{aligned} \quad (5.8.)$$

Recall that H_t, Z_t are a health commodity and another commodity respectively; x_1 is a health care good; and x_c is a good used in the production of Z_t. The implicit assumption underlying Equ 5.8 is that time is combined in fixed proportions with inputs x_1 and x_c to produce commodities. This assumption while restrictive is often invoked in household production models (e.g. Atkinson and Stern (1979)). The two constraints are not independent if the consumer can freely trade time for money in the labour market. For these individuals, the time constraint can be collapsed into the money constraint by trading time for money at the margin. Thus the two constraints in Eq. (5.8.) can be combined to give:

$$y_u + T_t w - (p_1 + wt_1)x_1 - (p_c + wt_c)x_c = 0 \quad (5.9.)$$

Alternatively, if x_c is the numeraire this can be written as:

$$Y - c_1 x_1 - x_c = 0 \qquad (5.9a.)$$

where, c_1 is total access cost ($c_1 = p_1 + w\ t_1$) and $Y = y_u + T_t w$. This reduces the problem to the conventional single constraint problem where the utility function in Eq. (5.8.) is maximised subject to (5.9.) or (5.9a.).

For those individuals working a fixed number of hours, the scarcity value of time is not the marginal wage and so the individual will be subject to separate time and income constraints. In these circumstances, the demand for medical care is a function of both money *and* time. One way of estimating the *monetary* value of time is to observe the rate at which individuals trade time for money in their choice of health care. (i.e. their choice between a high cost/low time medical care and a low cost/high time alternative).[8] If such a trade-off does not exist, time and travel costs are highly correlated and so it is not possible to impute the value of time from behaviour.

5.6 Empirical estimation of travel cost models

As has been noted in section 5.2, the travel cost model has rarely been used to evaluate health care. In contrast, the environmental economic literature on the travel cost model is vast. The next two sub-sections briefly review two versions of the environmental travel cost model. The third sub-section outlines how these models must be modified in order to evaluate health care.

5.6.1 Single-site travel cost models

The purpose of the traditional recreational travel cost model is to estimate the benefits associated with a single recreation site over a specific time period such as a

[8]In fact a utility maximisation problem subject to two constraints has two duals, one of which minimises monetary costs subject to utility and the time constraint the other which minimises time costs subject to utility and income constraints (Bockstael, Strand and Hanemann 1987).

season. This approach estimates the demand for a site based on the behavioural assumption that users experience diminishing marginal utility each time they re-visit the site within this period of time (Bockstael, 1995).

The trip demand equation is as follows:

$$x_1^i = \beta_0 + \beta_1 c_1^i + \beta_2 S^i + \varepsilon^i \qquad (5.10.)$$

Where, x_1^i is the number of trips ($x_1 = 1,2,3..q$) the *i*th individual makes to the site; c_1^i is their access cost; S^i is a vector of the characteristics of the individual (e.g. age, income and whether they are a member of a recreational organisation); β_0 is the constant term; β_1 is the coefficient on the cost term and β_2 is a vector of coefficients for variables in S^i, and ε^i is an error term. The CV of a decline in access costs is:

$$CV = e(c_1^0, U^0) - e(c_1^f, U^0) = \int_{c_1^0}^{c_1^f} x_1^c \qquad (5.11.)$$

where U^0 is the initial level of utility and x_1^c is the Hicksian demand for the site. The CV is often approximated using the Marshallian consumer surplus (i.e. $CS = \int_{c_1^0}^{c_1^f} x_1^m$).

The total welfare benefits associated with the site can be estimated by setting c_1^f equal to the cost at which the individual ceases to visit the site and c_1^0 equal to a zero cost in order to capture the entire area under the demand curve:

$$CV_1 = \int_0^{c_1^*} x_1^c dc_1 \qquad (5.12.)$$

where c_1^* is the "choke" access cost. The single-site travel cost model collects data at the site of interest and so no account is taken of non or less-frequent visitors (Willis and Garrod 1991). Hence, $x_1 \geq 1$ and so the density function of x_1 is truncated normal:

$$E\left[x_1^i | x_1^i \geq 1\right] = \beta_0 + \beta_1 c_1^i + \beta_2 S^i + \frac{\phi((1-\beta_1 c_1^i + \beta_2 S^i)/\sigma)}{1-\Phi((1-\beta_1 c_1^i + \beta_2 S^i)/\sigma)} \qquad (5.13.)$$

To overcome the bias a truncated maximum likelihood model should be used (Maddala 1983, pp.165-167).

5.6.2 Multi-site models

The travel cost model has also been used to model the demand for different sites. Multi-site studies often apply a random utility model (RUM) and focus on the individual's choice among a set of alternate sites on a single occasion. As has been outlined in chapter three, the RUM involves specifying a utility function to represent the characteristics of each site. Applying Eq. (3.12.) to the model:

$$U_j^i(z_j, y_j^i, S^i) = W_j^i(z_j, y_j^i, S^i) + \varepsilon_j^i \qquad (5.14.)$$

where z_j is a vector of k on-site characteristics (i.e. $z_j = (z_j^0,..,z_j^k)$ for the jth site; y_j^i is the individual's income; and S^i is a vector representing individual characteristics. If we define one of the alternatives (j = 0) to be the individual not attending any site, the access cost associated with each site is the difference in income ($c_j^i = y_0^i - y_j^i$). The main application of this type of model is in the valuation of quality differences between sites. To illustrate the welfare measurement of quality change assume there are only two sites and that they differ in only one respect. The welfare benefit/loss associated with the change in quality is:

$$CV_2 = e(c_1, z_1, U^0) - e(c_1, z_2, U^0) \qquad (5.15.)$$

where $z_1 = (\hat{z}_j^0, z_j^2..z_j^k)$ and $z_2 = (\tilde{z}_j^0, z_j^2..z_j^k)$. Mäler (1974) has shown that this measure of welfare change is the area between the Hicksian demand curves associated with z_1 and z_2 providing the individual only values a site if they use it (i.e. weak complementarity holds). In this case:

$$CV_2 = \int_{c_1^0}^{c_1^*} [x_1^c(c_1, z_2, U^0) - x_1^c(c_1, z_1, U^0)] \qquad (5.16.)$$

In practice, the area between the two Hicksian demand curves is often approximated using the area between the Marshallian demand curves.[9]

5.6.3. The health care travel cost model

There is some scope for using the single-site or the multi-site travel cost model in the evaluation of health care. For example, the single-site model could be used to value a treatment which requires the patient to make multiple visits to a single medical facility (e.g. a doctor's surgery) over a period of time. Alternatively, a multi-site model could value quality differences between different facilities. However, it is important to stress that the scope for applying these models is limited, because health care facilities have features that set them apart from recreational sites.

Firstly, health care goods are often homogeneous products that are supplied from different sites. For example, a patient can obtain the same pharmaceutical drug from many different pharmacies. Secondly, demand depends on the type of health care a patient requires. Although a single facility might offer a range of health care services, we are interested solely in determining the demand for one specific service—not for the facility as a whole.

These features make it difficult to directly apply either the single-site or multi-site travel cost model in the evaluation of health care. One way of adapting the travel cost model is to focus on the relationship between distance to the *closest* facility and demand for different services (e.g. mammographic screening) rather than the demand for a service at a particular facility. For example, if identical products are offered at different locations, then the characteristics of the site z_j can be ignored, because they do not influence choice (e.g. $z_1 = z_2$). In which case, data on S^i and c_1^i can be collected in different areas and the relationship between demand for health care and the distance to the *closest* facility modeled in order to value care.

Although non-site specific models are likely to be the most common form of health care travel cost model, it should be recognised that health care is not always a homogeneous product. Medical facilities may offer similar, but not identical products (e.g. women might prefer to be treated by a female GP). In this case, the model should be extended to incorporate on-site characteristics (z_j). Such a formulation is similar to the recreational travel cost models discussed above.

5.7. Estimating travel cost models

Estimation of a travel cost model might appear to be relatively straightforward, because it involves observed behaviour and thereby avoids many of the difficulties that arise when trying to directly elicit preferences using stated preference methods. In practice, estimation is just as difficult, because it requires the researcher to overcome a different set of problems stemming from the unobserved nature of travel costs. As Randall (1994) notes, unlike market prices which can be directly observed, travel costs must be imputed from behaviour. The remainder of this section discusses the major elements of a travel cost survey.

5.7.1 Travel cost survey methods

A survey can be conducted in person, over the phone, or sent through the mail to the respondent with a request to complete and return it. None of these techniques is unambiguously superior to the others in that it yields better results for all types of questions (Bradburn 1983). The choice between these techniques depends on the type of travel cost model being implemented as well as practical considerations, such as the cost of undertaking the survey.

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[9] For a discussion of the issues surrounding the validity of using Marshallian demand curves in this context see Bockstael and McConnell (1993).

Mail surveys are the cheapest method, but tend to produce lower responses rates than telephone or face-to-face interviews. The reason for this is they place a greater onus on the respondent, because the survey must be completed and returned to the interviewer. This can lead to sample selection bias if the likelihood of a return is linked to the respondent's usage of the good under evaluation (e.g. non-users might feel that the survey does not apply to them). For this reason, it is preferable to conduct travel cost surveys by telephone or use face-to-face interviews, assuming the researcher has sufficient funds to cover the higher costs of these modes of delivery.

The choice between telephone and face-to-face interviews is not clear cut. If a single-site model is required, face-to-face interviews are the cheapest method, because information can be collected from visitors (patients) at the site (facility) of interest. This method of data collection can be used because no information is required on non-users in the single-site travel cost model. Whereas, other forms of the travel cost model require information from the population affected by the disease. Given that a travel cost survey must be conducted over a wide geographic area, a telephone survey is the most cost-effective means of collecting the relevant data.

5.7.2. Travel cost survey design

The format of a typical travel cost survey is quite different to a stated preference survey. A stated preference survey describes a good by setting up a scenario and then asks the respondent to express a value contingent on a market existing for the good. This normally involves one or two key valuation questions. In contrast, a travel cost survey must quantify all aspects of the cost associated with receiving a good or service at sometime in the past.

In recent years there has been a great deal of research undertaken to improve the quality of contingent valuation surveys (see chapter nine). This followed a recognition that responses are sensitive to such factors as the wording and order of questions, the description of the good under evaluation (i.e. contingent valuation scenario) and the context in which the valuation questions are asked. There has been little comparable research on travel cost survey instruments. The remainder of this section draws on the few studies that have been conducted in order to make some suggestions on the wording of travel cost survey questions.

(i) Questions regarding the distance traveled

Information on travel distance can be obtained through direct questioning (e.g. How far the did you travel to obtain health care?), but this relies on respondents being able to accurately estimate the distance they traveled when they sought care. Previous empirical work suggests that many respondents have difficulty in accurately estimating travel distances (Ashby, Buxton and Gravelle 1989).

Another way of ascertaining travel distance is to ask respondents for their residential location and destination. The travel distance can then be imputed from the road distance between her place of residence and the medical facility. This method is not free from error, because the respondent might not have taken this route or may have initiated the journey from another location (e.g. from her place of work). Additional questions could be used to reduce measurement error, but this increases the length of the questionnaire and the burden on the respondent.

(ii) Unit travel costs

In order to calculate travel cost, the distance traveled must be multiplied by a unit cost of travel. Using survey questions to estimate the cost of travelling by a private vehicle is problematic, because most people have difficulty assessing vehicle running costs. They seem to pay more attention to routine costs, such as cost of petrol, than to cost which are incurred infrequently (e.g. cost of maintenance and depreciation) (Hensher 1985; McFadden 1996). For this reason, most travel cost studies apply a third party assessment of the running cost such as those produced by motoring organisations.

For those users that travel by public transport, unit travel costs are not meaningful and the total cost of the journey (i.e. ticket price) should be used. The time taken is also likely to be much longer, because public transport routes often require the user to travel to a "transport hub" and then to their destination (Ashby, Buxton and Gravelle 1989, p.25) .

(iii) Valuing time

As section 5.5 highlights, the component of costs which is by far the most difficult to measure is the value of an individual's time. What options are open to the applied researcher in trying to value time costs? One of the simplest solutions is to adopt a range of values to represent likely values for time. A range of benefits can then be estimated based on these values. Although this approach is rather arbitrary, if plausible assumptions are made about the value of time (e.g. 50 per cent of the marginal wage to 150 per cent of the marginal wage), the range is likely to encompass the individual's true value of time. Some other solutions are discussed in Shaw (1993).

5.8 Summary and Conclusions

This chapter has been concerned primarily with the use of revealed preference methods in the evaluation of health care. Revealed preference methods study actual choices concerning goods which in some way affect the individual's health. The overwhelming majority of studies have used averting behaviour as a means of evaluating policies designed to improve the quality of the environment and public safety.

Most of this chapter is devoted to examining the TCM which is another revealed preference method that has rarely been used in the evaluation of health care. The TCM was originally developed to value recreation areas. The method is based on the premise that observed behaviour at different distances from a recreation site provides an insight into a potential user's valuation of that site. The purpose of the traditional recreational travel cost model is to estimate the benefits associated with a single recreation site over a specific time period. More recently, the approach has been extended to model an individual's choice among a set of alternate sites on a single occasion. Both of these models require some modifications if they are to be used in the valuation of health care.

One of the main challenges for travel cost research is to convert physical measures of access, such as the distance traveled or time taken to receive health care, into monetary costs. This issue is the focus of two sections of this chapter. Section 5.5 examines method by which time can be valued. Although many studies equate the value of time with the marginal wage, it has been argued that the conditions under which this result holds are quite restrictive. Firstly it must be assumed that a individual receives no (dis)utility from the time she spends at work relative to the time she spends undertaking leisure activities (Cesario 1976). Secondly, an individual must have flexibility over her hours of work. If either of these conditions is not met the value of time is likely to diverge from the marginal wage. Section 5.7 is mainly concerned with other components of access cost such as the unit cost of travel. Again, there are difficulties with measuring these components, even in physical terms (e.g. travel distance). All these issues provide scope for further work that should be undertaken so that the method can be fully developed as a tool for health care evaluation.

Chapter 6

Applying the travel cost model to evaluate the use of mobile mammographic screening units

> [There is] a current lack of mammography screening programs in country areas which has led to most lesions presenting at the palpable stage... (House of Representatives Standing Committee on Community Affairs 1995, p.40)

6.1. Introduction

This chapter demonstrates how the travel cost method can be used to evaluate mobile mammographic screening services in rural areas of New South Wales, one of Australia's six states. Section 6.2 provides an overview of the mammographic screening services available in Australia. Section 6.3 contains a theoretical discussion of the methods that can be used to quantify the benefits of reducing the access costs associated with screening. An empirical application of this approach is discussed in section 6.4 and the results are presented in section 6.5. Finally, the estimates of the benefits of a hypothetical program to use mobile screening units in rural towns are employed in an indicative cost–benefit analysis in section 6.6. The conclusions are summarised in the closing section.

6.2. Overview of mammographic screening services in Australia

For Australian women, the lifetime risk of developing breast cancer is one in 14. In 1988, the most recent year for which there is complete data, there were 2361 deaths from the disease (Jelfs et al., 1994). In an attempt to reduce this mortality, a national population-based mammographic screening program was initiated in 1991 (NPEDBC, 1994). This program supplements existing methods of detection, such as diagnostic mammography that have been used to detect *symptomatic* cases of breast cancer for many years. Although the Australian program is primarily targeted at women in the 50–69 years age group, women aged between 40–49 and 70–79 years may also screened if they request it (Ryan, 1991).

In 1989-90, prior to the commencement of the National Program for the Early Detection of Breast Cancer (NPEDBC), the Australian Radiation Laboratory undertook a survey to determine the location of all mammographic screening units in operation in hospitals (public and private) and in private radiology practices. In all, the survey identified 267 mammographic units in use in Australia at that time. The geographic distribution of these units is illustrated in figure 6.1, where each black dot represents a screening unit. From this figure, one can conclude that there was a high concentration of screening units around the state capital cities (e.g. Sydney and Melbourne) and in some coastal areas of Australia at that time. In contrast many inland rural towns did not have mammographic screening facilities.[1]

The NPEDBC supplements existing facilities with the introduction of an additional 100 screening units to screen an estimated 550 000 to 860 000 women each year (NPEDBC Monitoring and Evaluation Reference Group 1994). Under the program, mammograms are available from accredited screening units free of charge.

One of 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 aim 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 that visit towns too small to have fixed screening units. The alternative approach is to place fixed units only in major regional centres. Women in smaller towns must travel to these centres in order to have a mammogram. The remainder of the chapter examines how the travel cost method can be used to evaluate whether mobile screening units should be used to screen women in 10 different rural towns.

[1] Only 27% of women aged between 40-79 years resident in New South Wales lived in rural areas (Smith 1996a).

Source: Thompson et al. (1991)

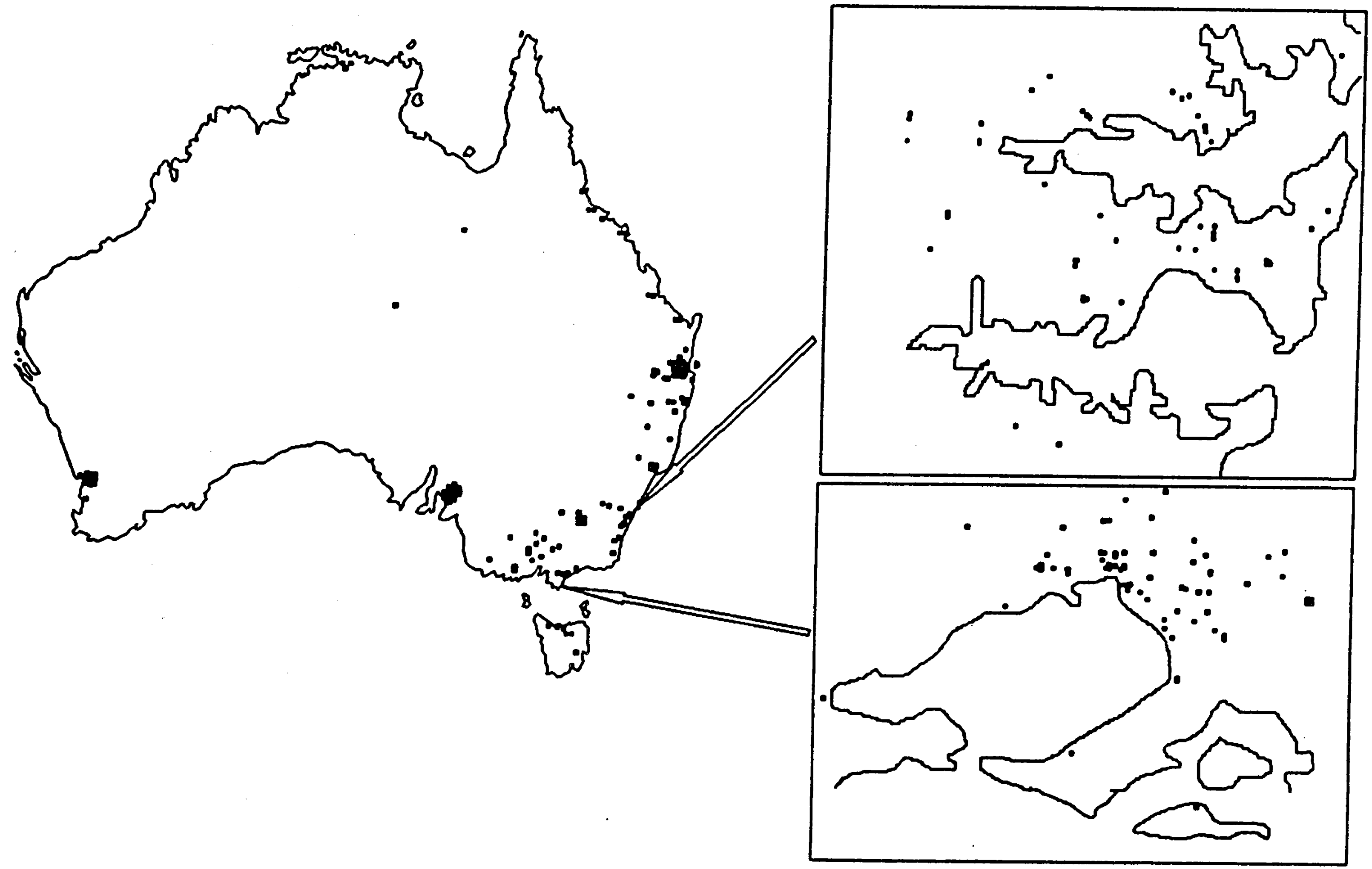


Figure 6.1 The geographic location of mammographic screening units in Australia (1989-90)

6.3. Evaluating the Benefits of Mobile Screening Clinics

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. This chapter illustrates how the travel cost method can be used to estimate the benefits of increased access to screening facilities in rural towns. The introduction of mobile units can be evaluated by comparing the benefits of improved access with the higher cost of providing mobile screening units.

6.3.1. Welfare measures of reductions in access costs

The current Australian guidelines for mammographic screening recommend that women in the target age group (50–69 years) be screened once every two years. Within this screening interval a mammogram can be modelled as a "binary good" since a woman's only decision is whether to have a (single) mammographic screen or not (see chapter four). The dichotomous nature of this decision leads to some modification of traditional welfare measures (see chapter three).

Consider a two-good world consisting of x_c and x_1, where good x_c is a composite commodity and x_1 is a mammogram. Then:

$$x_1 = \begin{cases} 1 \text{ if the woman has a mammogram} \\ 0 \text{ if the woman does not have a mammogram} \end{cases}$$

Each woman is assumed to maximise her utility:

$$U = U(x_1, x_c) \quad (6.1.)$$

$$\text{s.t.} \quad y_u + t_w w - p_1 x_1 - p_c x_c = 0 \quad (6.2.)$$

$$T - t_w - t_c x_c - t_m = 0 \quad (6.3.)$$

where, y_u is unearned income; t_w is the time spent working ($t_w = T - t_m - t_c$); w is the wage rate; p_1 and t_1 are the monetary and time costs associated with having a mammogram; p_c and t_c are the vectors of price and time costs associated with consuming x_c.

Eq. (6.3.) reflects the time constraint imposed on patients consuming medical care. If the value of time is the marginal wage, then the two constraints Eq. (6.2.) and Eq. (6.3.) can be combined:

$$y_u + T_t w - (p_1 + wt_1)x_1 - (p_n + wt_n)x_n = 0 \qquad (6.4.)$$

Alternatively, this can be written as:

$$Y - c_1 x_1 - x_c = 0 \qquad (6.4a.)$$

where Y is total income ($Y = y_u + t_w w$), c_1 is total access cost ($c_1 = p_1 + wt_1$), and $p_c + wt_c$ is defined equal to one so x_c becomes the *numeraire.* This reduces the problem to the conventional single constraint problem where Eq. (6.1.) is maximised subject to Eq. (6.4.) or (6.4a.) and the value of time is the marginal wage. Other values for time are examined in the sensitivity analysis in section 6.2. An important feature of a binary good is the existence of a critical price or, in this case, a critical cost (c_1^*) at which the good ceases to be consumed. This amount represents a woman's willingness to pay for mammographic screening (see chapter four). In the case of a binary good, the demand function takes on a simple form. Assume access cost is initially at a level c_1^0 such that $x_1 = 0$ and $x_c = Y$. If access cost declines below c_1^*, the woman switches to consuming a mammogram (i.e. $x_1 = 1$, $x_c = Y - c_1^*$). If it declines further, the woman is able to increase her expenditure on x_c as well as have a mammogram.

The dual to the utility maximisation problem is expenditure minimisation subject to attainment of a minimum level of utility:

$$\min c_1 x_1 + x_c = Y \qquad (6.5.)$$

$$\text{s.t.} \quad u(x_1, x_n) \geq \overline{U} \qquad (6.6.)$$

Again, women switch to having a mammogram if the access cost falls below a critical level $c_1^{\#}$ (the Hicksian critical cost). There are two expenditure functions conditional on $x_1 = 0$ and $x_1 = 1$:

$$e(c_1, Y, \bar{u}) = \begin{Bmatrix} e^0 = x_c & \text{if} \quad c > c_1^{\#} \\ e^1 = x_c - c_1^{\#} + c_1 & \text{if} \quad c \le c_1^{\#} \end{Bmatrix} \tag{6.7.}$$

The nature of the welfare change brought about by the visit of a mobile unit depends on whether women in rural towns perceive mammograms provided by fixed and mobile units to be perfect substitutes. When this is the case, the gain in welfare associated with a mobile unit visiting a rural town is due solely to the decrease in access costs. On the other hand, if fixed and mobile screening units are not perfect substitutes (e.g. if fixed units provide a higher quality of service) welfare measures must account for the difference in quality as well as the change in access costs. It is a requirement of the NPEDBC that all public mammographic screening units undergo a process of accreditation to ensure that they are of a minimum standard. It is therefore assumed that mammograms from different sites are perfect substitutes (i.e. they are of uniform quality), and so only welfare change associated with a reduction in access cost is derived below.[2]

In the case of a divisible good, the benefits (or losses) that accrue to a consumer from a change in access cost can be represented by the CV which is the area to left of the Hicksian demand curve between the initial and final costs:

$$\begin{aligned} CV = e(c_1^f, U^0) - e(c_1^0, U^0) &= \int_{c_1^0}^{c_1^f} \frac{\partial e}{\partial c_1} dc_1 \\ &= \int_{c_1^0}^{c_1^f} x_1^c dc_1 \end{aligned} \tag{6.8.}$$

where, c_1^0 and c_1^f are the access costs associated with using a fixed site and a mobile unit respectively, x_1^c is the Hicksian compensated demand and U^0 is the initial level of utility. Recall from chapter three that the compensating variation

[2] The conditions under which travel cost models can be used to measure quality changes are discussed in Johansson (forthcoming).

(CV) from a reduction in access cost is the area to the left of the ordinary Marshallian demand curve.

6.3.2. Specification of the random utility model

The previous section derives a measure of welfare change associated with a reduction in access costs. In this section, it is reformulated in probabilistic terms using a random utility model. In order to make this model operational, an appropriate conditional utility function must be specified to represent a woman's decision on whether to have a mammogram.

The conditional utility function for the *i*th individual is:

$$V_j\,(m_j, Y^i, S^i) = W_j\,(m_j, Y^i, S^i) + \varepsilon^i_j \qquad (6.9.)$$

where W_j is a conditional utility function; m_j denotes whether the individual has a mammogram; S^i is other characteristics of the consumer and ε^i_j are errors of observation. Women must make a dichotomous choice on whether to attend a screening unit. Let j = 1 denote the decision to have a mammogram and j = 0 not to have a mammogram. From the point of view of the investigator, an individual will choose to have a mammogram if :

$$W_1\,(1, Y^i - c^i_1, S^i) + \varepsilon^i_1 > W_1\,(0, Y^i, S^i) + \varepsilon^i_1 \qquad (6.10.)$$

By assuming a joint probability function on ε^i_j the decision can be reformulated in probabilistic terms:

$$\pi^i_1 = \Pr[\varepsilon^i_0 - \varepsilon^i_1 < W_1\,(1, Y^i - c^i_1, S^i) - W_0\,(0, Y^i, S^i)] \qquad (6.11.)$$

where π^i_1 is the probability that the individual chooses to have a mammogram, given her access cost, income and other characteristics (Hanemann, 1984). In order to calculate empirical estimates, it is assumed that a random sample of n individuals (i = *1..n*) is drawn from the population under study (consisting of N

individuals). If a maximum likelihood probit estimator is applied, the probabilities are :

$$\pi_1^i = \Phi(W_1^i - W_0^i)$$
$$\pi_0^i = 1 - \pi_1^i \qquad (6.12.)$$

where $\Phi(.)$ is the cumulative density function of the standard normal distribution. The estimated probability π_1^i may be used to forecast the population's demand by assuming that each observation in the sample is representative of a group of θ individuals ($\theta = \frac{N}{n}$) who face a common price and have identical incomes and measured characteristics. The probability π_1^i can be interpreted as the proportion of the *i*th group that have a mammogram. The CV can be calculated by integrating under the cumulative normal distribution between the initial and final access costs (see Eq. (3.16) in chapter three). It is important to note that such an approach provides a measure of *each* individual's CV. In keeping with most applied welfare economic analysis, the indicative cost–benefit presented in section 5.6 assumes that welfare change can be represented by aggregating these individual CVs. Despite criticism of this practice,[3] the use of such an aggregate measure has been justified on the grounds that a positive aggregate CV will in all probability lead to a potential Pareto improvement in social welfare (Ng 1991).

Following Hanemann (1984), two specifications are commonly used. The simplest specification is a linear functional form. If the woman has a mammogram, then $W_1^i = \alpha_1 + \beta_1(Y^i - c_1) + \gamma_1 S^i + \varepsilon_1$, and if she does not then $W_0^i = \alpha_0 + \beta_0 Y^i + \gamma_0 S^i + \varepsilon_0$. Hence,

$$W_1^i - W_0^i = (\alpha_1 - \alpha_0) - \beta\, c_1^i + (\gamma_1 - \gamma_0)S^i + \varepsilon_1 - \varepsilon_0 \qquad (6.13.)$$

The linear specification imposes the severe limitation that income has no influence on the decision to have a mammogram. This arises because the coefficient on disposable income must not vary (i.e. $\beta = \beta_0 = \beta_1$) by alternative, if

[3] For example see Blackorby and Donaldson (1990).

there is to be a stable underlying utility function (Gertler, Locay and Sanderson, 1987).

An alternative specification is the log specification where $W_1^i = \alpha_1 + \beta_1 \ln(Y^i - c_1^i) + \gamma_1 S^i + \varepsilon_1$ and $W_0^i = \alpha_0 + \beta_0 \ln(Y^i) + \gamma_0 S^i + \varepsilon_0$. This leads to:

$$
\begin{aligned}
W_1^i - W_0^i &= (\alpha_1 - \alpha_0) + \beta \log(1 - \frac{c_1^i}{Y}) + (\gamma_1 - \gamma_0) S^i + \varepsilon_1 - \varepsilon_0 \\
&\approx (\alpha_1 - \alpha_0) - \beta \frac{c_1^i}{Y} + (\gamma_1 - \gamma_0) S^i + \varepsilon_1 - \varepsilon_0
\end{aligned}
\tag{6.14.}
$$

where $\frac{c_1^i}{Y^i}$ represents the proportion of an individual's income spent on a mammogram. If c_1^i is small relative to Y^i this is approximated by the negative income share ($-\frac{c_1^i}{Y^i}$) associated with having a mammogram. The marginal utility of income is given by $\lambda^i = -\frac{\beta}{Y^i}$. The merits of this specification are discussed in Johansson, Kriström and Mäler (1989).

6.3.3. Partially observed access cost data

In order to estimate either the linear specification (Eq. (6.13.)) or the income share specification (Eq. (6.14.)), data are needed on the access cost incurred by a woman when having a mammogram. These costs cannot be observed for women who do not 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 access cost or income share equation which is estimated using the sub-set of *k* individuals that have attended a screening clinic (*k*<*n*). The reduced form equation is either:

$$c_1^i = \Pi_0 + \Pi_1 S^i + \Pi_2 X^i + v^i \tag{6.15.}$$

or,

$$\frac{c_1^i}{Y^i} = \Pi_0 + \Pi_1 S^i + \Pi_2 X^i + v^i \qquad (6.15a.)$$

where X^i 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^i and X^i respectively; v^i is an error term. The estimated parameters from Eq. (6.15.) or Eq. (6.15a.) are then used to calculate the *predicted* access cost or income share variable of all *n* individuals in the sample.

6.3.4. Mammographic screening equation

The random utility function can then be estimated using the maximum likelihood probit model based on the predicted rather than actual access cost or income share:

$$W_1^i - W_0^i = (\alpha_1 - \alpha_0) - \beta \hat{c}_1^i + (\gamma_1 - \gamma_0) S^i + \varepsilon_1^i - \varepsilon_0^i \qquad (6.16.)$$

or

$$W_1^i - W_0^i (\alpha_1 - \alpha_0) - \beta \frac{\hat{c}_1^i}{y^i} + (\gamma_1 - \gamma_0) S^i + \varepsilon_1^i - \varepsilon_0^i \qquad (6.16a.)$$

This constitutes the second stage of the two-stage procedure. The coefficient on access cost (Eq. (6.16)) or income share variable (Eq. (6.16a.)) should have a negative sign since the probability of attending should decline as the access cost increases. The use of $\hat{c}_1$ or $\frac{\hat{c}_1}{Y}$ introduces an additional source of random variation which invalidates the standard asymptotic co-variance matrix of the second stage equation. To take this into account an adjustment procedure is applied to the asymptotic co-variance matrix for a two-equation OLS-Probit model (Maddala 1983, p.245).

6.4 Empirical application

The remainder of this chapter illustrates the use of the method by undertaking an indicative cost–benefit analysis of a hypothetical program to have mobile screening units visit 10 randomly selected rural towns in New South Wales. None of the towns had a permanent mammographic screening facility, so the residents of these towns travelled to fixed screening sites located at different distances from these towns.

The study employs data from a random telephone survey of 10 rural towns in New South Wales which was collected as part of the *Cancer Action in Rural Towns* (CART) Project. A rural town is defined as any postcode with a population of between 5 001–15 000 persons aged 18-70 years, that is more than 50km from a major city in New South Wales (Sydney, Newcastle or Wollongong). The towns were randomly selected from the 42 eligible towns in New South Wales. Several questions relevant to the travel cost model were added to a much larger telephone survey on cancer-related behaviours (the relevant questions are reproduced in appendix A). The survey used a simple random sampling method to select 1000 households per town from the telephone directory. An introductory letter and consent form was sent to each household. Households that returned the consent form were then telephoned and a computer-assisted interview was conducted with the person who had the next birthday. All women in the first 200 participants from each town were asked the travel cost section of the survey. Of the women contacted by telephone, the consent rate varied between 85 per cent and 91 per cent across the 10 towns. In all, 901 interviews were completed involving women aged between 40 and 70 years. The survey was conducted over several months from January to April 1994.[4]

In the travel cost section of the survey, all women were asked if they had a mammogram some time within the previous two years (See Q9 in appendix A). Those who had a mammogram were asked additional questions: (i) relating to their reasons for having a mammogram (Q12); (ii) whether they were referred by

---

[4] Data from a further 10 towns were also collected and were used to estimate an earlier travel cost model (Clarke, 1995). Unfortunately limitations in the earlier data set did not allow the two data sets to be combined.

their GP (Q11); (iii) the type and location of the facility (Q10 and Q15); (iv) the distance they had travelled (Q13); (v) their mode of transport (Q14); and (vi) whether it was the sole reason for their travel (Q16). All respondents were also asked if they had received advice from a GP or nurse to have a mammogram in the previous two years (Q17.).

Question 16 was included in order to address the issue of joint consumption, which arises whenever women can defray some of the travel costs by undertaking other activities in the town where they have their mammogram. In these circumstances, less than full access costs should be attributed to having a mammogram. However, as Hof et al. (1985) demonstrate, it is not possible to assign an exact proportion of the costs to any one activity when a household engages in joint production. Hence, two different approaches are employed to deal with this problem. Initially those undertaking joint consumption were eliminated from the sample (127 women). The alternative approach adopted was to include these women and assign them an arbitrary proportion of the total access costs. How this affects the estimates of the benefits is examined in the sensitivity analysis.

6.4.2. Dependent Variable

The dependent variable is set to one if a woman within this age group had screening mammogram within the last two years, and to zero if she had not. Women who had diagnostic mammograms were excluded from the sample (55 observations). After purging 23 incomplete observations, the sample consisted of 645 women. Only 161 of these women had been screened in the last two years.

6.4.3. Explanatory variables

Access Cost

The access costs associated with having a mammogram can be divided into three components: medical costs, travel costs and the opportunity costs of time. The latter two are a function of travel distance. Two questions were asked on travel distance in the survey. The first asked respondents to state the distance they travelled, and the second the name of the town where they had their mammogram (See Q 13 and Q15 in appendix A). The latter was judged to be more reliable because it is often difficult for respondents to recall accurately how far they travelled (see chapter four). The distance was calculated by measuring the shortest road distance between their town of residence and the location where they said they had a mammogram.

The three components of access cost were then calculated as follows:

> *Medical costs:* The medical costs depended on whether women had a mammogram at a public screening centre or through a private radiologist.[5] The former provides the service at no charge to the user, while the Medicare Benefits Schedule fee for the latter was $78.50. However, if the woman was referred by a General Practitioner she is eligible to claim a rebate under Australia's universal public health insurance system of approximately 85 per cent, which would reduce the cost to approximately $13.
>
> *Travel costs:* More than 93 per cent of the women in the sample who had a mammogram travelled to the screening unit by a private vehicle. In order to simplify the calculations, access costs have been calculated using an estimate of the private vehicle operating cost of $0.50 per km. This estimate was provided by an Australian motoring organisation and is based on the cost of running and maintaining a two-litre car (NRMA, 1993).
>
> *Time costs:* Time is valued at the marginal wage rate. In order to ascertain the total time taken it has been assumed that all travel is undertaken at 90 km per hour and that it takes one hour to be screened.[6]

All three costs are combined to obtain the access cost (c_1) for each woman.

[5] Some women chose to use a private radiologist because it was the closest available screening facility.
[6] Screening time includes time spent finding the screening unit and waiting time.

Income

Although the survey did not include a question relating to the respondents' income, estimates of household income were inferred from several questions on the individual's occupation, their hours of work and their spouse's occupation. Estimates of household income are obtained by coding the occupations according to the *Australian Standard Classification of Occupations* (Australian Bureau of Statistics, 1992), and then using published data on the 1992 *Average Weekly Earnings* (Australian Bureau of Statistics, 1993) of adult men and women for that occupation. In the case of women, their weekly income is adjusted to reflect the degree to which they were working a full-time job (i.e. the number of hours they worked divided by the average number of hours worked in that occupation). Single women who were unemployed or who had retired were assumed to have an income equal to the appropriate Social Security benefit. Married women were assumed to have access to half the income of their spouse. The weekly income variable was then scaled to reflect the two-year time scale over which the decision to have a mammogram is made (i.e. each individual's weekly income was multiplied by 104 weeks).

Income share

The income share specification in section 4.2 requires the construction of a variable $\frac{c_1}{Y}$. In order to construct this variable the access cost (c_1) and the household income (Y) must be calculated for each woman in the sample.

Other explanatory variables

The other explanatory variables included in the model are defined in table 1. Previous studies indicate that mammographic screening rates decrease with age (Costanza, 1994), which may be due to the disutility of travel increasing with age. Screening rates have also been shown to increase with the level of education (Adelson, 1992). It is more difficult to determine the expected sign on "marital status", because it will depend on domestic arrangements within the household. The coefficient on the "advice" variable should have a positive sign.

Variable	Definition	Mean (S.D.)
Access cost	Access cost comprised: medical costs, out-of-pocket expenses and the cost of time	108.34(87.45)
Income Share	Access cost divided by income	0.008 (0.004)
Advice	1 if General Practitioner or Nurse advised them to have a mammogram, 0 else	0.19
Education		
Senior High School	1 if highest level of education is senior high school, 0 else	0.12
Tech College	1 if highest level of education is technical college, 0 else	0.09
University	1 if highest level of education is University	0.09
Other Variables		
Married	1 if currently married, 0 else	0.74
Age	Age in years	54.55 (9.56)

Table 6.1. Variable definitions and explanatory statistics

6.5. Results

6.5.1. Parameter estimates

Both the linear and income share specifications were estimated and the results are displayed in table 6.2. The initial specification includes all variables described earlier in this section. Under the linear specification (model 1) the only variables significant at the five per cent level were "access cost", "advice" and the "marital status" dummy variable. In model 2 only "income share" and "advice" were significant at this level. A likelihood ratio test is used to test the joint significance of the three education variables. The χ^2 test statistic was 6.4 in the linear model and 1.17 in the income share model and so the null hypothesis that the coefficients on the education variables are zero was not rejected at the five per cent level of significance in both models. The insignificant variables were then dropped from the specification (models 3 and 4):

The "goodness of fit" of the model is approximated using the likelihood ratio index (LRI) (Greene, 1992). The likelihood ratio index lies between 0 and 1, with high values signifying a better fit. The LRI in the range of 0.18 to 0.20 can be considered reasonable for a cross-sectional model of this type.

Both models were also tested for multiplicative heteroscedasticity (Greene, 1992). For the purposes of the test it is assumed that if heteroscedasticity is present it is a function of the independent variables (i.e. $Var(\Delta\varepsilon) = [\exp(\delta z)]$, where z is a vector of *all* the independent variables). The models were estimated using this general form and a likelihood ratio used to compare the models. The test statistic for this asymptotic test is -2[L(General)-L(Restricted)]~χ^2, where L(General) is the maximum likelihood value of the log-likelihood function and L(restricted) is the maximum likelihood value under the constraint $\delta = 0$. All test statistics were below their critical values at five per cent level of significance, and so the null hypothesis of homoscedaticity is not rejected.

	Initial Specification		Final Specification	
Variable	**Model 1** Linear	**Model 2** Income share	**Model 3** Linear	**Model 4** Income share
Constant	-0.514 (1.001)	-1.255 (2.783)[b]	-0.689 (4.067)[b]	-0.654 (5.065)[b]
Access costs	-0.004 (4.284		-0.003 (4.171)[b]	
Income Share		-47.83 (3.249)[b]		-47.52 (3.421)[b]
GP Advice	1.351 (9.138)[b]	1.422 (9.933)[b]	1.37(10.135)[b]	1.429(10.011)[b]
Education				
Senior High school	0.292 (1.344)	0.111 (0.554)		
Technical College	0.127 (0.572)	0.073 (0.336)		
University	0.468 (2.237)[c]	0.283 (1.413)		
Other Variables				
Married	0.320 (2.079)[c]	0.172 (1.140)	0.288 (2.088)[c]	
Age	-0.003 (0.394)	0.008 (1.108)		
LLF(β) (Full model)	-290.48	-295.04	-293.96	-297.06
LLF(0) (Intercept only)	-362.43	-362.43	-362.43	-362.43
L RI	0.20	0.19	0.19	0.18
(Homoscedaticity) χ^2	5.5	7.4	1.96	0.08

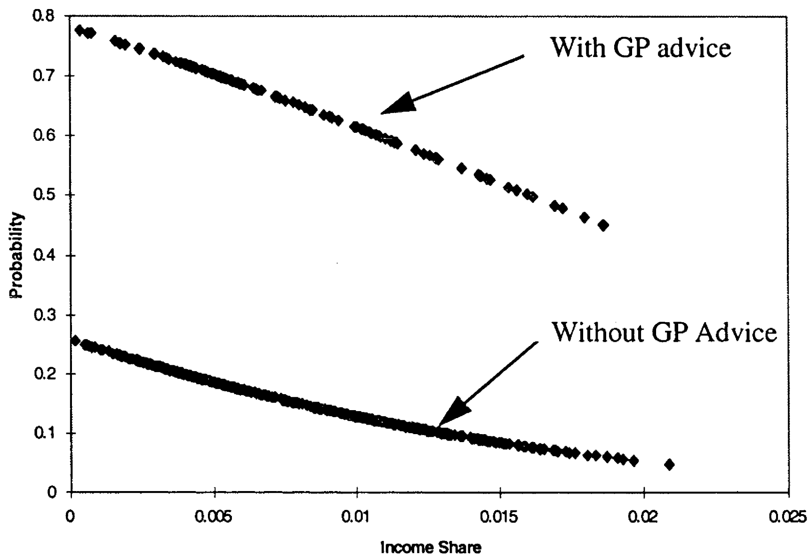
[a]Asymptotic *t*-ratios are reported in parentheses.
[b]Significant at 1 percent level.
[c]Significant at 5 percent level.

Table 6.2 Parameter estimates of the random utility model[a] (n=645)

6.5.2 Effect of access cost on the probability of attendance

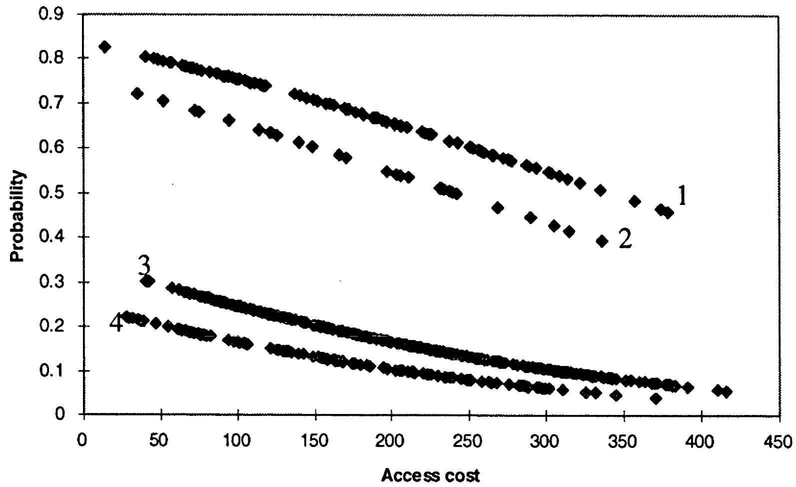
The relationship between "access cost" (c_1^i) and the predicted probability of having a mammogram ($\hat{\pi}_1^i$) has been calculated using the final specifications listed in table 6.2. These are illustrated in figure 6.2(a) and 6.2(b) below:

Figure 6.2(a): The predicted probability of having a mammogram (Income share specification)



All the points in figures 6.2(a). and 6.2(b). represent predicted probabilities for individuals in the sample based on their characteristics. The predicted probabilities for the income share specification are presented in figure 6.2(a). The upper curve illustrates the probability of attending for those women that have been given advice by a GP or nurse to attend and the lower curve represent the probability for women who have not received advice. The effect of receiving advice on $\hat{\pi}_1^i$ is dramatic since it increases the probability of attending by more than 0.5. The comparative predicted probabilities for the linear specification are illustrated in 6.2(b). In this figure there are four lines because there is a second covariate: "marital status" which has a positive effect on the probability of attendance. The four curves represent $\hat{\pi}_1^i$ for each of the separate pairs of characteristics (i.e. Married/Advice, Not Married/Advice, Married/ No Advice, Not Married/No Advice). Once again advice from a GP or nurse has a dramatic effect on the probability of attendance.[7]

Figure 6.2(b): The predicted probability of having a mammogram (Linear specification)



1- With GP Advice/Married
2- With GP Advice/Not Married
3- Without GP Advice/Married
4- Without GP Advice/Not Married

The price elasticities of demand has also be calculated using the estimated equations in table 5.2. Davis and Wohlgenant (1993) have derived a formula for the price elasticity:

$$\eta_{c_1} = \sum_{i=1}^{n} \frac{\partial \hat{\pi}_1^i}{\partial c_1^i} \cdot \frac{c_1^i}{\hat{D}_s} \qquad (6.17.)$$

where, $\hat{D}_s$ is the expected demand over the sample of n households ($\hat{D}_s = \sum_{i=1}^{n} \hat{\pi}_1^i$).

Using Eq. (6.17.) the price elasticities estimated at the mean access cost are estimated to be -0.52 for the linear and -0.26 for the income share specification. Interestingly, the latter is close to a previous estimate of -0.20 for the price elasticity of a mammographic screening service in Scotland (Henderson, Mckenzie and Haiart 1988).

[7] The impact "advice" has on probability of attendance might be overstated, because the "advice" variable was obtained through self-report. Women who have been given advice, but have not had a mammogram may not remember receiving the advice or might be reluctant to report it.

6.6 Cost–benefit analysis

This section employs the results from the previous section to demonstrate how the discrete choice model can be used to estimate the benefits of reducing access costs. A hypothetical program that involves introducing mobile mammographic screening units in 10 rural areas of New South Wales is evaluated. It is important to note that this study is *not* a cost–benefit analysis of breast cancer screening *per se*, but an evaluation of the provision of one method of service delivery. A societal perspective is used in the analysis.

6.6.1. Cost–benefit analysis of mobile screening

The program evaluated is a one-off visit by a mobile screening unit to each of the 10 rural towns. This analysis should be regarded more as a demonstration of the travel cost method than a detailed evaluation of the use of mobile screening units in rural areas. For the sake of brevity, estimates are based on the income share equation only. However, either of the models estimated in section 6.5 could be used to simulate the welfare benefits associated with a wide variety of other policy options.

Given the geographic dispersion of the 10 rural towns chosen for this study, women in different towns face a large variation in the distance to the nearest fixed screening site and therefore gain different benefits from the introduction of mobile units. In order to determine the access cost in the absence of a mobile unit it is assumed that all users travel to the nearest fixed screening site. The distance between the nearest fixed site and the towns in the sample is reported in the second column of table 6.3. The towns have been ranked according to this distance. The introduction of mobile screening units does not totally eliminate travel costs since some intra-town travel is required. To account for this, it is assumed that the introduction of a mobile unit reduces the travel distance to 10 km round trip and the total time taken (waiting and screening time) remains one hour.

The data on the cost of providing mobile services is based on estimates from Carter and Cheok (1994). The average cost differential between mobile units and fixed units was estimated to be $20.34 per woman screened. The cost of screening "new" women (i.e. those who would not have been screened if the mobile unit was not available) was $93.40.

The introduction of a mobile mammographic screening program might also lead to cost savings from less-invasive treatment. In Australia, these treatment costs are not borne by the individual and so the demand for screening is likely to be insensitive to any cost savings.[8] The importance of these savings to third parties, in this case the Commonwealth Government, has been the subject of some debate. While Salkeld and Gerard (1994) suggest that these savings are likely to be small relative to the overall resources required for organised screening, Butler, Furnival and Hart. (1995) indicate that savings might be in the range of 8 per cent to 23 per cent of the cost of a screening program. For the reasons outlined in chapter four, these savings are not included in the current analysis. This issue would need to addressed in a more comprehensive cost–benefit analysis of breast cancer screening.

The costs and benefits of a one-off visit by a mobile unit are reported in table 6.3. The benefits are calculated for each observation in the sample by numerically integrating the cumulative density function between the two access costs and multiplying this by the estimated marginal utility of money (see chapter three). The average CV for women in the sample is reported for each town. These ranged from $1.46 for town one (15km from a fixed screening unit) to $48.20 for town 10 (160 km from a fixed screening unit). Differences in the average CV between towns at the same travel distance from a fixed screening unit can be attributed to the proportion of women in each town that are given advice to have a mammogram. For example, towns four and five are the same distance from a fixed unit, but town four has a higher average CV, because a higher proportion of women in this town were given advice to have a mammogram.

[8] Breast cancer treatment is covered by Australia's comprehensive health insurance system Medicare. Women living in rural areas who are undergoing treatment also receive a travel allowance for treatment related travel (Australian Parliament 1995, p. 42)

The average CV was multiplied by the number of women in each town to calculate the total welfare benefits associated with the program. Similarly, cost estimates of providing mobile units were calculated and the benefit cost ratio reported in the last column of table 3[9]. The results suggest that the benefits outweigh the costs of providing a mobile unit in towns four to 10.

The travel cost method can also be used to calculate a "break-even distance". This is the distance at which the aggregate CV from providing the units just equals the cost. Since CV is dependent on the reduction in access costs, a simple algorithm was developed to compare the total benefits with the total costs for hypothetical fixed screening units at various distances from all 10 towns. The "break-even point" across the 10 towns is calculated to be at 29.04 km. This suggests that it is worthwhile having mobile units visit towns that are located more than 29 km from a fixed screening unit.

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[9] It should be noted that a benefit cost ratio can incorrectly rank mutually exclusive projects, because it takes no account of the magnitude of the benefits and costs. In these cases the net present value of different projects should be compared (see Boadway and Bruce 1984, p. 294)

Town		Probability of being screened (Average)		Average CV	Total Benefits $\sum CV$	Total Costs	Benefit–cost Ratio
No	Distance	Fixed Unit	Mobile Unit				
1	15km	0.37	0.37	$1.46	$2521	$12776	0.2
2	20km	0.24	0.27	$3.59	$8743	$18484	0.5
3	20km	0.32	0.34	$4.75	$8346	$14513	0.6
4	50km	0.38	0.42	$20.37	$35803	$19897	1.8
5	50km	0.28	0.32	$15.59	$16516	$9874	1.7
6	65km	0.32	0.36	$24.39	$37546	$15579	2.4
7	95km	0.26	0.35	$32.65	$34503	$14340	2.4
8	130km	0.23	0.32	$43.11	$77144	$23210	3.3
9	135km	0.19	0.29	$39.05	$80024	$26845	2.9
10	160km	0.21	0.32	$48.20	$120436	$36056	3.3

Table 6.3. Benefits and costs of mobile screening

6.6.2. Sensitivity analysis

The cost–benefit analysis calculations in table 6.3. are subject to a degree of imprecision and uncertainty. A sensitivity analysis is normally used to test the effects of varying key assumptions. The two areas of greatest imprecision in the travel cost model are the monetary valuation of time and the allocation of joint costs. This section varies both these assumptions relative to a "baseline" case of screening towns four to ten under the standard assumptions outlined in section 6.4.

The model estimated in section 6.5 values time at the marginal wage. For many women time might have a different value, because they are not employed in a job with flexible hours or because time has a "commodity value" (see chapter five). In order to test the sensitivity of the results, two values of time were adopted: (i) value of time is 50 per cent of the marginal wage; and (ii) value of time is 150 per cent of the marginal wage. Although these values are arbitrary, previous studies such as Cauley (1987) adopted values for time that fall within this range. The random utility model was re-estimated and the results are reported as models 5 and 6 in table 6.4. The effect varying the value of time has on the cost–benefit analysis is summarised in table 6.5. The results suggest that a change in the value of time has only a small impact on the total benefits.

The second assumption to be tested was the allocation of joint costs for women who had undertaken multi-purpose trips. Instead of excluding these women, an arbitrary proportion of the access cost is attributed to having a mammogram: (i) 50 per cent of access costs; and (ii) 100 per cent of access costs. The parameter estimates are reported as models 7 and 8 in table 6.4. and the cost and benefit estimates summarised in table 6.5. The results suggests that including women who undertake joint consumption will lead to a slight decline in the benefit-cost ratio without affecting the overall conclusion that benefits outweigh the costs of using mobile units in towns four to ten.

Variable	Assumptions relating to the value of time		Assumptions relating to joint production	
	Model 5 Time valued at 50% of the wage rate	**Model 6** Time valued at 150% of the wage rate	**Model 7** 50% of access costs	**Model 8** 100% of access costs
Constant	-0.658 (5.397)[b]	-0.651 (5.398)[b]	-0.053 (0.522)	-0.031 (0.298)
Income Share	-43.24 (3.58)[b]	-52.50 (3.58)[b]	-99.311 (6.819)[b]	-95.97 (6.907)[b]
GP Advice	1.430 (10.592)[b]	1.420 (10.57)[b]	1.425 (11.87)[b]	1.440 (11.97)[b]
No. Obs	645	645	772	772
LLF(β)(Fullmodel)	-296.82	-297.28	-410.63	409.95
LLF(0)(Intercept only)	-362.43	-362.43	-509.95	-509.95
L RI	0.18	0.18	0.19	0.19

[a]Asymptotic *t*-ratios are reported in parentheses.
[b]Significant at 1 percent level.
[c]Significant at 5 percent level.

Table 6.4 Parameter Estimates for the income share specification[a]

Scenario	Total Benefits	% Δ Benefits	Total Cost	Benefit–cost Ratio
Baseline	$401972	---	$145800	2.8
Time valued at 50% of marginal wage for those not on flexible hours	$379477	-6%	$140329	2.7
Time valued at 150% of marginal wage for those not on flexible hours	$426577	6%	$145028	2.9
Including women undertaking joint consumption (@ 50% of access cost)	$616901	53%	$287926	2.1
Including women undertaking joint consumption (@ 100% of access cost)	$657681	61%	$252931	2.6

Table 6.5 Results from the sensitivity analysis

6.7. Summary and conclusions

This chapter has examined how the travel cost method can be used to quantify the benefits of mobile mammographic screening units. The traditional travel cost model has been modified to take account of the binary nature of the decision to have a mammogram. The resulting demand curve has been used to measure the welfare benefits of reducing access costs of mammographic screening. These welfare measures were employed in an indicative cost–benefit analysis used to evaluate the introduction of mobile mammographic screening in several rural areas of New South Wales. The results suggest that the level of welfare benefits associated with such a program will depend on a town's distance from the nearest fixed screening unit, with the average CV per individual ranging from $1.46 to $48.20.

The travel cost approach provides an alternative to contingent valuation in the evaluation of some health care goods. Its main strength is that it is based on observed behaviour and therefore can produce a more reliable estimate of welfare gain. However, more basic research is required to further develop the method if it is to be used in the evaluation of other types of medical care.

Appendix 6A: Estimation of the access cost and income share equation

The variables included in the reduced form income share and access cost equation were: (i) dummy variables to represent each of the towns; and (ii) exogenous variables from the second stage probit equation. The coefficients of the reduced form equations are reported in table 6.6 below.

Table 6.6. Parameter estimates of the access cost/ income share equation

Variable	**Access cost equation** (Linear specification)	**Income share equation**
Constant	159.32 (1669)	0.0001 (0.020)
Town Dummy Variables		
Town 1	103.59 (63.15)	-0.008 (2.445)
Town 2	167.11 (3.185)	-0.0007 (0.250)
Town 3	73.73 (1.337)	-0.0014 (0.483)
Town 4	38.079 (0.775)	-0.0022 (0.823)
Town 5	213.44 (3.965)	-0.013 (4.388)
Town 6	175.32 (3.552)	-0.0076 (2.848)
Town 7	34.83 (0.773)	0.0014 (0.591)
Town 8	128.03 (1.964)	-0.0015 (0.435)
Town 9	238.54 (4.583)	-0.0066 (2.387)
Variables from Equation 1		
GP Advice	-32.175 (1.274)	0.0001 (0.075)
High school	80.93 (2.147)	-0.259 (1.270)
Technical College	-9.64 (0.220)	0.0006 (0.264)
University	49.72 (1.365)	0.0003 (0.137)
Married	14.6 (0.447)	0.002 (1.074)
Age	-1.936 (1.497)	-0.00009 (1.176)
No. of observations	161	161
R^2	0.28	0.24

t-ratios are reported in brackets.

Chapter 7

The expressed preference approach

> ... we have been too prone, on the one hand, to overstate the difficulties of introspection and communication and, on the other, to underestimate the problems of studying preferences revealed by observed behaviour.
> (Sen 1973, p.258)

7.1 Introduction

The origins of the contingent valuation method (CVM) are in environmental economics where it has been used to value non-market and unpriced goods. In recent years there has been growing interest in using it to value health care (Pauly 1995). The purpose of this chapter is not to provide a comprehensive overview of the method since this task has been undertaken elsewhere (e.g. Donaldson 1993; Gafni and O'Brien 1995; Johansson 1995; Johannesson 1996). Instead, several issues that are directly relevant to the empirical application of the method presented in the next chapter are discussed.

This chapter is divided into five sections. Section 7.2 provides a brief literature review. Again a distinction is drawn between studies that value changes in health and those that value health care. Section 7.3 discusses the important role that information plays in the valuation of health care. Section 7.4 examines three issues that come under the broad category of motivations for contingent valuation responses. Section 7.5 examines some statistical issues that arise when trying to elicit measures of willingness to pay (WTP) though contingent valuation surveys. The final section contains a summary and conclusions.

7.2 Background

7.2.1 A brief history of the contingent valuation method

The first contingent valuation study was probably conducted by Davis (1964), who surveyed recreational hunters to value an outdoor recreation area. Several other contingent valuation studies soon followed (e.g. Cicchetti and Smith 1973). These early studies were designed to overcome the "unpriced good" problem associated with the valuation of recreation areas. However, it soon became evident that the CVM had the potential to capture other values not reflected in behaviour. These "non-use" values were a major theme of the influential essay by Krutilla (1967) *Conservation Reconsidered.* The two most important non-use values associated with the environment are: (i) *existence value*—the value people ascribe to the existence of a wilderness area even though they do not intend to visit it (Kutialla 1967); and (ii) *option value*—the value people place on having access to a resource in future, even though they do not currently use it (Weisbrod 1964). Revealed preference methods do not capture non-use values. The need for a technique to quantify non-use values was one of the primary motivations behind the development of the method in environmental economics (Portney 1994).

The valuation of non-use benefits moved from an academic pursuit to one of great legal and financial significance following United States Court of Appeals decision (*State of Ohio vs U.S Department of Interior*) to take non-use values into account when calculating environmental damage claims (Shavell 1993, p.372). It is in this context that the use of the CVM has proved to be very controversial, with several leading economists questioning both the importance of non-use values, and the ability of the CVM to measure them (Diamond and Hausman 1993). In an effort to resolve this controversy, the National Oceanographic and Atmospheric Administration (NOAA), the agency responsible for damage assessment in connection with oil spills, commissioned a report from a "Blue Ribbon" panel of economists into the conduct of contingent valuation studies involving environmental damage assessment. The panel was co-chaired by the Nobel laureates Kenneth Arrow and Robert Solow. The resulting recommendations have been very influential in shaping the NOAA proposed regulations for the use of the CVM in environmental damage assessment and have set the agenda for research in this area.

7.2.2. Development of the contingent valuation method in health economics

As has been outlined in chapter two, contingent valuation experiments can be conducted in two ways. They can be used either to value health directly or to value health care. These methods overcome different aspects of the valuation problem. In the former case, CVM is in effect asking the individual to express a value contingent on it being possible to engage in the direct exchange of money for a change in health status. Whereas, contingent valuation studies that value health care ask an individual to state her total WTP if the good was traded at market prices, or alternatively her WTP in taxes (or insurance premiums) to have access to the health care in future if she requires it. Although the focus of the remainder of this thesis is on the valuation of health care services, for completeness this review examines both approaches.

(i) Valuing changes in health

Following a suggestion by Mishan (1971) that survey methods could be used to value health, the contingent valuation approach has been used to value reductions in morbidity associated with improvements in environmental quality and changes in risk of mortality associated with different modes of transport.

Many environmental health studies value health symptoms resulting from exposure to air pollution. Instead of using the defensive behaviours approach (outlined in chapter five), respondents are asked to directly value a change in their health. One of the first studies to adopt this approach was Loehman et. al. (1979), they used a mail survey to ask respondents to value the alleviation of various symptoms (e.g. shortness of breath and chest pains), in an effort to standardise the units in which health is measured, Loehman's study includes two levels of severity (mild and severe) and asked the respondents how much they were willing to pay for one, seven and 90 days of symptom relief. A similar approach to valuing other symptoms was adopted by Kenkel, Berger and Blomquist (1994). The use of the CVM in these studies is an attempt to overcome the limitations on the use of revealed preference methods imposed by joint production. As has been noted in chapter two, it is often not possible to value individual symptoms using revealed preference methods because a single averting behaviour alleviates multiple symptoms simultaneously. In theory, the expressed preference approach does not suffer the same fate, because Hicksian demand functions can still be estimated (see chapter two).

The CVM has also been used to value the health benefits from improved transport safety. A major study in this field is Jones-Lee, Hammerton and Philips (1985) which estimated the WTP for a reduction in the risk of dying in different forms of traffic accidents.

The valuation of health care interventions using this approach has also been advocated. Johannesson, Jönsson and Karlsson (1996, p.292) suggest that clinical trials could be evaluated in this manner:

> ...the results of the clinical trial could be used to describe the health consequences of different treatments and then these health improvements could be valued using the contingent valuation method in either a general population sample or a sample of patients with the disease under study.

Tolley and Fabian (1994) argue that this approach could be used to determine the level of research funds that should be devoted to incurable diseases, such as Alzheimer's disease and AIDS.

(ii) Valuing health care

The alternative approach is to value health care directly. This involves asking respondents what they would be willing to pay to receive health care, or alternatively how much they would contribute through an insurance premium or taxes to have the option of receiving care in future. This holistic approach requires respondents to weight up their preferences for the various outcomes of health care (both positive and negative) and then transform them into a single amount.

Studies include Johannesson, Jönsson and Borgquist (1991) and Johannesson et. al. (1991), both of which consider different treatments for hypertension. The former surveyed patients who were currently undergoing hypertension treatment. They were asked their WTP to continue treatment. The second study involved valuing a non-pharmacological treatment program. Again, users of the program were asked what they were willing to pay to continue receiving treatment after they had been involved in the program for 48 months. A more recent example of a contingent valuation experiment that has valued a health care service is Ryan (1996) who evaluated assisted reproductive techniques, such as in vitro fertilization.

From this brief review, it is clear that studies that have valued health and studies that have valued health care come from two quite different traditions within economics. Studies that have valued health have done so mainly within the context of evaluating quasi-public goods such as safety regulations or environmental protection. In contrast studies that have valued health care have *tended* to focus on preventative medical services and elective health care. It is the latter approach which is applied in the evaluation of mobile screening units in the next chapter.

7.3. The role of information in the evaluation of health care

It has long been recognised that the market for health care is characterised by product complexity, uncertainty and asymmetry of information between patient and doctor. Even before the seminal contribution by Arrow (1963), Musgrave (1959, p.13) had classified health care as a good which should be "considered so meritorious that [its] satisfaction is provided for through the public budget, over and above what is provided by the market". Unfortunately, Musgrave was not forthcoming on what made health care a "merit good" (McLure 1968). This was left to Head (1966) who argued that imperfect knowledge is its defining characteristic: "merit goods may be defined as those of which, due to imperfect knowledge, individuals would choose to consume too little"(p.216).

Imperfect knowledge can manifest itself in at least two ways: (i) a health care good is complex and many consumers are not be able to assess all of its attributes; and (ii) given that health outcomes are subject to uncertainty, consumers may have difficulty in perceiving the probabilistic nature of the benefits of health care. In these circumstances, the demand for health care goods can be considered a function of the information available to the consumer (Keeler 1995; McClellan 1995). If the consumer is supplied with more information, it may alter her choices. To illustrate this point, consider the two demand curves in figure 7.1 that represent a consumer's preference for a health care good (x_1) based on two different information sets. The inner demand curve denoted by **ab** represents the consumer's demand based on the current state of information available in the health care market. The outer curve **ac** represents her demand if she were more informed. If the price of x_1 is p_1^0, the individual consumes x_1^0 which is less than x_1^1, the quantity of care she would consume if she had more information. In this way, x_1 is a merit good, since the individual consumes a sub-optimal quantity of health care due to a lack of information. However, figure 7.1 illustrates only one side of the story. It is equally possible that imperfect information may result in over-consumption of x_1 if the market demand curve lies to the right of a demand curve based on a more comprehensive information set (e.g. see Dranove 1995).[1]

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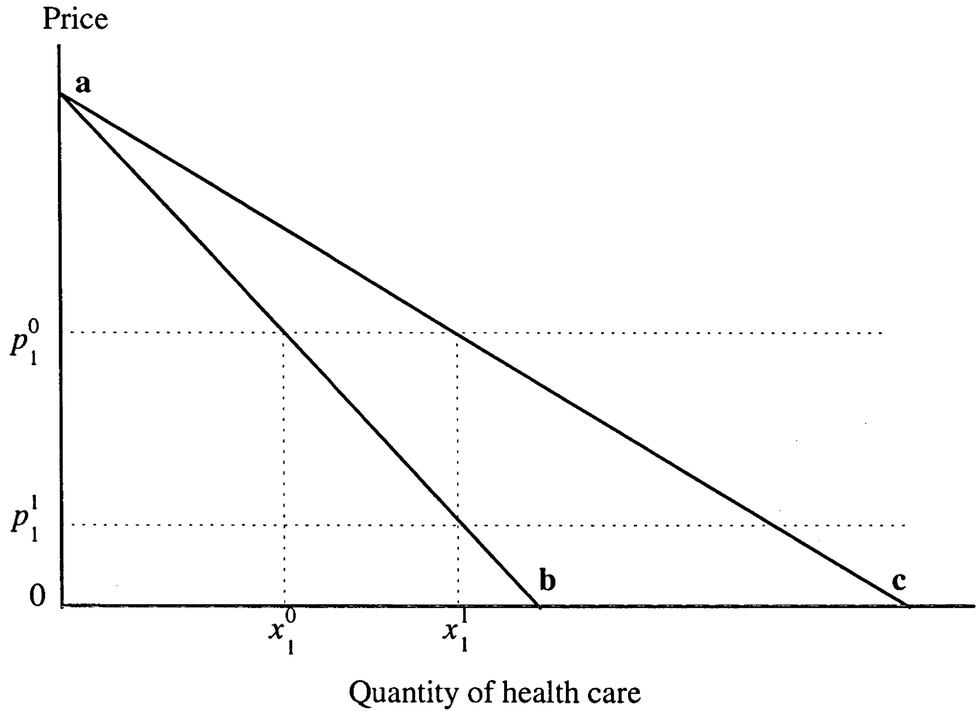
[1] One way of correcting the informational distortions is to offer the consumer a subsidy of $p_1^0 - p_1^1$ as a means of increasing their level of consumption on the inner demand curve to x_1^1 which is the level she would have consumed had she had more information at price p_1^0. In this way, imperfect information provides a rationale for the price subsidies that exist in most developed countries. However, there is a difficulty in implementing this type of corrective policy, since the price adjustment depends on the consumer's marginal valuation of the good. Different consumers may have different marginal valuations and so a uniform price reduction would not bring all consumers to x_1^1. As Sandmo (1983) suggests merit goods call for a system of individualised subsidies if the distortion in preferences is to be eliminated. An alternative to a price subsidy is to subsidise the dissemination of information. The discussion of an optimal subsidy implicitly assumes that distortions do not occur for other goods. People do not have full information with respect to many non-health care goods; especially but not exclusively capital goods.

Figure 7.1. Demand for health care based on different information



How does imperfect information affect the evaluation of health care benefits? Firstly, if the demand for health care is a function of information, the perceived benefits will also depend on the information available to the consumer in the health care market. This can easily be illustrated using figure 7.1. Consider a consumer who faces a zero price. If the consumer's demand curve is **ab,** then the total benefits of health care are represented by the triangle **ab0**. If she were supplied with more information, the total benefits would be **ac0**. The area between these two triangles (**abc**) is not captured by revealed preference methods. As Pauly (1995, p.115) notes: "If people are not completely informed, a risk may not be assigned the value it would have under full disclosure". Secondly, there is no reason why individuals have access to a uniform set of information. An important feature of many medical markets is "small area variation" which arise when a "person's chances of receiving a particular medical intervention depend heavily on geographic location" (Phelps 1995, p.253). One explanation for this phenomenon is that information supplied to consumers varies between regions (Phelps 1992). This means that consumers living in different regions, who may have the same underlying demand for health, can have different revealed preferences due to local (small) area variations in information supplied to them.

In these circumstances, stated preference methods, such as CVM, would appear to have an advantage over revealed preference methods, in that individuals can be provided with information on the health care good prior to being asked their WTP. Not only does this give them a minimum level of information with which to value the good, but it is also likely to decrease disparities in the information available to different individuals. In this way, the CVM may provide a means of measuring preferences that is more reliable than relying on preferences revealed through observed behaviour.

However, before endorsing the use of CVM in applied work, it is important to discuss what information should be provided to an individual before eliciting her preferences for health care goods. Theory provides little guidance on this issue; for example, Phelps (1995, p.254) refers to a "'fully informed' demand curve to which patients would move if they possessed full information about the value of medical services." The problem with this definition for the applied economist is that it provides no guidance as to what constitutes "full information". It cannot mean all the information that exists on a particular type of health care (i.e. all published and unpublished clinical trials, pharmacological evidence etc), because all but a few specialised individuals would be unable to process it. Instead, it must be possible to define a sub-set of information that individuals draw on when expressing (or revealing) their preferences. It is clear from the above definition that any information that has the potential to move the demand curve should be included in this "full information" set. Unfortunately, we encounter a fundamental problem in trying to define this set because it is impossible to know *ex-ante* what information influences an individual's marginal valuation of a good or service without first providing them with the information and seeing how it affects the process of valuation. Hence, it is not possible to filter out irrelevant information. This is another side of the fundamental paradox that Arrow believes is central to the problem of valuing information (Arrow 1962).[2]

Herein lies the crux of the problem. If a stated preference survey supplies an individual with more information than is available in the market, it is still open to the charge that her marginal valuation would be different if she were provided with additional or different information. Such sentiments have been expressed by Rice:

> The problem is that no matter how hard we try to improve information, it will not be sufficient to make patients able to judge the true marginal value of medical care services. (Rice 1993, p.210).

It is difficult to rebut this criticism by resorting to notions such as a "fully informed" demand curve since it is impossible for the researcher within a welfare economic framework to define an information set that should be provided to an individual for their preferences to be regarded as a reflection of their "true marginal values". It would therefore seem more sensible to define an optimal level that may fall short of "full information"—especially in the real world where information is not produced or communicated costlessly.

Developing a process by which an optimal information set is defined is a major challenge for health care contingent valuation research. In this regard three possible approaches should be explored. One way would be to conduct in-depth interviews with respondents to gain an insight into what information they are drawing on when answering contingent valuation questions. Such an approach is similar in form to a "verbal protocol" study in which respondents are asked to explain how they arrived at their answer (e.g. see Schkade and Payne 1993). Another way would be to conduct a study where respondents were not supplied with a standard information set, but allowed to ask the interviewer questions until they felt confident to express their WTP. A third approach would be to provide different sub-sets of respondents with different information to see how it affects their WTP.

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[2] The paradox Arrow highlights is that the purchaser does not know the value of information until she has the information, but then has acquired it without cost.

It is also important to recognise that institutions and mechanisms have developed in recent years that reduce informational deficiencies in the market for *some* types of medical care. As McClellan (1995, p.240) notes:

> ...health care purchasing agents demand not only medical care per se but also costly services to address information problems in the production of medical care. Purchases involving utilization review, managed care programs, and other such potentially [useful] information- or effectiveness-improving technologies are an inextricable part of the production of health care and demand for it... {"useful" has been added}.

It is not self-evident why an individual when provided with this level of information is not able to make decisions which reflect the true marginal value of health care (at the time of purchase), in the same way she makes decisions about other private goods based on imperfect information (e.g. the purchase of a automobile). Why then should her revealed preferences for health care not count? Further it is not always desirable to supply more information in a contingent valuation experiment before eliciting preferences. For example if the estimates of WTP from a contingent valuation experiment are to be compared with estimates from a travel cost model then participants in the contingent valuation experiment must be supplied only with information that is available in the market place.

In summary, the state of information in the health care market is a vexing issue for the applied welfare economist. In trying to resolve this issue it would seem useful to step back from the notion that agents require "full information" and instead recognise that there may be an optimal level of imperfect information. Having said this, it is still an open issue as to whether consumers suffer informational deficiencies in health care markets, and hence whether and to what extent it is necessary to provide agents with information before eliciting their preferences.

7.4 Motivations for contingent valuation responses

Mainstream economic theory sheds little light on how people form their preferences. As Simon (1986) notes, "neoclassical economics provides no theoretical basis for specifying the shape and content of a utility function". Instead it takes preferences as given and focuses on an examination of what choices people make using these preferences. It does not matter what motivates these preferences. Similarly, the importance of individual preferences in the allocation of resources is one of the fundamental ethical postulates of normative welfare economics. As Randall (1981,p.156) states: "Value, in the economic sense, is ultimately derived from individual preferences". In this way, if an individual prefers state A over state B, then state A is ascribed a higher value—the reason why state A is preferred over state B is not relevant.

It may therefore come as somewhat of a surprise that the respondent's motivation when answering stated preference questions has been a central theme in the debate over the validity of the CVM. This debate has taken place on two levels. The first level relates to whether the respondent's answers reflect her true preferences. Economists place great store on the methodology of revealed preference and consequently tend to display skepticism towards methods involving stated preferences (Hanemann 1996). Part of this skepticism is due to the belief that there are incentives for individuals to misrepresent their true preferences when responding to stated preference surveys. On the second level, there has been some debate as to whether certain types of preferences should be excluded or given less weight in normative analysis. This has included the criticism by Diamond and Hausman (1993) that contingent valuation responses reflect a general moral satisfaction (a warm glow) and a wider debate over the importance of altruistic values in cost–benefit analysis.

7.4.1 Strategic behaviour

The problem of strategic behaviour was first raised by Samuelson in his seminal 1954 paper on public goods. He believed that it was in the self interest of each individual to misrepresent her preferences for public goods. Strategic behaviour can come in two forms. The most common form is "free-rider" behaviour which occurs when respondents believe they can gain an advantage by understating their true WTP. To engage in such behaviour, respondents must believe that the amount they will pay for the good is related to the value they state and that there is a high probability of the good being provided even if they understate their true WTP

(Mitchell and Carson 1989, p.143). The second type of strategic behaviour occurs when respondents overstate their true WTP in the belief that provision of the good is positively related to the amount they state and that the amount they will end up paying is not related to this amount.

The problem of free-riding is not confined to public goods. As Culyer (1980) highlights, strategic behaviour can arise whenever there is doubt about the enforcement of a contract between the providers of a service and demanders, especially when the delivery of the service and payment does not take place at exactly the same time. This is a feature of most health care transactions, since the consumption of care is often not directly linked to payment (i.e. it is financed through insurance or tax contributions). The potential for free-riding leads to sub-optimal outcomes in the health care market.

A comprehensive discussion on the potential impact of strategic behaviour on contingent valuation responses is contained in Mitchell and Carson (1989). They suggest that incentives to engage in strategic behaviour depend on the respondent's: (i) perception of her payment obligation; and (ii) expectations regarding the provision of the good. They show that these incentives are minimised if a respondent perceives that she will pay the amount offered, and if the provision of the good depends on her stated preference.

There is an extensive literature which tests for strategic behaviour in contingent valuation studies (e.g. Milon 1989). Most studies have shown little evidence of strategic behaviour in the valuation of environmental public goods. These findings are supported by laboratory experiments which have shown that strategic behaviour is present, but at a much lower level than predicted by theory (Bohm 1995, p.105). For example, in a recent experiment reported in Anderoni (1995) approximately 75 per cent of subjects did not engage in free-rider behaviour. Of these, approximately half knew that they could free-ride, but chose not to, while the other half were confused about the incentives of the experiment. There are no studies that test for strategic behaviour in the provision of health care programs.

7.4.2. Are contingent valuation responses motivated by charitable giving?

Another motivation for contingent valuation responses has been put forward by Diamond and Hausman (1993) who argue that responses reflect moral satisfaction with the good or a "warm glow" from giving, rather than underlying preferences (also see Kahneman and Knetsch 1992). Although this argument has been formulated in the context of the assessment of environmental damage, it has a bearing on evaluation of health care—especially if individuals view their responses as akin to a charitable donation to alleviate the suffering of others.

Traditional theories of charitable giving model it as a donation to a privately provided public good (Becker 1974). Assume an individual is endowed with income y^i that she uses it to purchase a private good x^i and make a donation (g^i) to a charity. If there are n individuals and the charity receives no assistance from government then $G = \sum_{i=1}^{n} g^i$ is the total budget for the charitable public good. If the charity is a pure public good, the utility function is represented by:

$$U^i = U^i(x^i, G) \qquad (6.1.)$$

Eq. (6.1.) suggests that the individual's utility depends on the extent of charitable activities as a whole, rather than on the size of her own contribution to it. From the point of view of an individual, her own contributions and the rest of the community's contributions are perfect substitutes. However, the former involves a reduction in the use of x^i, while the later involves no such sacrifice (Cornes and Sandler 1986). Hence, charitable giving should be characterised by free-riding behaviour, but this is often not borne out in real world behaviour (Sugden 1984). In practice a large number of people make donations to charities, especially those charities contributing to improvements in human health. One way of overcoming these shortcomings is to assume that charitable giving is motivated not *only* by the extent of charitable activity (G), but also by a "warm glow" from giving (Andreoni 1990). Here the utility function is of the form:

$$U^i = U^i(x^i, g^i, G) \tag{6.2.}$$

In Eq. (6.2.) individuals gain utility both from the overall extent of charitable activity and their contributions to it (g^i). The later may be due to social pressure to contribute to charities. For example, donating to a charity may increase social acceptance or avoid the discomfort of having to refuse a request to donate (Diamond and Hausman 1993, p.28). A person with a utility function of this form has been termed *impurely altruistic*. The pure public good model can be seen as a special case of Eq. (6.2.) when $g^i = 0$. At the opposite extreme, $U^i = U^i(x^i, g^i)$ in which case there is no public good aspect to charitable giving. Such an individual can be regarded as purely *egoistic*.

Diamond and Hausman (1993, p. 27) draw heavily on this theory to explain responses to contingent valuation questions concerning public goods:

> If people give charitable contributions in *large* part for the pleasure of giving, then it is also plausible that they will give large answers to CV questions asking them to evaluate environmental improvements.... For hypothetical contributions, one can achieve a "warm glow" from an *unlimited* number of large answers.{emphasis added}

To translate their argument into a health care context, consider a contingent valuation study that values a new mammographic facility. If an individual's WTP reflects the warm glow, their responses do not reflect the effectiveness of the new facility, but rather the utility of being seen to give to a worthy cause. Further, Diamond and Hausman believe that this warm glow does not represent a legitimate value and should therefore be excluded from valuation of the benefits of the program.

How is the warm glow reflected in responses to contingent valuation surveys? In order for the "warm glow" hypothesis to be a useful theory it must be refutable in that it is possible to make logically valid predictions and to compare them with actual human behaviour (Silberberg 1990, pp.12-13). In this case, the behaviour at issue involves responses to contingent valuation questions and so Diamond and Hausman must establish a logical relationship between the "warm glow" and the presence of certain behaviours when responding to contingent valuation questions. In the above quotation they suggest that the warm glow will be maximised if respondents reply with an *unlimited* number of large answers. Although they do not justify why the "warm glow" will produce this behaviour it does provide a prediction that enables their hypothesis to be empirically tested (e.g. see Smith 1996b). However, a difficulty arises here, because in later work Diamond (1996, p.69) suggests that the warm glow will produce exactly the opposite behaviour:

> From the perspective of warm glow, it is interesting to consider the *typical* pattern for responses when people are asked in succession for WTP for two different causes. Generally, this results in a decrease in the WTP for the cause that is asked about second. One interpretation of this finding that has been made is that one is observing two goods that are substitutes. *An alternative interpretation is that the substitutatbility occurs in the warm glow rather than in the environmental commodities.* {emphasis added}

Instead of warm glow producing an unlimited number of large answers it now produces a decrease in the WTP for the second and subsequent questions. If both of these behaviours are caused by the "warm glow", then it is consistent with such a wide range of behaviours that their hypothesis appears impossible to refute. Instead it seems to be more an assertion about what Diamond and Hausman believe are motivations behind WTP responses.

7.4.3. The valuation of altruism

Altruism arises whenever people are concerned about the wellbeing of others. Altruism within the family has been widely recognised since Becker (1974) who argues that individuals not only maximise 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. It is also possible that altruism extends beyond the family, because individuals might be concerned about members of society outside their social group (see Culyer 1971). Both forms of altruism can influence an individual's WTP for a health care program that affects others.

In its most general form, altruism can be modelled as an interdependence between utility functions. Consider an individual who derives utility not only from the consumption of private goods (previously defined as x^i) and her health status (H^i), but who is also concerned about the wellbeing of another individual (r). This individual's utility function can be represented by:

$$U^i = U^i(x^i, H^i, U^r(x^r, H^r)) \qquad (7.3.)$$

Such an individual is often regarded as displaying *non-paternalistic* altruism, because any change that increases individual r's utility will in turn increase the utility of individual i.

This is not the only form of altruism that can exist. It has often been observed (e.g. Tobin 1970; Culyer 1980; Pauly 1992) that in most societies there is stronger support for increasing access to certain basic goods, such as health care, than increasing equality in the distribution of income per se. This may be due to individuals only being concerned about some aspects of the wellbeing of others. For example, the utility function of an individual that is only concerned about another individual's health can be represented by:

$$U^i = U^i(x^i, H^i, U^r(H^r)) \qquad (7.4.)$$

Eq. (7.4.) has been termed *health focused* altruism. It is theoretically possible that altruism may be *non-health focused*, in which case x^j rather than H^j would appear in the utility function.

There has been much recent debate on the importance of quantifying altruism when undertaking a cost–benefit analysis. This issue is highly relevant to the CVM since a respondent's WTP may in part reflect "non-use" values such as altruism. One side of this debate has argued that altruism should be given lesser (or no) weight when calculating the benefits of a program. As Milgrom (1993, p.420) states:

> *...the part of willingness-to-pay (WTP) that arises on account of altruistic feelings must be excluded from the benefit-cost calculation in order to identify correctly the projects that are potential Pareto improvements.* {emphasis in original}

Jones-Lee (1991, 1992) offers some support for this view since he has shown that a society where some or all individuals are *non-paternalistic* the altruistic component of their WTP can be ignored since the marginal benefits and costs are scaled up by the same factor. However, the conditions under which this result holds are limited. Firstly, this only occurs for a marginal change and society must be at the *social welfare optimum* (i.e. the marginal social utility of income is equal across all individuals) (Johansson 1995, p.132). Secondly, it only holds for non-paternalistic altruism, importantly if altruism focuses only on one aspect of wellbeing (e.g. health- focused altruism) then it should be taken into account (Jones-Lee 1991). Finally, it is difficult to see why impure altruism (as discussed in the previous section) should be excluded, because the "impure altruist" gains a "warm glow" benefit regardless of the effect of her charitable donation. The implications of each of these factors for health care contingent valuation studies have yet to be fully resolved. In these circumstances Johansson (1995) suggests collecting information on an individual's total WTP and the WTP for her own health.

7.5 The implementation of the contingent valuation method

7.5.1 Elicitation methods

Early contingent valuation studies used an open-ended valuation question in which the respondent is asked to state her maximum WTP. Since this method of valuation is generally unfamiliar to respondents, it tends to result in a high rate of non-response and a significant proportion of respondents stating a zero WTP (Mitchell and Carson 1989, p.97). The latter are commonly referred to as "protest zeros". Several alternative methods of elicitation have been developed to assist the respondent in expressing their WTP.

One of the first was the sequential bidding game in which a bid is offered to the respondent who accepts or rejects it. Higher or lower amounts are then offered in subsequent rounds of bidding until the respondent's maximum WTP is ascertained. The main argument in favour of using sequential bidding over open end questions is that it imitates an auction. However, there is a major shortcoming with this method known as "starting point bias" which arises when the starting bid influences the final WTP. Many studies applying the bidding game format display this bias (e.g. Cummings et. al. 1986; Roberts et. al. 1985; Boyle et. al. 1985).

In order to overcome this problem, Mitchell and Carson developed the payment card method. This involves showing respondent a card with a range of values from $0 to a large amount. The respondent is then asked: "Which amount or any amount in between is the most you would be willing to pay" (Mitchell and Carson 1989, p.100). The method can also lead to bias, because the range and spacing of the amounts offered can influence the final WTP.

Shortcomings with both methods led to the development of a dichotomous choice survey format in which the respondent is offered a single bid and this amount is randomly varied between respondents. This approach was developed by Bishop and Heberlein (1979) in an experiment designed to value goose hunting permits. The dichotomous approach has its foundations in the random utility model. The main advantage of the method is that it places less burden on respondents, because it only requires them to state if they are willing to pay *at least* the amount offered. In this respect a respondent provides a lower bound if she answers "yes" and an upper bound if she answers "no" to their maximum WTP (Hanemann and Kanninen 1996). Hereinafter, this approach is referred to as the single-bounded (SB) approach. Arrow et. al. (1993) recommend this format over open-ended questions in their report to NOAA.

A shortcoming of the SB approach is that it is statistically less efficient than the open-ended format and so it requires much larger samples to achieve the same level of precision. One way of improving statistical efficiency is to add a follow-up question in which the respondent is asked if she would pay a higher or lower amount depending on the response to the first question. The extra information that the double bounded (DB) model provides reduces the variance of the estimator for the mean WTP (Hanemann, Loomis and Kanninen 1991). Both methods are illustrated in the empirical application discussed in the next chapter.

7.5.2. Optimal Design

The purpose of an optimal design is to construct the contingent valuation experiment so that for a given sample size it produces the maximum information on the estimators of interest. Unlike the open-ended approach, dichotomous choice questions require the researcher to formulate a range of bid values prior to conducting the survey. These values must be carefully chosen, because a poor bid design can lead to bias and large variances in the estimates of the WTP.

In an effort to improve bid design, contingent valuation researchers have drawn on experimental design work conducted in the bioassay field where similar statistical models are used to predict the dose–response relationship between levels of exposure to a substance and the subsequent effect on animals or insects. This dose–response relationship is often modelled using probit or logit models, where the independent variables are the dose and the characteristics of the animal and the dependent variable is the resulting behaviour (Kanninen 1993). In a contingent valuation study the bid represents the dose and subject's response ("yes" or "no") the dependent variable.

An optimal experimental design depends on the criteria that the researcher is attempting to maximise. Different criteria produce different optimal designs. For example, if the design criterion is to minimise the asymptotic variance of the estimates of WTP, then the bid vector should consist of just two values either side of the true mean (Kanninen 1993). Alternatively, if the researcher wishes to test the distributional assumptions of the fitted binary response model then a range of bid values is required in order to "trace out" the WTP distribution (Alberini 1995). This is particularly true of the upper tail of the distribution, because assumptions about the shape of the right hand tail are likely to have a dramatic impact on the mean (Johansson 1995, p.112).

Unfortunately, the optimal design literature assumes that the researcher knows the true parameter values before conducting the survey. In experimental bioassay research this is often not a problem since many studies involve the replication of previous results. In these circumstances, the researcher has a good idea of what the true parameter values might be. This is rarely the case when conducting contingent valuation experiments, because most studies attempt to quantify values about which we have little prior knowledge. Consequently, the adoption of a narrow range of bids such as the two-bid design suggested by Kanninen is a risky strategy, because the survey data is uninformative if the real parameter values fall outside the expected range. In this respect, the DB approach has an advantage over the SB approach in that it is much more robust if the bid vector is poorly chosen, because the follow-up bids which are either half or double the initial bid, are likely to fall closer to the individual's true WTP. For example, if the initial bid vector is too high, the majority of respondents will refuse the initial bid and be offered a lower bid that could be more informative.

In practice, most contingent valuation studies adopt the more conservative design strategy of conducting a pilot survey with a bid vector spread over a wide range. Using the responses from this pilot survey, the bid vector is reduced to five or 10 different values over a narrower range. An alternative approach is a sequential design in which a sub-set of the sample is collected and then estimation is used to improve the design before collecting another set of observations. Nyquist (1992) suggests that an optional design would place one bid at the median WTP since this ensures maximum variation in responses for this bid. Kanninen (1993) illustrates that up to four stages of data collection and estimation significantly improve the efficiency of estimation.

7.5 Summary and conclusions

This chapter has discussed several aspects of contingent valuation that have received less attention in the existing health care literature. The common theme of this chapter is that these issues provide background material on some of the theoretical aspects of the empirical application involving mobile breast cancer screening units which is developed in the next two chapters.

Section 7.2 provides a brief history of the use of the method in environmental and health economics. The method was originally intended to overcome the "zero-price" problem associated with recreation areas. It was then extended to measure non-use values associated with the environment (e.g. option value). The health care applications of the method have largely been in line with its initial development in environmental economics in that they have primarily been concerned with quantifying "use values".

The role which information plays in influencing the value of health care goods and services is a complex issue. It has been argued that individual values in part depend on information so the degree to which patients are informed of treatment options is likely to influence their revealed preferences. For this reason, the CVM may have an advantage over revealed preference methods, because it supplies respondents with information before eliciting their WTP. The question that then arises is what information should be supplied as part of the contingent valuation experiment. In trying to answer this question it would seem necessary to abandon the notion that agents require "full information" and instead recognise that there may be an optimal level of imperfect information.

Section 7.4 addresses three issues relating to the motivations behind responses to contingent valuation surveys. Firstly, responses may be motivated by "strategic behaviour" which arises when individuals misrepresent their true preferences by under or overstating their true WTP. Secondly, it has been suggested by Diamond and Hausman that respondents could be motivated by a "warm glow" associated with giving. Finally, respondents could be motivated by altruism in that they may be concerned about the health of others.

The final section provides an overview of the various elicitation methods and optimal design issues that arise when conducting contingent valuation surveys.

Chapter 8

Estimating the welfare benefits of mobile mammographic screening using the contingent valuation method

> The Committee believes that mobile units play an important role in facilitating access to screening for women in rural areas..., but it may be inappropriate to use mobile units in certain metropolitan areas where there are already fixed screening units available (Senate Standing Committee on Community Affairs 1994, p.21)

8.1 Introduction

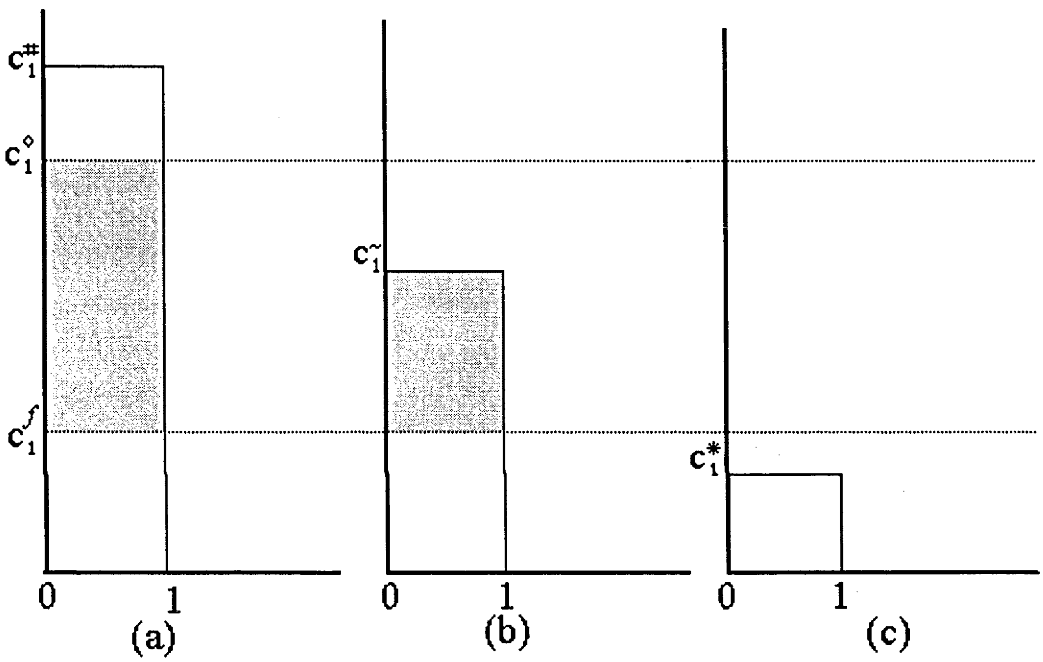
In chapter six, the travel cost method was used to quantify the benefits of introducing mammographic screening units in rural areas of New South Wales. This involved estimating a demand curve based on the time and travel costs of women at various distances from screening facilities. The benefits of reducing travel distance through the introduction of mobile screening facilities was then estimated using this demand curve. In this chapter, the contingent valuation method (CVM) is applied to the same problem in order produce comparable estimates using stated preference methods.

8.1.2 Benefits of mobile mammographic screening

If a mobile screening unit visits a town that does not have a permanent mammographic screening facility, women who use the service benefit by having to travel a lesser distance to have a mammogram. Recall from chapter six that women using a local service can reduce their time and travel costs when they have a mammogram. The total cost of attending a screening unit was shown to be $c_1 = p_1 + wt_1$, 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 women must travel to have a mammogram. It is useful at this point to review the measures of welfare change derived in chapters three and six.

Consider a town in which a woman must incur a cost of c_1^0 to have a mammogram at a permanent facility located outside her town. If a mobile screening unit visits the town, her access cost is reduced to c_1^f. The welfare benefits differ from the divisible case, because a mammogram is a "binary good". The population of women eligible for screening can be divided into three groups which are illustrated in figures 8.1(a) to 8.1(c).

Figure 8.1. The welfare benefits from a visit by a mobile screening unit



The three figures represent women with three different marginal valuations for a screening mammogram (denoted by $c_1^\#$, $c_1^\sim$ and c_1^*). These critical access costs represent their willingness to pay (WTP) for a mammogram. Figure 8.1(a) represents a woman who is prepared to travel to a permanent facility, because her critical access cost 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 8.1(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 the critical cost at which she chooses not to have a mammogram (i.e. $c_1^f - c_1^\sim$).

The final figure 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 benefit from the visit of a mobile screening unit.

As has been discussed in the previous chapter altruism should be taken into account when it is paternalistic, in that it stems from concern about one aspect of wellbeing rather than general welfare (e.g. concern about the other people's access to health care). Since these values are not reflected in market behaviour they cannot be valued using indirect methods such as the TCM.

8.2 Methods

A contingent valuation experiment was performed on 458 women who were resident in 19 randomly selected rural New South Wales towns. These towns represented all but one of the towns involved in the *Cancer Action in Rural Towns* (CART) Project (see chapter six).[1] The CART project is a randomised control trial of a community-wide intervention to promote behavioural change relating to skin, breast, cervical and lung cancer. A matched pairs design was used, with one town from each pair randomly allocated to either the experimental or control group. Towns were matched to take account of demographic characteristics such as age, ethnicity, occupation and education levels, as well as geographic location, geographic isolation (estimated from population density) and average summer temperature (CART Project Team 1993).

In experimental towns a community action intervention was implemented over a two-year period with the aim of reducing the incidence of breast, cervical, skin and smoking-related cancers. This involved the formation of a community committee to initiate and maintain health promotion interventions over the life of the project. As part of the project, baseline (pre-intervention) data was collected using a random community survey of individuals between the ages of 18–70 years in all 20 towns (November 1993 to March 1994). Female respondents were asked additional questions relating to their travel costs; some of these data were used in the travel cost model estimated in chapter six.

[1] The valuation of mobile units was not directly related to the evaluation of the CART project. Instead it is an example of how joint production can lower the cost of conducting experimental research!

A follow-up survey on a sub-set of women who participated in the CART baseline survey was conducted as part of the CART project in order to examine the effects of the intervention on their cancer-related behaviour. However, unlike the previous travel cost study, the contingent valuation experiment was conducted separately. This was necessary, because the contingent valuation protocol (see below) involved sending subjects information on breast cancer and mammographic screening prior to the telephone interview. The distribution of this information sheet conflicted with one of the medical objectives of the CART project, which was to assess the subject's knowledge of mammographic screening. It was therefore decided to conduct a separate contingent valuation survey on a sample of women who were included in the baseline survey, but who were not going to be interviewed as part of the CART follow-up survey.[2]

8.2.1 Description of the contingent valuation survey

The survey protocol was as follows. All women were initially sent a letter informing them of the study. Enclosed with this letter was an information sheet that included a question on their WTP for a mobile screening unit to visit their town. The letter also contained a reply paid card (see appendix B) to enable subjects whose phone numbers had changed in the intervening three-year period to pass on this information. In all, 15 women returned these cards and were contacted on the new telephone numbers supplied. All subjects were telephoned in the evening by experienced telephone interviewers employed by a market research company (Purdon and Associates). The survey instrument and protocol was approved by the Ethics Committee of the Australian National University. Of the 595 women in the sample, 131 could not be contacted, 6 refused to participate or had died since the last survey, leaving a total of 458 completed interviews (a participation rate of 77%).

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[2] The sample consisted of non-smokers aged more than 40 years at the time of the survey. The smokers were removed from the sample because they were required for other aspects of the CART project. Although removal of smokers was unfortunate, it was decided that the benefits of having a sample of women in the age group who had consented to participate in a follow-up survey outweighed the disadvantage of having a sample that was not representative of the general population.

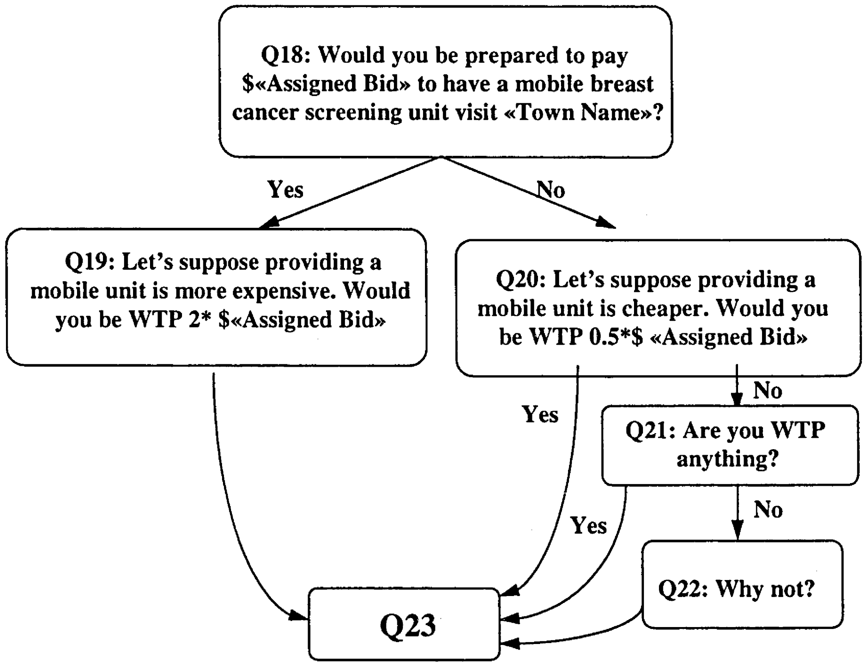
Design

A hybrid mail–telephone survey was used to ascertain the WTP for mobile mammographic screening units. Initially women were contacted by mail and provided with an information sheet (see appendix B) which included two questions: (i) "Would you use a mobile unit to have a mammogram if it visited «Town Name»?"; and (ii) "Would you be prepared to pay «Assigned Bid» to have a mobile breast cancer screening unit visit «Town Name»?". Respondents were then informed that these questions would be asked again in the telephone survey and that they were included in the information sheet so as to provide them with an opportunity to think about the issue before being interviewed. The fields, «Town Name» and «Assigned Bid» related to the respondent's residential location and the randomly selected bid. Each of the information sheets and telephone surveys contained different fields to enable the questions to be tailored to each individual.

The telephone survey was then conducted. Most subjects were contacted by telephone one to three weeks after receiving the information by mail. The telephone survey was divided into three sections (see appendix B). The first section collected background information on the respondent, such as their date of birth, occupation and whether she had knew anyone who had been diagnosed as having breast cancer in the last five years. The second section contained questions relating to screening behaviour over the previous five years and formed the basis of the TCM to be discussed in the following chapter. The third section set out the contingent valuation scenario and asked respondents their WTP for a visit by a mobile unit.

A double-bounded dichotomous choice format was used in the telephone survey in which each respondent was offered a randomly selected bid and then offered a higher or lower follow-up bid depending on their answer to the initial question (see figure 8.2). The bid amount in the initial WTP question matched that provided on the information sheet. If the respondent refused the initial bid she was offered approximately half the amount. Alternatively if she accepted the initial bid she was offered approximately double the amount. Respondents were also given the option of stating they "didn't know" whether they would accept the initial bid. In this case they were offered half the amount of the initial bid in a follow-up question to determine whether their "don't know" response was due to being indifferent to the initial amount offered or as a result of having difficulty expressing their preferences.

Figure 8.2. Flow diagram of the WTP questions



The adoption of a double-bounded format requires the researcher to select a bid vector. In line with the literature on optimal design (see chapter seven), the survey was conducted in two batches. The first batch consisted of 400 women randomly selected from the sample with the initial bids amounts ranging from \$5–\$200 (i.e. \$5, \$20, \$50, \$100, \$150, \$200) and the follow-up bids ranging from \$2–\$400 (see table 8.3). After 150 surveys had been conducted, Kriström's non-parametric method was applied and two additional bids of \$75 and \$300 were added to the bid vector (see below). The former was added because it was close to the median WTP and the latter because it assisted in the estimation of the right-hand tail of the distribution. The second batch of 195 surveys was then dispatched.

Another important feature of the survey was that respondents who rejected both the initial and follow-up bids were asked an additional question on whether they were willing to pay anything for the service. This allowed the respondent to be classified as either having a zero WTP or a WTP that is less than the lower bid. Women who refused to pay anything for the service were asked to provide a reason.

Development

The survey instrument was developed in a series of stages. The survey was initially tested on a focus group of female employees at their workplace. It was then piloted on 25 women in one of the rural towns. The pilot survey contained an additional section that was designed to assess the length and acceptability of both the survey and the information sheet (see Appendix B). The final survey was conducted in two batches from October to December 1996.

8.3 Descriptive statistics

Table 8.1 lists the characteristics of respondents. The average age of the respondents was 58 years. More than 39 per cent of the respondents had a gross household income of less than $15 000 (many of these were recipients of the aged pension). For most respondents (69%), the highest level of education attained was junior high school, which means that they received 10 years or less of education.

Table 8.1. Personal characteristics of the survey respondents (n = 458)

Variable	Values	Numbers (%)
Age	40–49	132 (29%)
	50–59	138 (30%)
	60+	189 (41%)
	NR	0
Education	Junior high school	318 (69%)
	Senior high school	48 (11%)
	Technical college	40 (9%)
	University	44 (9%)
	Other/NR	8 (2%)
Employment status	Employed	189 (41%)
	Unemployed	1 (0%)
	Out of the labour force	169 (37%)
	Retired	97 (21%)
	NR	2 (0%)
Household Income (Gross)	<$15 000	180 (39%)
	$15 000-30 000	109 (24%)
	$30 000-45 000	66 (14%)
	$45 000-60 000	42 (9%)
	$60 000-75 000	15 (3%)
	$75 000-90 000	6 (1%)
	$90 000 +	10 (2%)
	NR	29 (6%)

NR = Non response.

Table 8.2 gives an indication of respondents' personal experience of breast cancer and mammographic screening. In all, 61 per cent of respondents knew someone who had suffered from breast cancer and 76 per cent had had at least one mammogram in the last five years. A majority of respondents (79 %) stated that they would use a mobile unit if it visited their town, and 92 per cent could remember receiving the letter and information sheet.

Table 8.2. Knowledge and experience of breast cancer and mammographic screening

Variable	Value	Number (%)
Knew someone with breast cancer (Q3)		
	Yes	278 (61%)
	No	171 (37%)
	NR	9 (2%)
Number of mammograms in last five years(Q5)	One	110 (24%)
	Two	158 (34%)
	Three or more	80 (17%)
	None	109 (24%)
	NR	1 (0%)
Would use a mobile screening unit if it visited their town (Q17)		
	Yes	364 (79%)
	No	78 (17%)
	DK	14 (3%)
	NR	2 (1%)
Received the information sheet (Q16)		
	Yes	415 (92%)
	No	34 (6%)
	DK	6 (1%)
	NR	3 (1%)

NR = Non response ; DK = "Don't know"

Table 8.3 lists the responses to the different bid amounts offered in the initial and follow-up WTP questions. The left hand side of the table lists the responses to the initial WTP question for each bid (Q18). The right hand side lists the responses to the higher or lower follow-up bids (Q19 and Q20). The table can be interpreted as follows: in total 60 women were offered the lowest bid of $5. Of these, 51 accepted, six refused and three expressed no preference. The 51 women who accepted were then offered a bid of $10. Of these, 44 accepted, six refused and one woman expressed no preference. The six women who declined and the three women who expressed no preference to the initial bid of $5 were offered the lower bid of $2. Of these, only two women accepted, five women declined and two women expressed no preference. The responses for the other bids can be interpreted in a similar manner.

Table 8.3. Summary of responses to the initial and follow-up WTP questions

Initial Bid	Response	No.	Follow-up bid	Response	No.
$5	Y	51	$10	Y	44
	N	6		N	6
	DK/NR	3	$2	Y	2
				N	5
				DK/NR[#]	3
$20	Y	37	$40	Y	20
	N	14		N	12
	DK/NR	4	$10	Y	2
				N	11
				DK/NR	10
$50	Y	28	$100	Y	13
	N	28		N	14
	DK/NR	2	$25	Y	9
				N	20
				DK/NR	2
$75	Y	26	$150	Y	14
	N	27		N	9
	DK/NR	3	$40	Y	9
				N	20
				DK/NR	4
$100	Y	31	$200	Y	11
	N	29		N	16
	DK/NR	3	$50	Y	13
				N	18
				DK/NR	5
$150	Y	16	$300	Y	3
	N	38		N	12
	DK/NR	3	$75	Y	9
				N	27
				DK/NR	6
$200	Y	14	$400	Y	4
	N	53		N	8
	DK/NR	1	$100	Y	14
				N	34
				DK/NR	8
$300	Y	6	$500	Y	0
	N	34		N	5
	DK/NR	3	$150	Y	8
				N	28
				DK/NR	2

DK = "Don't know"; NR = Non response; Y = Yes; N = No.

[#]DK and NR from both follow-up questions have been combined

The final table in this section examines the relationship between having a WTP that is greater than zero and the intention to use the mobile screening unit. A contingency table classifying each respondent according to her response to Q21 and Q17 is presented in table 8.4. On the basis of the responses to both questions, it is possible to gain some insight into the motivations of the respondents. If they were willing to pay something and intended to use the unit they can be classified as "users" (296 women). On the other hand if they intended to use the unit, but were not willing to pay anything, they were "free-riders" (64 women). Similarly, if they did not intend to use the unit, but were willing to pay something, they were classified as "altruists" (36 women). Finally, if they did not intend to use or pay for the unit they were "non-users" (41 women).

Table 8.4. The association between intended use and a positive WTP (n = 458)

	Would you use the unit if it visited «Town Name»? (Q17)		
Would you be willing to pay something? (Q21)	**Yes**	**No**	**Don't Know**
Yes	296(users)	36 (altruists)	7
No	64 (free-riders)	41 (non-users)	1
Don't know	4	1	7

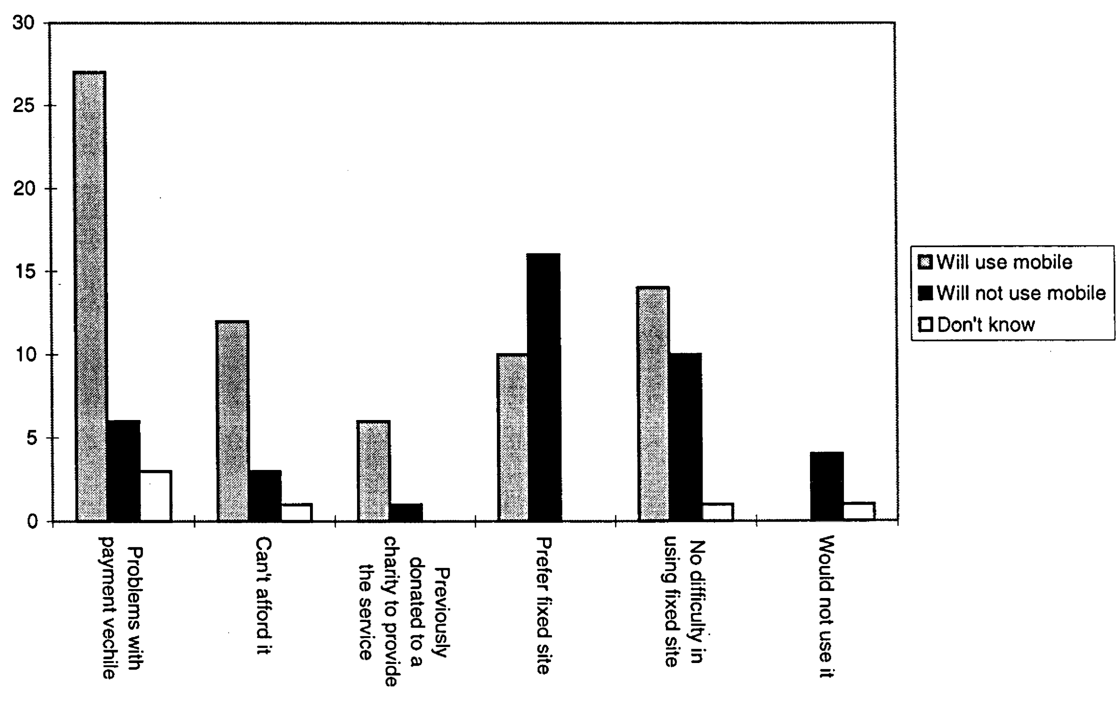
NR = 1.

8.3.1 Zero willingness to pay and protest responses

A total of 106 women (23 per cent of the sample) declined to pay anything for the good (see table 8.4). These respondents along with 12 respondents who stated they "didn't know" were asked a follow-up question on why they had answered in this way (Q22). This question prompted a wide variety of responses, some of which are reproduced in appendix C. On the basis of these responses, women with a zero WTP were classified into six categories (the number of respondents in each category are given in parentheses): (i) problems with the payment vehicle—"I already pay too much tax"(36 women); (ii) not being able to afford to make a payment—"I can't afford it"(16 women); (iii) having previously made a payment to a charity to provide a mobile screening service (7 women); (iv) prefer to use the substitute site (26 women); (v) felt it was just as easy to travel to the substitute site (25 women); (vi) not intending to have a mammogram (5 women). As Michell and Carson (1989) have noted it is important to distinguish between respondents who have a genuine zero WTP and protest zero responses, the later being respondents who state a zero WTP because they "reject the evaluation process itself for one reason or another"(p.267). Under this definition responses that are classified in either categories (i) or (iii) can be regarded as protest zero response. All the other reasons *could be* motivated by a genuine zero WTP. The responses of a further three women could not be classified into any of these categories.

Figure 8.2 graphs the number of women in each of the six categories who stated that they would or would not use the mobile unit (Q17). All categories except the last (i.e. those women not intending to have a mammogram) contained women who stated that they had a zero WTP, but intended to use the mobile unit (i.e. free-riders). The estimate of the number of free-riders should be regarded as conservative, because some women who stated they did not intend to use the unit may change their mind if it visited their town.

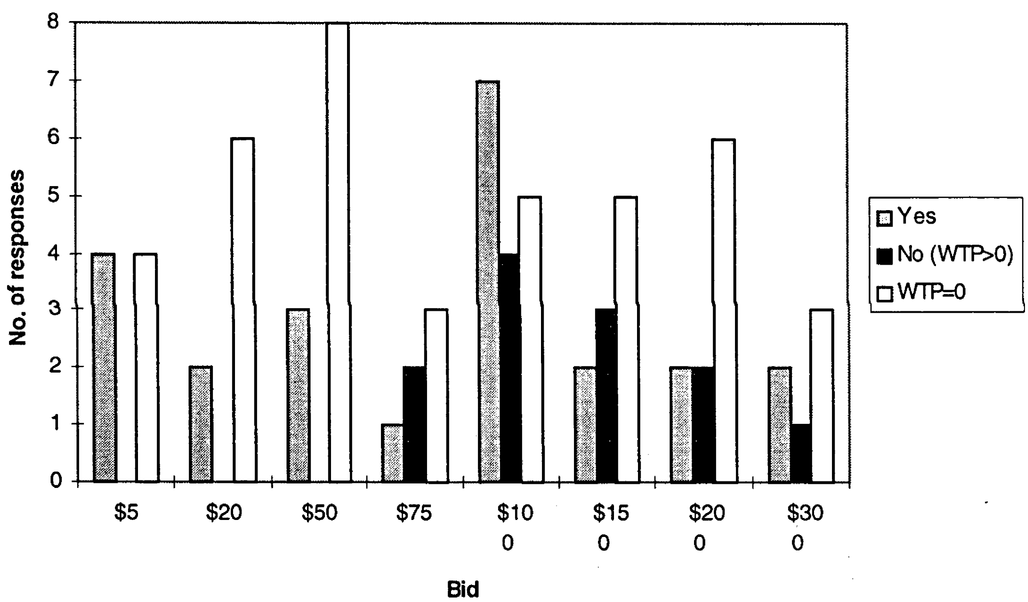
Figure 8.3. Reasons for a zero willingness to pay by intended use



8.3.2 Non-users WTP responses

Some insight into the nature of altruism can be gained by examining the responses of the 77 women who stated that they did not intend to use the mobile unit. Figure 8.4 shows their responses to the initial WTP question. Interestingly, the proportion of respondents accepting the amounts offered is roughly constant across the entire range of bids.[3] While all respondents who rejected the first three bids ($5, $20 and $50) stated they had a zero WTP. This is in contrast to response of women who intended to use the unit— their WTP decreased as the size of the bid increased (see below).

Figure 8.4. The responses of non-users to the initial WTP question



8.4 Estimates of the WTP for a mobile screening unit

The WTP for a visit by a mobile screening unit was estimated in several ways. Firstly, a simple non-parametric method was used to estimate the mean and median WTP. Secondly, a single-bounded (SB) model was applied, based on responses to the *initial* WTP question. Finally, a double-bounded (DB) model was developed using the response to both the *initial* and *follow-up* WTP questions.

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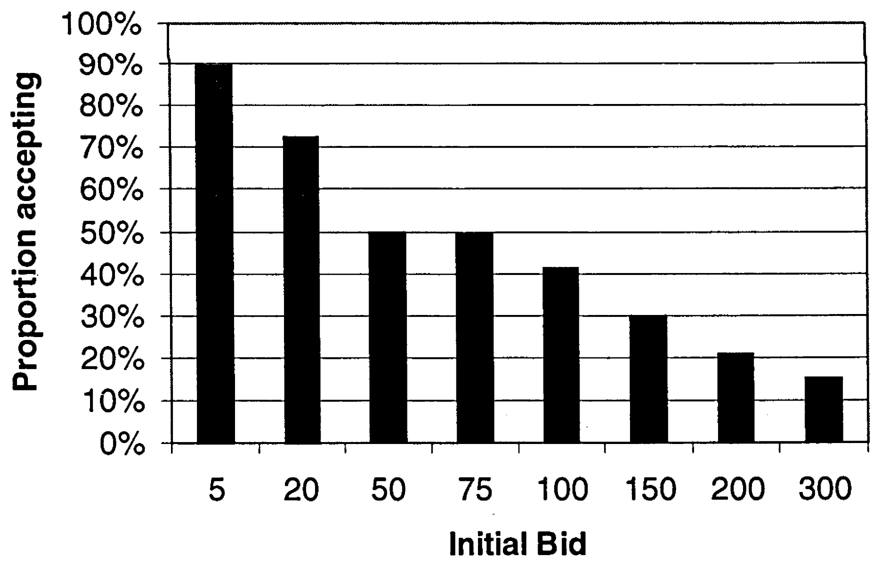
[3] Such behaviour is consistent with the view of Diamond and Hausman (1993) that charitable payments do not decline with the level of the bid (see chapter seven).

8.4.1 Non-parametric analysis

The proportion of positive responses to the initial WTP question is set out in figure 8.3 below. Kriström (1990) has developed a non-parametric approach for estimating the mean and median WTP. It uses linear interpolation based on the proportion of "yes" responses to estimate an empirical survivor function. [4] Using this function, the median is the amount where the proportion of "yes" responses is 0.5. The mean is more difficult to calculate, because it requires the researcher to make an assumption about the shape of the right-hand tail of the distribution beyond the highest bid. Kriström uses linear extrapolation based on the proportion of "yes" responses for the highest and second highest bids as means of determining the point where the survivor function crosses the x-axis. The estimated mean WTP is the area under this function. Using this approach, the mean and median WTP were estimated to be $105 and $75 respectively.

Figure 8.5. The survivor function[5] for the initial willingness to pay question (n = 438)*



*20 DK/NR responses have been removed

[4] In order to calculate the mean and median WTP using Kriström's method, the "don't know" responses have been deleted from the sample.
[5] The survivor function must be a non-increasing sequence of proportions and so the procedure outlined by Kriström (1990) is used to adjust the proportion accepting the bid of $100 below that of proportion accepting the $75 bid.

8.4.2 Parametric analysis: Single bound dichotomous choice model

A SB dichotomous choice contingent valuation model was applied based on responses to the initial WTP question. Although this approach is less statistically efficient than the DB dichotomous choice model presented in section 8.4.6, it is easier to estimate and does not suffer from the potential bias that can be introduced if the same respondent is asked consecutive WTP questions. As has been noted in chapter seven, the SB approach is based on the RUM which involves specifying a utility function to represent a woman's decision on whether to accept the initial bid.

Recall from chapter three that the universal conditional utility function can be represented by:

$$V_j(z_j, y^i, S^i) = W_j(z_j, y^i, S^i) + \varepsilon^i_j \qquad (8.1.)$$

where W_j is a "universal" utility function. In this case z_j denotes whether the individual accepts the bid (i.e. $z_1 = 1$ represents acceptance and $z_0 = 0$ represents rejection), y^i is income and S^i is a vector of other characteristics of the consumer and ε^i_j are errors of observation. The *i*th respondent accepts a given bid amount (B^i) when:

$$W^i_1(1, y^i - B^i, S^i) + \varepsilon^i_1 > W^i_0(0, y^i, S^i) + \varepsilon^i_0 \qquad (8.2.)$$

By assuming a joint probability function on {ε^i_j}, the decision can be reformulated in probabilistic terms:

$$\Pr(WTP \geq B^i) = 1 - G(B,S) = \Pr[\varepsilon^i < \Delta W^i] \qquad (8.3.)$$

where $\Delta W^i(B,S) = W^i_1(1, y^i - B^i, S^i) - W^i_0(0, y^i, S^i)$ and $\varepsilon^i = \varepsilon^i_0 - \varepsilon^i_1$. Eq. (8.3) represents the probability of the *i*th individual accepting the bid that is offered (Hanemann, 1984). To operationalise this approach, the researcher must specify a utility function and choose an appropriate probability distribution.

Specification of parametric models

Previous research has shown that the specification adopted can have considerable influence on the estimates of the welfare benefit (Sellar, Chavas and Stoll 1986). Instead of using a single specification to estimate WTP, various different specifications are employed. Recall the two specifications for the RUM in chapter six. The simplest is the linear model:

$$\begin{aligned} \Delta W_1^i(B,S) &= (\alpha_1 - \alpha_0) - \beta B^i + (\gamma_1 - \gamma_0)S^i + \varepsilon_1 - \varepsilon_0 \\ &= \alpha - \beta B^i + \gamma S^i + \varepsilon \end{aligned} \tag{8.4.}$$

where $\alpha = \alpha_1 - \alpha_0$ is a constant term; β is the coefficient on the bid B and $\gamma = \gamma_1 - \gamma_0$ is a vector of coefficients on any other characteristics of the individual included in the model. An alternative specification is the "income share" specification:

$$\begin{aligned} \Delta W_2^i(B,S) &= (\alpha_1 - \alpha_0) + \beta \log(1 - \frac{B^i}{Y^i}) + (\gamma_1 - \gamma_0)S^i + \varepsilon_1 - \varepsilon_0 \\ &\approx \alpha - \beta \frac{B^i}{Y^i} + \gamma S^i + \varepsilon \end{aligned} \tag{8.5.}$$

The researcher must also choose a probability distribution for the error term. If $G(B,S)$ is a standard normal cdf, then the probability that the individual accepts the bid becomes:

$$\Pr(WTP \geq B^i) = \pi_1^i = \Phi(\Delta W_q^i(B,S))$$

where q = 1,2 depending on the specification. This leads to a probit model in which the dependent variable represents the response to the initial bid and the independent variables are the "bid" (or "income share") and other characteristics of the individual such as education and age.

Linear and income share models

Many contingent valuation experiments include only the "bid" offered (B) and a constant term (α) as independent variables in the RUM. These univariate models assume that all individuals draw their WTP from the same distribution. It is not possible to employ a univariate model in the present study, because the benefit a woman gains from a visit by a mobile unit depends on her (unobserved) WTP for mammographic screening and the distance to nearest substitute screening site. This suggests that the benefits will vary both within and between towns and so a more complex multivariate model is required. The following variables were included in a multivariate model:

Bid and income share

In the linear specification, the initial bid was included as an independent variable. In the income share specification, the bid was divided by household income($\frac{B}{y}$).

The household income variable (y) was based on a question which asked the respondent to choose one of seven income categories ranging from \$0–\$15 000 p.a. to \$75 000–\$90 000 p.a. An open ended category for households with incomes above \$90 000 p.a. was also included. The mid-points of these categories were used to form the income variable.[5] The signs on both the "bid" and "income share" variables should be negative.

In this study only household income data were collected. The decision on whether to collect household or individual income data is not an easy one, since it depends on budgetary arrangements within the household. However given the high proportion of respondents that are married (72 per cent) it is highly likely that many households had a joint budget and so the use of household income in this study would seem appropriate."

Distance to the nearest facility

The distance to the closest permanent screening facility was included, because the WTP (for those who would use this unit) should rise as this distance increases.

Intended use of mobile unit

From table 8.2 it is clear that only 79 per cent of women intended to use a mobile unit if it visited their town. Women who do not intend to use the mobile unit might still value the unit visiting their town for altruistic reasons. A dummy variable was included to indicate "intended use". If users had a similar degree of altruism to non-users one would expect that their WTP would be higher, because their responses would reflect use as well as any non-use values. In this case, the dummy variable "intended use" should have a positive sign.

Familiarity with breast cancer and mammographic screening

The WTP may also depend on the familiarity of the respondent with breast cancer and mammographic screening. A dummy variable "knowledge" was included in the initial specification to examine how responses were affected by the respondent knowing someone who had breast cancer. A dummy variable "received information" was included in order to test whether receiving the information sheet prior to answering the telephone survey affected the WTP.

Other variables

To control for age and education and potential effects of the CART intervention, several other dummy variables were included in the initial specification.[6]

In line with other contingent valuation studies such as Desvousges et. al. (1993) protest zero responses were eliminated leaving 372 women in the sample.

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[5] The final category was open ended (income >$90,000 p.a.). For the 2% of the sample in this category it was assumed they had a combined income of $100,000.

[6] Income was not included as an independent variable, because its inclusion is not consistent with a stable underlying utility function. (See Gertler, Locay and Sanderson 1987)

Table 8.5. Variable descriptions and summary statistics (n = 372)*

Variable	Description	Mean(S.D.)
Bid	The initial bid offered	105.88(87.09)
Income share	Bid divided by respondent's household income	0.004(0.005)
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 else	0.81
Education		
Senior high school	Equals one if respondents highest level of education was senior high school, 0 else	0.11
Technical college	Equals one if respondents highest level of education was technical college, 0 else	0.09
University	Equals one if respondents highest level of education was university, 0 else	0.09
Other variables		
Age	Respondent's age	56.58(9.44)
Married	Equals one if respondent is married, 0 else	0.72
Knowledge	Equals one if respondent knows someone who has had breast cancer in the last five years.	0.61
CART	Equals one if the respondent lives in a CART intervention town, 0 else	0.63
Received information	Equals one if the respondent stated that they had received the information sheet, 0 else	0.91

*The variance is not reported for dummy variables.

Results

The results of the multivariate models are presented in table 8.6. models 1 and 2 represent the initial specification of the linear and income share models respectively. The only variables significant at the five per cent level in both specifications were "intended use" and "bid" and "income share". However, there is always a danger in applying an arbitrary cut-off point for significance, because several other variables were also reasonably significant, but not at the five percent level. In model 1 these included Distance ($p = 0.12$), and Age ($p = 0.15$) and Marriage ($p = 0.06$).[7] In model 2 "distance" was significant ($p = 0.07$). For this reason all these variables were retained in the final specifications (models 3 and 4).

[7] It is likely that the significance of Age and Marriage is due to their close correlation with income.

Variable	Initial Specification		Final Specification	
	Model 1 Linear model	**Model 2** Income share	**Model 3** Linear	**Model 4** Income share
Constant	0.549 (0.883)	-0.232 (0.377)	0.909 (1.660)	-0.0258(0.124)
Bid	-0.008 (8.307)[b]		-0.008 (8.286)[b]	
Income share		-143.54(-6.702)[b]		-148.14(7.467)[b]
ln(Bid)				
Distance	0.002 (1.563)	0.002 (1.840)[d]	0.002 (1.916)[d]	0.00211(2.155)[c]
Intended use	0.500 (2.708)[b]	0.530 (2.869)[b]	0.466 (2.598)[b]	0.4975(2.788)[b]
Married	0.315 (1.855)[d]	0.106 (0.621)	0.277 (1.666)[d]	
Senior high school	0.156 (0.673)	0.136 (0.608)		
Technical College	0.464 (1.678)[d]	0.301 (1.151)		
University	0.292 (1.102)	0.172 (0.677)		
Age	-0.012 (1.449)	0.0003(0.041)	-0.015 (1.875)[d]	
Knowledge	0.161 (1.085)	0.049 (0.318)		
CART	0.185 (1.112)	0.101 (0.624)		
Received information	-0.138 (0.544)	0.082 (0.331)		
No. Observations	372	372	372	372
LLF(β) Full model	-201.12	-211.56	-204.21	-212.85
LLF(0) Intercept only	-256.94	-256.94	-256.94	-256.94
LRI	0.22	0.18	0.21	0.18
Mean WTP	-	-	$132.03	$141.75

t-ratios are reported in brackets.
[b] Significant at 1 percent level.
[c] Significant at 5 percent level
[d] Significant at 10 percent level

Table 8.6. Estimation results for the multivariate probit models

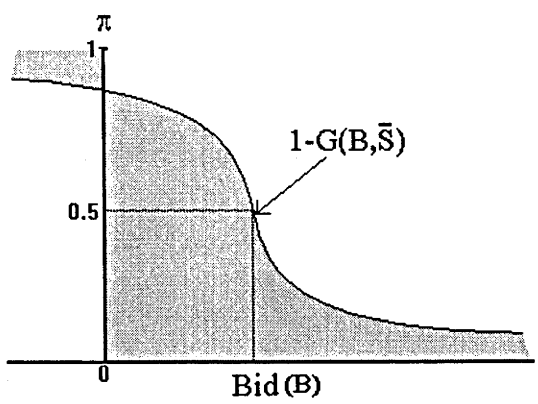
8.4.3 Evaluating the welfare benefits of screening

The welfare benefits gained by introducing mobile screening units can be estimated from the cumulative distribution function (cdf) associated with each of these specifications. Since the welfare benefits in the multivariate model are a function of B and S they vary across individuals. In what follows, the welfare benefits for an individual with a given set of characteristics ($\bar{S}$) are derived. The cdf *for this individual* is $1-G(B,\bar{S}) = prob(WTP \geq B | S = \bar{S})$. This represents the probability that the *i*th respondent accepts the bid. The mean WTP is:

$$CV = \int_0^{\infty}[1-G(B,\bar{S})]dB - \int_{-\infty}^{0}G(B,\bar{S})dB \qquad (8.6.)$$

In Eq. (8.6) the individual can have a positive or a negative WTP for the good under evaluation. In this case, the total welfare benefit corresponds to the shaded areas over/under the cdf in figure 8.6.

Figure 8.6. The probability of accepting the bid offered in the WTP question



It seems unlikely that women have a negative WTP for the visit of a mammographic screening unit, because it has the characteristics of a voluntarily consumed private good. In this case a probility distribution that is defined only over positive values is required. Two possibilities are to adopt a log specification or to introduce a spike into the probability at zero. Both of these approaches are examined in the next section.

8.4.4 More complex models

As Johansson (1995) notes, ruling out negative bids has implications for the range of specifications that can be used when estimating contingent valuation models. One specification that is consistent with a non-negative WTP is the log specification (Johansson, Kriström and Mäler 1989). An alternative is to introduce a spike in the cdf at zero. Both of these models are illustrated below:

(i) The log normal model

A specification commonly used in applied work is the log normal probability. This rules out negative bids, because the probability of accepting the bid converges towards one as B nears zero[8]:

$$\Delta W_3^i(B,S) = \alpha - \beta \log B^i + \gamma S^i + \varepsilon \qquad (8.7.)$$

This can only be used to model the WTP of that proportion of the population that have a positive WTP. Hence women with a genuine zero WTP were deleted from the sample for this specification.[9]

The results of the log model are shown in Table 8.7. The initial specification (model 5) includes all the independent variables discussed in section 8.4.3. It also includes a log income variable. Although a specification cannot be derived from an underlying utility function it was included in an "ad hoc" manner in order to examine the effect income had on the log normal model. The variables not significant at the 5 per cent level were then removed and a final specification estimated (model 6). All the variables in the final model had signs consistent with expectations. In particular, the sign on income was positive, suggesting that WTP increases with income.

[8] There has been some controversy on whether the log specification (Eq. 8.6) constitutes a valid RUM. Initially, Hanemann (1984) asserted that it was not consistent with economic theory, but more recently, he has withdrawn his objection and demonstrated how it is consistent with the theory of the RUM (see Hanemann and Kanninen 1996).

A difficulty with the log specification is that it has a "fat tail", because a large proportion of the density is attributed to bid values beyond the range of those offered to respondents in the sample (Ready and Hu 1995). This often produces estimates of the mean that are unrealistically high and, under some conditions, unbounded. One way of overcoming this problem is set an upper bound by "pinching" the cdf to ensure that it reaches zero at a finite level B^*. This bound should reflect the minimum bid for which probability of accepting is zero. In the case of the log normal model, the probability of an individual accepting the bid becomes:

$$\overline{\pi}_3^i = \Phi(\Delta W_3^i(B,S))(1-\frac{B^i}{B^*}) \quad \text{if } 0 < \mathrm{B} \le \mathrm{B}^* \qquad (8.8.)$$

This is the log normal probability model with a multiplicative term $(1-\frac{B^i}{B^*})$ added so as to "pinch" the function to ensure that the cdf reaches zero at B^*. The log-likelihood function for this model is simply:

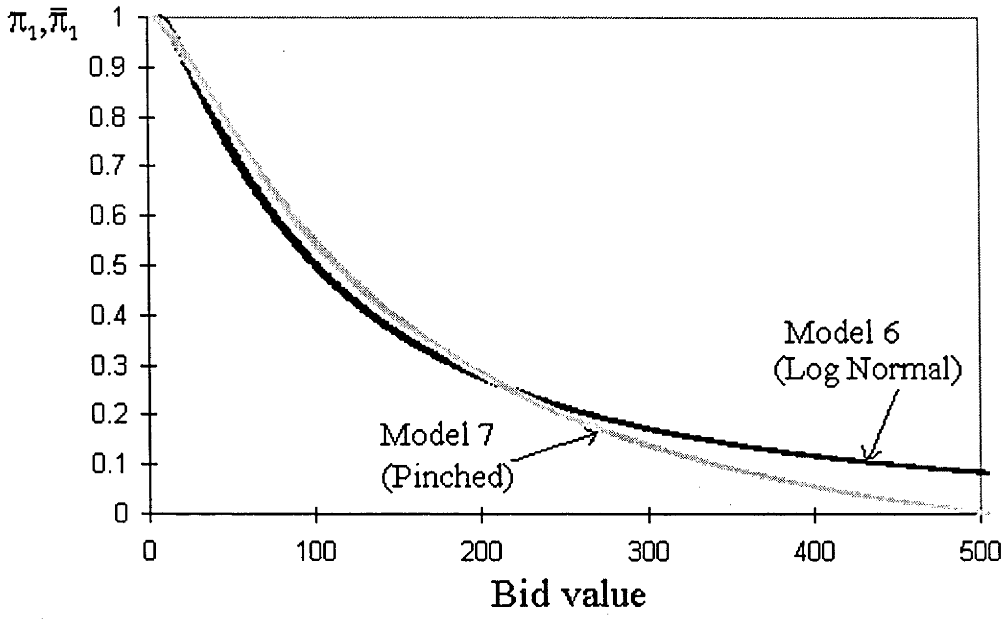
$$\ln L = \sum I^i \ln \overline{\pi}_1^i + (1-I^i)\ln(1-\overline{\pi}_1^i) \qquad (8.9.)$$

where $I^i = 1$ if the individual accepts the bid (otherwise $I^i = 0$). In order to apply the log pinch model, the researcher must set the upper bound B^*. In this study, B^* was set equal to \$500. Although this truncation point is arbitrary, it can be defended because no respondents accepted a bid of \$500 when it was offered to them in the follow-up WTP question (see table 8.3).

Equation 8.10 was minimised using LIMDEP 7.0 (Greene 1995) and the results are listed in table 8.7 (model 7). In addition to the log of the "bid" and the "distance" variable, the log of income was also highly significant. Using these models the probability of a "representative individual" (whose covariates have been set to their mean values) accepting different bids is illustrated in figure 8.7.

[9] A woman was considered to have a genuine zero WTP if she did not intend to use the service (Q17) and stated she had a zero WTP (Q21).

Figure 8.7. The log normal and pinched log normal cdf#



#These estimated probabilities are based on an individual that has an income of $26 462 p.a. and is 125 km from the nearest substitute site (i.e. the covariates have been set to their mean values).

(ii) Spike normal model

As has been previously discussed, the log specification is based on the assumption that all individuals have a WTP greater than zero. However, it is likely that a proportion of the sample gains no benefit from the introduction of mobile screening units, and so it would seem appropriate to incorporate their preferences into the model. This can be achieved by classifying individuals who reject the "bid" as either having a positive WTP which is less than B, or a zero WTP. To distinguish between these two types of negative responses, let T be an indicator variable. In this study, such a variable could be based on the individual's response to Q21. If a individual's WTP>0 then T = 1, and if WTP = 0 then T = 0. There are three combinations of responses. Firstly, an individual accepted the initial bid, (I = 1; T = 0) with a probability of $\pi_2^i = \Phi(\Delta W_1^i(B,S))$. For simplicity, a normal cdf with a linear specification has been assumed. Secondly, she could decline initial bid but have a positive WTP (I = 0; T = 1), in which case the probability is $\pi_3^i = \Phi(\Delta W_1^i(0,S)) - \Phi(\Delta W_1^i(B,S))$. Finally, she could have a zero WTP (I = 0, T = 0), in which case the probability is $\pi_4^i = 1 - \Phi(\Delta W_1^i(0,S)$. Such a model has been termed a "spike" probability model by Hanemann and Kriström (1995).

Consequently the log-likelihood function takes on the following form:

$$\ln L = \sum T^i I^i \ln \pi_2 + T^i (1 - I^i) l \ln \pi_3 + (1 - T^i)(1 - I^i) \ln \pi_4 \tag{8.10.}$$

Eq. (8.10) was minimised using LIMDEP 7 and the results reported as model 8 in table 8.7.

8.4.5 Calculating welfare measures.

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 (i.e. from zero to infinite). If numerical integration is applied, the usual practice is to truncate the distribution at a finite value. In this study, the cdf was truncated at $500, because no individual accepted this bid. It is clear from Eq. (8.6.) that the estimated mean WTP depends on the covariates and therefore varies across individuals in the sample. It can be computationally burdensome to calculate the WTP for each individual in the sample, especially when calculating confidence intervals (see below). One way of reducing the amount of computation required is to calculate the WTP of a "representative" group of individuals, in particular, to set (continuous) covariates to their mean values and determine the WTP for each combination of dummy variables.

For example, consider the linear specification (model 1). The continuous variables are "bid", "distance" and "age". If "distance" and "age" are set to their mean values, the cdf can be integrated over B for each combination of dummy variables. The overall mean WTP can be approximated by estimating the weighted average of these four "representative" individuals (see. table 8.8). For example, if a woman of average age (56.6 years) lives at an average distance (105.9km) from a permanent screening site, is married and intends to use the mobile unit, her estimated WTP is $149.26. If a woman of the same age and distance to substitute site is not married, her WTP declines to $119.38. The overall sample mean is based on a weighted average of all four combinations.

	Log Specification			Spike model
Variable	**Model 5** Initial Log	**Model 6** Final log	**Model 7** Log Pinch	**Model 8** Spike model
Constant	1.824 (1.145)	0.075 (0.072)	-2.537 (1.553)	0.842 (1.591)
Bid	--			-0.009(11.595)[b]
ln(Bid)	-0.869 (8.211)[b]	-0.847(8.222)[b]	-0.782(4.027)[b]	
Distance	0.003 (2.343)[b]	0.003(2.777)[b]	0.006(3.166)[b]	0.002 (1.714)[d]
Intended use	-0.209 (0.888)			0.839 (5.590)[b]
Log(Income)	0.242 (2.032)[b]	0.363(3.761)[b]	0.599(3.520)[b]	
Married	0.064 (0.333)			0.301 (1.758)[d]
Senior high school	0.150 (0.547)			
Technical College	0.398 (1.336)			
University	0.297 (0.941)			
Age	-0.017 (1.176)			-0.017 (2.274)[c]
Knowledge	0.066 (0.401)			
CART	0.157 (0.819)			
Received information	-0.018 (0.066)			
No. Observations	347	347	347	372
LLF(β) Full model	-163.58	-166.39	-166.198	-236.029
LLF(0) Intercept only	-236.76	-236.76	-236.76	-325.51
LRI	0.31	0.30	0.30	0.27
Mean WTP	--	--	$146.07	$128.70

t-ratios are reported in brackets.
[b] Significant at 1 percent level.
[c] Significant at 5 percent level
[d] Significant at 10 percent level

Table 8.7. Estimation results for the log normal and spike models

Table 8.8. The estimated WTP based on the characteristics of a "representative" individual

For an individual aged 57 years and living 126 km from a fixed site	Use mobile unit	Married	Proportion of the sample	WTP
1	1	1	0.58	$149.26
2	0	1	0.14	$100.60
3	1	0	0.23	$119.38
4	0	0	0.05	$75.99
Weighted average			1	$132.03

Thus, the estimated mean WTP for the linear specification reported in table 8.6 of $132.03 is based on the estimates reported in table 8.8.

There is a need to determine the statistical precision of the welfare benefit estimates based on the estimated equations. As Bockstael and Strand (1987) have noted, the parameter estimates used to calculate welfare measures are themselves random variables, and so the confidence intervals should be calculated for estimates of WTP. One method of calculating confidence intervals is the Duffield and Patterson (1991) approach which is 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 any of the RUMs.[10] 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-φ) confidence interval is then obtained by ranking the calculated WTPs and dropping the $\varphi / 2$ values from each tail.

The calculation of confidence intervals facilitates comparison between different specifications and is necessary if estimates of the WTP are to be compared with the welfare benefits estimated using other methods such as the travel cost model (see chapter nine). The mean WTP and C.I (based on 500 replications) for the linear

[10] For the sake of brevity only linear and income share specification are reported. These form the basis of a test of convergent validity of the CVM in chapter nine.

specification was $132.03 (95 % C.I: $112.4–$151.1). In comparison the mean WTP of $141.75 based on the income share specification had a wider confidence interval (95% C.I: $115.0–$176.47).

8.4.6 Double-bounded dichotomous choice model

The SB dichotomous choice model is statistically much less efficient than the open-ended format and so it requires larger samples to achieve the same level of precision. One way of improving efficiency is to add a follow-up question in which the respondent is asked if she would pay a higher or lower amount depending on the response to the first question. For example, if the subject rejects $B then she is asked a lower amount in a follow-up question, say $\$B_{min}$, while a subject who accepts $B is asked if she is willing to pay a higher amount ($\$B_{max}$). Using the response to both questions, the respondent's WTP can be assigned to one of four intervals:

$0-\$B_{\min}$	(no/no)
$\$B_{\min}-\$B$	(no/yes)
$\$B-\$B_{\max}$	(yes/no)
$\$B_{\max}-\infty$	(yes/yes)

The probabilities for the linear specification are as follows:

$$\begin{aligned}
\Pr\{yes\,/\,yes\} &\equiv \pi_{11} = \Phi(\Delta W_1(B_{\max},S)) \\
\Pr\{yes\,/\,no\} &\equiv \pi_{10} = \Phi(\Delta W_1(B,S)) - \Phi(\Delta W_1(B_{\max},S)) \\
\Pr\{no\,/\,yes\} &\equiv \pi_{01} = \Phi(\Delta W_1(B_{\min},S)) - \Phi(\Delta W_1(B,S)) \\
\Pr\{no\,/\,no\} &\equiv \pi_{00} = 1 - \Phi(\Delta W_1(B_{\min},S))
\end{aligned} \tag{8.11.}$$

Given these probabilities, the log-likelihood function for the double-bounded model is:

$$\ln L = \sum_{i=1}^{n} [I_{YY}^{i} \ln \pi_{11}^{i} + I_{YN}^{i} \ln \pi_{10}^{i} + I_{NY}^{i} \ln \pi_{01}^{i} + I_{NN}^{i} \ln \pi_{00}^{i}] \tag{812.}$$

where $I^i_{YY}, I^i_{YN}, I^i_{NY} I^i_{NN}$ are binary indicator variables (e.g. if the individual accepted the initial and follow-up bid $I^i_{YY} = 1$ and the rest of the indicator variables ($I^i_{YN}, I^i_{NY} I^i_{NN}$) are zero) This has been termed an "interval data" probit model by Alberini (1995). The merits of using this approach have been the subject of recent debate. At issue is how the follow-up question affects the individual's expressed WTP. An implicit assumption of the DB model is that the same stochastic process underlies the respondent's answer to the initial and follow-up question. This assumption needs to be tested, because the DB model is similar to the bidding game which has been shown to suffer from "starting point" bias (see chapter seven).

Hanemann and Kanninen (1996) suggest that a simple non-parametric test of consistency of the responses to the initial and follow-up questions that can be applied whenever the bid vector contains a separate, but overlapping sets of bids. The test is based on a comparison of the conditional probability of the subject accepting a bid if it is offered in the follow-up question with the unconditional probability of it being offered in the initial WTP question. For example, if the first bid vector consisted of ($\$B = B_1, \$B_{\max} = B_2, \$B_{\min} = B_3$) and in the second ($\$B = B_2, \$B_{\max} = B_4, \$B_{\min} = B_1$) then a standard result in probability theory that:

$$\Pr\{\text{"yes" to } B_2\} = \Pr\{\text{"yes" to } B_2 | \text{"yes" to } B_1\} \cdot \Pr\{\text{"yes" to } B_1\} \quad (8.13.)$$

This test can be applied to the current data since several bid vectors overlap. For example, the consistency of responses to ($\$B = 100$, $\$B_{\max} = 200, \$B_{\min} = 50$) can be compared with responses to a higher bid vector ($\$B = 200, \$B_{\max} = 400, \$B_{\min} = 100$). The proportion of positive responses can be calculated using table 8.3. For example, 31 women accepted and 29 women rejected the initial bid of \$100 so the $\Pr\{\text{"yes" to } \$100\} = 0.52$. While 13 women accepted and 14 women rejected a bid of \$100 if offered to them as a follow-up bid once they have agreed to pay \$50 so $\Pr\{\text{"yes" to } 100 | \text{"yes" to } 50\} = 0.48$. Finally half the women offered the initial bid of \$50 agreed to pay it so $\Pr\{\text{"yes" to } 50\} = 0.50$. Hence, $\Pr\{\text{"yes" to } 100 | \text{"yes" to } 50\} \cdot \Pr\{\text{"yes" to } 50\} = 0.48 \times 0.50 = 0.24$. The results for each pair of overlapping bid vectors are presented in table 8.9.

Table 8.9. Results of a non-parametric test of consistency of responses to the WTP questions

Bids	Pr{"yes" to B_2}	Pr{yes to B_2 | "yes" to B_1}	Pr{"yes" to B_1}	Pr{yes to B_2 | "yes" to B_1}× Pr{"yes" to B_1}
B_1=50; B_2=100	0.52	0.48	0.49	0.24
B_1=75; B_2=150	0.30	0.61	0.49	0.30
B_1=100; B_2=200	0.21	0.41	0.51	0.20
B_1=150; B_2=300	0.17	0.25	0.30	0.08

The results in table 8.9 are inconclusive. In the second and third rows Eq. (8.13.) holds, suggesting that the first and second bids come from the same stochastic generating process, but in the first and last cases the result does not hold.

To explore this issue further, a parametric test of consistency developed by Cameron and Quiggin (1994) was applied. Their approach involves treating responses to the first and follow-up bid as if they were valuing separate, but related, goods. Instead of modelling the response to the initial and follow-up bids separately a bivariate probit model allows for linkages between the responses to both bid values.

Table 8.10 lists the results for two bivariate probit models. The first (model 9) is simply an extension of model 3 with the same specification applied to the follow-up question. The two equations are estimated jointly to allow for correlation in the error terms. The mean WTP based on the initial WTP question is \$130.59, while the mean WTP for the second question is \$123.47. To test if these responses are drawn from the same distribution, cross equation restrictions on the coefficients are applied. Model 10 constrains the coefficients to be equal across both models (i.e. so that they have the same mean WTP). A likelihood ratio test was used to compare model 9 with model 10. The test statistic for this asymptotic test is 51.42, well above the critical value at a five per cent level of significance($\chi^2_{6,95\%} = 11.07$), so the null hypothesis that the mean of the underlying distribution is identical is therefore rejected.

Table 8.9. Estimation results for the bivariate probit model

Variable	**Model 9** Bivariate probit	**Model 10** Bivariate probit (Fixed coefficients)
Equation 1		
Constant	0.745 (1.367)	0.9457(2.952)
Bid	-0.008 (8.823)[b]	-0.0052(10.541)[b]
Distance	0.002 (2.065)[c]	0.0006(1.509)
Use	0.589 (3.277)[b]	0.554 (5.396)[b]
Married	0.246 (1.389)	0.355 (3.486)[b]
Age	-0.013 (1.789)[d]	-0.0221(4.463)[b]
Equation 2		
Constant	1.291 (2.564)[b]	0.9457(2.952)[b]
Bid	-0.006 (7.397)[b]	-0.0052(10.541)[b]
Distance	0.0003 (0.303)	0.0006(1.509)
Use	0.442 (2.526)[b]	0.554 (5.396)[b]
Married	0.470 (2.954)[b]	0.355 (3.486)[b]
Age	-0.027 (3.593)[b]	-0.0221(4.463)[b]
ρ	0.591 (5.677)[b]	
LLF(β)	-407.01	-432.71
Mean WTP (Equation 1)	\$130.59	
Mean WTP (Equation 2)	\$123.47	

t-ratios are reported in brackets.
[b] Significant at 1 percent level.
[c] Significant at 5 percent level
[d] Significant at 10 percent level

Why might a respondent's WTP decline when she is asked a follow-up question? One explanation is that the follow-up question comes as something of a surprise. In this study, 92 per cent of respondents received the information sheet that contained the initial WTP question. The information sheet did not foreshadow a follow-up question. The surprise at being asked if they would be WTP a different amount in the follow-up question might induce a negative reaction. If this occurs it is inappropriate to apply the probabilities of the DB model (Eq. 8.11) since there are separate probabilities for accepting the initial and follow-up questions. One way of incorporating a change in probability is to introduce a background disposition to say "no" that applies only to the second question. This changes the probabilities in (8.11.) to:

$$
\begin{aligned}
\bar{\pi}_{11} &= (1-\theta_u)\pi_{11} \\
\bar{\pi}_{10} &= \theta_u \pi_1 + (1-\theta_u)\pi_{10} \\
\bar{\pi}_{01} &= (1-\theta_d)\pi_{01} \\
\bar{\pi}_{00} &= \theta_d(1-\pi_1) + (1-\theta_d)\pi_{00}
\end{aligned}
\qquad (8.14.)
$$

where θ_u is the probability of responding "no" to the second bid given that the respondent agrees to the initial bid, θ_d is the probability of saying "no" to the second bid given the respondent has refused the first bid (Hanemann and Kanninen, 1996). This model is referred to as the "resentment" model is listed in table 8.11.

Table 8.11. Estimation results from a double-bounded resentment model[a]

Variable	**Model 10** DB two way resentment	**Model 11** DB one way resentment
Constant	1.195 (2.571)[c]	1.097 (2.309)[c]
Bid	-0.006(10.174)[b]	-0.006(12.179)[b]
Distance	0.002 (1.961)[c]	0.001 (1.655)[d]
Use	0.617 (4.201)[b]	0.602 (4.024)[b]
Married	0.317 (2.188)[c]	0.303 (2.046)[c]
Age	-0.023 (3.389)[b]	-0.020 (2.863)[b]
θ_u	0.36 (10.020)[b]	0.41 (10.884)[b]
θ_d	-0.119 (0.80)	
LLF(β)	-456.15	-456.77
Mean WTP		$150.81

[a] *t*-ratios are reported in brackets.
[b] Significant at 1 percent level.
[c] Significant at 5 percent level
[d] Significant at 10 percent level

The probability of responding negatively to the second bid, given that the respondent agrees to the initial bid (θ_u), is highly significant. The results suggests that for any bid level these respondents have a 0.36 lower probability of accepting the follow-up bid if it is higher than the initial bid. Further θ_d is negative, but not significant, suggesting that there is no change in probabilities if the follow-up bid is lower. There appears to be an asymmetric "resentment effect" in operation, since the reduction in probability only applies when the follow-up bid increases. Setting $\theta_d = 0$ in Eq

(8.14) and re-estimating the DB model leads to model 11. This specification produces the highest estimates of the mean WTP of $150.81.

8.5 Discussion and conclusions

The survey design used in this study represents a significant departure from previous health care contingent valuation experiments in that it combines two modes of delivery. The subjects were provided with some background information, the contingent valuation scenario, and the initial WTP question before the telephone survey was conducted. This is in contrast to previous studies which have relied on only one of these modes. For example, Ryan (1996) conducted a contingent valuation survey using a mail survey alone and Kartman, Stålhammar and Johannesson (1996) used a telephone survey. This hybrid design has several advantages over these previous studies because it combines the best features of both modes of delivery: (i) conducting contingent valuation surveys by telephone produces a much higher response rate than is generally experienced in studies involving mail surveys; (ii) sending respondents information provides them with more background information than is normally possible to convey in the course of a telephone interview; and (iii) respondents are given the opportunity to think about issues prior to the telephone interview. It should be noted that the design significantly increases the complexity of administration, because the questions supplied by mail must match the questions in telephone survey. This means individuals must be randomly assigned to bids prior to the mail out of the personalised information to ensure that mail and telephone information matches. Such a protocol can be implemented with the aid of a computer data base (Microsoft Access) and a word processing package that has the capacity to undertake "mail merges" (Microsoft Word). Another issue to consider is how to treat respondents who do not receive the information sent by mail. In this study this was not a major problem, because only eight per cent of respondents fell into this category, but it may be a problem in other studies.

Interestingly, there appears to be no relationship between responses to the WTP questions and the respondent's knowledge or familiarity with breast cancer or mammographic screening. Firstly, those subjects who knew someone who had breast cancer did not have a significantly different WTP, because the "knowledge" variable is insignificant in all the regression models. Secondly, respondents who received the information sheet did not have a significantly different WTP (see models 1 and 2). Finally WTP responses were not significantly different between the CART intervention and control towns.

There is some evidence of strategic behaviour, in that 61 percent of the respondents who expressed a zero WTP also stated that they intended to use the mobile unit if it visited their town. Altruism was also present, because 47 per cent of women who stated they would not use the mobile still accepted positive WTP bids.

In regard to other motivations, the most surprising is that some women who had previously made a payment to charity to a provide mobile screening service were not willing to pay anything in taxes. Such behaviour is the exact opposite of that observed in previous studies (e.g. Navrud 1992) that found that people are less willing to make charitable donations than to state positive WTP amounts.

The choice between the DB and SB model is a difficult one. On the one hand, the DB model is statistically more efficient than the SB model. On the other, responses to the follow-up WTP question were not consistent with the initial WTP question in that respondents have a higher probability of refusing the second bid if the amount offered is greater than the first. Although there are several explanations for this phenomenon, it is most likely due to the "resentment" experience by some individuals when they are asked to pay a higher follow-up bid. This effect may be re-enforced by the protocol of the survey, because it gave most respondents notice that they would be asked a WTP question, but no indication that they would be asked a follow-up question. In the telephone interview, the follow-up question is introduced without prior warning immediately after the initial WTP question. The subject had had days (and in some cases weeks) to think about whether they would accept the initial bid, but only a few seconds to formulate a response to the follow-up bid.

There are two ways of dealing with this inconsistency. The first is to ignore the follow-up question entirely and rely on the SB model. Depending on the specification, this produces estimates of mean WTP that range from $128.70 (model 8) to $146.07 (model 7). A second approach is to explicitly model the negative responses by allowing the probability of rejecting the bid to vary between the two questions. This approach produced an even higher estimated mean WTP of $150.81. These estimates represent both use and altruistic values associated with the visit of a mobile screening unit.

In conclusion, this chapter provides estimates of the benefits of mobile mammographic screening in several rural towns in New South Wales. Although these estimates are plausible, the CVM is still in the early stages of development and policy conclusions should not be based on these estimates alone.

Chapter 9

Validating the contingent valuation method

> The crucial issue concerning the CV method is obviously to what extent it can simulate actual choice, i.e. the validity of the method. The ultimate test of validity is to compare hypothetical payments with real money transactions and *to carry out such studies is in my option the single most important issue in CV research* {emphasis added} (Johannesson, 1993).

9.1 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 and non-market goods. The primary aim of this chapter is to test the validity of the CVM by comparing the benefit estimates from the previous chapter with those derived from a travel cost model based on data from the same women. The chapter is divided into two parts. Sections 9.1 to 9.4 review the extensive literature on testing the validity of the CVM. Section 9.5 then examines the validity of the contingent valuation experiment conducted in the previous chapter.

Three types of validity are generally distinguished in the psychology literature: content, criterion and construct 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 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. *Construct validity* relates to whether the measure under consideration relates to other measures in a way that is predicted by theory. Tests of construct validity take one of two forms. Either they can involve comparing the measure with other measures to see if they conform in a manner that is predicted by theory or they can involve testing the measure to see if it accords with pre-existing theory (Bishop, Champ and Mullarkey 1995, p. 642). Each of these types of validity is examined in greater detail in sections 9.2 to 9.4 below.

9.2 Content Validity

Content validity refers to whether the survey instrument measures what it is intended to measure. In particular, is it designed and conducted in such a way so as to encourage respondents to reveal their true preferences. The content validity of a survey instrument should be examined before assessing other types of validity, because if there are problems with the content there is little point in proceeding further. An assessment of the content validity involves more than checking to see if a survey instrument is consistent with theory, because the researcher must also ascertain whether the survey can be understood by subjects. As Carson (1991, p.133) notes:

> One of the difficulties in designing a constructed market is that it must meet the dual criteria of satisfying the requirements imposed by economic theory and the need of the respondents for a meaningful and understandable set of questions.

Simultaneously satisfying both of these requirements is by no means easy. On the one hand, respondents must be provided with enough information to enable them to value the good. On the other, they must not be overloaded with information which can cause them to become confused or impatient (Bergstom and Stoll 1990), as there are no penalties for providing false or inaccurate responses to contingent valuation surveys.

9.2.1 Guidelines for conducting contingent valuation surveys.

In recent years, there have been several attempts to produce guidelines on how contingent valuation surveys should be conducted, the most notable being the "Blue ribbon" panel's report for the National Oceanographic and Atmospheric Administration (NOAA) (Arrow et. al. 1993). This report has had great influence on the conduct of contingent valuation studies in this area and its recommendations were largely incorporated into the NOAA proposed rules on assessing environmental damage. These rules attempt to codify standards for the conduct of contingent valuation studies that are to be *used in the assessment of environmental damage in court cases.* Given the amount of money at stake in these court cases, the guidelines are not concerned with the cost of implementation and explicitly adopt a conservative design methodology (NOAA 1994, p. 1146). To give just one example, the NOAA rules strongly recommend the use of face-to-face interviews:

> NOAA suggests that the trustee(s) consider seriously the use of in-person interviews for the final survey because of the *characteristics of a survey need for damage assessment*{emphasis added}. (Federal Register Jan 7 1994, p. 1144)

The cost of conducting a survey that complies with this recommendation is high. Schultze et. al. (1996, p. 110) suggest it might exceed $400 per completed interview.

The relevance of the NOAA's guidelines for the valuation of health care is open to debate. There is no question that the NOAA rules provide many practical and useful suggestions on the design and conduct of contingent valuation surveys; however, it is important to recognise that there are differences between health care and the non-use values that are the focus of the NOAA report (Johansson 1995, p. 79). To illustrate this point, consider the NOAA recommendation for the use of in-person interviews quoted above. The reason why in-person interviews are used in the assessment of environmental damage is that the only way to convey most environmental damage is through a visual representation of the affected area. Respondents gain a much greater appreciation of what they are valuing if they are shown a picture of the damage, rather than it merely being described to them. The use of in-person interviews in health care contingent valuation experiments is only necessary if the respondent *must be* provided with visual aids when eliciting values for health care (e.g. visual representations of the probabilities of various outcomes). So far there is no agreement on this issue (see below). Until this issue is resolved, there seems little point in considering the merits of this particular NOAA recommendation. In regard to the rest of the NOAA guidelines, it is probably best to use them as a starting point for further research than as a strict set of rules to which health care contingent valuation researchers must adhere.

In the last few years there have been several attempts to formulate recommendations on the design and conduct of contingent valuation studies involving health care (e.g. Gafni 1991; Morrison and Gyldmark 1992; Johannesson, Jönsson and Borgquist 1996). At this stage, no consensus exists between practitioners as to what constitutes a valid contingent valuation survey. For example, Johannesson (1993) has criticised Morrison and Gyldmark (1992), and Dolan (1997) has raised concerns about some aspects of Johannesson, Jönsson and Borgquist (1996).

9.2.2 Assessing the content validity of contingent valuation surveys

A contingent valuation survey must: (i) describe the good under evaluation; (ii) describe the conditions and structure of the market in which it is sold; and (iii) elicit values for the good (Carson 1991, p. 132). The first two form the scenario which is the focus of the remainder of this section. Given the diversity of goods and services to which the CVM can be applied, it is not possible to specify exactly what a scenario should contain.[1] Instead the following represents a list of elements the researcher could consider when assessing the content validity of a contingent valuation scenario:

(i) Description of the good or service

Most consumers are familiar with everyday goods such as bread or coffee since they make repeated purchases of these products over time. Consumers may be less familiar with consumer durables, since purchases are made infrequently, but they are able to gather information on the attributes of these goods (e.g. size, weight and other features) prior to purchase (i.e. preference research). The major challenge in contingent valuation research is to elicit meaningful preferences for an unfamiliar good in the course of the survey.

The following aspects are likely to have a bearing on the respondent's valuation of the good:

[1] The section draws in part on Fischoff and Furby (1988) and Bishop, Champ and Mullarkey (1995).

(a) Attributes of the good: It essential that the scenario provides the respondent with a clear statement of relevant attributes of the good being valued. The attributes of health care could include its efficacy, any potential side-effects and the process of care (Ryan 1996).

(b) Reference and target levels: The reference and target level of the good being valued must be conveyed to the subject. The reference level is that which they have access to in the absence of the intervention and the target level is that which they gain if the intervention takes place (Fischoff and Furby 1988). These levels should convey the magnitude and the nature of the welfare change.

(c) Extent and timing: The location and timing of the health service need to be clearly spelt out in the scenario since the geographic location and the temporal nature of the change are likely to influence value. In regard to the latter it is important to state whether it is a permanent or a one-off change that is being valued (Bishop, Champ and Mullarkey 1995, p.636).

(ii) The role of substitutes:

Since an individual's WTP is influenced by the price of substitute goods, the NOAA panel recommends the inclusion of a reference to substitutes in the contingent valuation scenario:

> Respondents must be reminded of substitute commodities... This reminder should be introduced forcefully and directly prior to the main valuation question to assure that respondents have the alternative clearly in mind (Arrow et. al. 1993, p.4608–9).

This suggestion is also relevant to health care, since there are often several alternative treatments for a given condition. For example, the pharmacological therapies for hypertension include beta-blockers, diuretics and ACE inhibitors. There are also several non-pharmacological treatments such salt reduction, diet and exercise. A respondent's WTP for any one of these treatments could be influenced by the price and effectiveness of the substitutes available to them.

There is evidence that reminders of substitutes influence WTP. Interestingly, contingent valuation studies that have asked different respondents to value alternative treatments for the same disease results in a similar mean WTP (e.g. Johannesson and Fagerberg (1992); Miedzybrodzka et. al. 1994). In contrast, a recent study by Donaldson, Shackley, and Abdalla (1997) that makes respondents aware of a substitute health care good (although not in the form recommended by the NOAA) leads to a significantly different WTP than if they were not informed.

(iii) Degree of certainty

A key feature of health care is that its use and outcomes are subject to uncertainty. For example, a healthy person does not know whether she will develop cancer at some stage in her lifetime, nor is she likely to know the efficacy of different types of cancer treatment. This has lead Gafni (1991) to suggest that the contingent valuation scenario should inform respondents of the likelihood of needing to use a treatment or service and its efficacy in probabilistic terms.

Ganfi's suggestion brings us back to the issue of what information respondents should be provided with before their expressed preferences can be regarded as accurate indications of their "true" values. Recall from chapter seven that this is a difficult issue because it ultimately depends on whether subjects take this information into account when formulating their preferences. Within an applied welfare economic framework it is not possible for the researcher to determine if this is the case without reference to the individual whose preferences are being elicited. Despite this difficultly, Morrison and Gyldmark (1993, p. 238) endorse Gafni's suggestion as the minimum "that should be provided in a survey to enable respondents to make reasonably informed decisions". However, in making such a recommendation they do not consider whether this information is meaningful or relevant to the respondent. In commenting on Morrison and Gyldmark's work, Johannesson (1993) argues that two important research questions must be explored before adopting such a recommendation: "Can an individual understand and act on probabilities?; Are probabilities taken at face value or weighted by some prior belief?"(p.358)

Before addressing both of these questions it is useful to briefly examine how probabilistic information can be conveyed to respondents. Following, Jones-Lee, Hammerton, and Philips (1985), several studies provide subjects with either numerical estimates of the probability or visual representations of the risk. Some studies that convey changes in health risks use visual aids (e.g. Fabian et. al. 1994, p. 289-97), while others use only verbal descriptions (e.g. Johannesson, Johansson, Löfgren 1997). Three examples of written and visual aids that convey the risk of breast cancer and the effectiveness of mammography are illustrated in figure 9.1. In the first two cases, women represented as "stick figures" are used to convey risk. In the top diagram the shaded "stick figure" represents a woman who suffers from breast cancer at some stage in her life while the unshaded ones represent women who are free of the disease. This is intended to convey the incidence of breast cancer in the general population. The middle diagram uses a similar approach to convey the efficacy of mammographic screening. This is not the only way of conveying risk. An alterative method is compare breast cancer with other common causes of death. The bottom figure illustrates this approach.[2]

In order to address Johannesson's first question, we briefly review two studies by Cohen, a cognitive psychologist who conducted a series of experiments into whether judgements based on risk conform with the rules of mathematical probability over almost two decades (Bell 1979). Some of his experiments involved asking subjects to choose between a lottery in which there was a single draw for a winning ticket in a smaller population of lottery tickets or multiple draws for a winning ticket in a larger population of tickets. Subjects tended to prefer the latter even if the mathematical probability of success was higher in the lottery with the smaller number of tickets (Cohen and Hansel 1958).

Although it is possible to explain these inconsistencies by arguing that people gain utility from the draw itself rather than the prize it might also be due to them perceiving that they have a higher probability of success in the second lottery. This has implications for the way that risks are presented in contingent valuation

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[2] All of these representations of health risks were used in a pilot contingent valuation survey on the benefits of a publicly funded program of mammographic screening. This survey differs from the contingent valuation survey on the value of mobile units reported in chapter eight.

surveys. For example, a respondent could be informed that "Seven women in 100 get breast cancer at some time in their lives" or alternatively "One in fourteen women will get breast cancer at some stage in her life". Although these imply almost the same risk in terms of mathematical probability, respondents may perceive them as conveying different levels of risk.[3]

Building on this experiment, Cohen and Chesnick (1970) asked respondents how many draws they would require in a lottery involving a larger population of tickets to prefer it to a lottery in which they had one ticket in a smaller population of tickets. Only 40 per cent of subjects choose the number of draws that made the mathematical probability of drawing from the second equal to the first. The other 60 per cent chose draws that were *relatively evenly distributed over all levels of mathematical inequivalence.* From these studies and others conducted in the field, Bell (1979, pp.7–8) draws two conclusions:

> The first is that in conditions of uncertainty people behave neither blindly nor randomly. The second is that in many instances human behaviour departs significantly from that which would be predicted by a model of man based on mathematical probability; for example equiprobable outcomes are not treated as such, independent events may be treated as related, preferences may be expressed where there is no mathematical justification, and concepts like hope, pessimism, or fairness may intrude.

Although such research only provides indirect evidence concerning the perceptions of probability it does suggest that this area warrants further research before Gafni's recommendation is accepted.

Turning to Johannesson's second question concerning the role of prior beliefs, again there is no health care contingent valuation study that has directly addressed this issue. However, some indirect evidence can be gleaned from medical interventions which involve informing patients of risk. For example, an intervention that informed women of the harm to the foetus from smoking while pregnant had the least impact on women who had smoked during a previous pregnancy. These women believed that if it did not happen before, it will not happen in future (Baric and MacArthur 1977). This suggests that strong prior

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[3] The first statement implies the probability of getting breast cancer is 0.07 and the second 0.071.

beliefs formed through personal experience are likely to be given a greater weight when determining preferences than information supplied by the researcher.

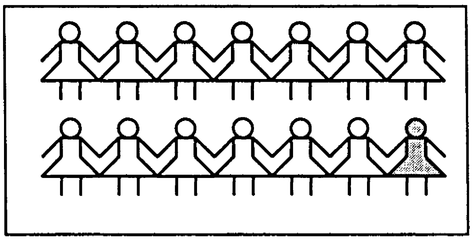
(iv) Payment mechanism

The payment mechanism is the means by which an individual pays for the good under evaluation. There are many potential payment vehicles, since WTP questions can be phrased in terms of higher user fees, higher taxes or increases in health insurance premiums. The best mechanism for payment or compensation depends on the type of health care being valued and its method of financing. Pauly (1995, p. 121) suggests that the natural payment mechanism is its current method of financing. If a particular type of care is covered by insurance then the appropriate mechanism is a change in premiums. Where as, if it is available "over the counter", then a user fee could be used. Such an approach minimises the likelihood of the method of financing becoming the focus of the respondent's attention. For example, a contingent valuation survey that values a good that is currently provided "free of charge" through using a hypothetical "user fee" might produce negative reactions from respondents.

Figure 9.1. Visual representations of health risks

What chance does a woman have of contracting breast cancer ?

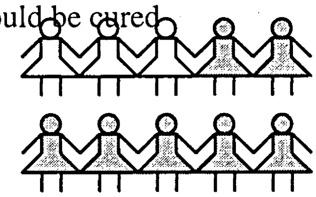
In NSW, one woman in fourteen will get breast cancer at some time in her life. The majority of cases occur when women are aged over 50.



How effective will this be in reducing deaths from breast cancer?

Mammographic screening is not able to help everybody. Evidence from overseas suggests that if women have regular mammograms the numbers dying from breast cancer may be reduced by up to 30%.

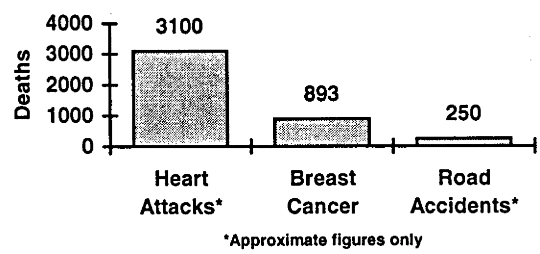
If all women were screened, then 3 out of every 10 women currently dying could be cured



How many women die of breast cancer each year?

Breast cancer is the most common cancer among Australian women. In 1991 there were 2807 new cases of breast cancer in NSW and 893 deaths from the disease. To put these numbers into perspective the chart compares the deaths from breast cancer with two other causes of death.

Comparison of deaths of women in 1991 from breast cancer, heart attacks and road accidents in NSW



From the graph above we can see that more than **three times the number of women die of breast cancer as on roads in NSW**. However, the number of deaths from breast cancer is much lower than from heart attacks.

9.3. Criterion validity

Criterion validity can be regarded as the most definitive test of validity, because it involves a comparison with a measure that is unequivocally closer to the theoretical construct than the measure whose validity is being assessed (Mitchell and Carson, 1989, 192). Although the individual's compensating or equivalent variation is the criterion by which WTP should be tested, these measures of welfare can never be directly observed. Instead, comparisons with welfare measures based on actual market transactions are generally regarded as the means by which to assess the criterion validity of the CVM (Bishop, Champ and Mullarkey, 1995, p. 646; Kealy, Montgomery and Dovidio 1990). Since most contingent valuation studies involve goods for which no market transactions can be observed, the focus of criterion validity research has been on developing simulated markets.

Simulated market experiments study the behaviour of subjects under controlled conditions. They differ from contingent valuation experiments in that they involve real monetary transactions. To date there have been no simulated market experiments involving health care products, but there have been a considerable number of studies involving other goods ranging from purely private goods such as strawberries and solar-powered calculators (Dickie, Fisher and Gerking 1987; Cummings, Harrison and Rustrom 1995) to quasi-public goods such as hunting permits (Bishop, Heberlein and Kealy 1988).

What scope is there for conducting simulated market experiments involving health care goods? Although in theory there is no reason why health care products could not be traded in a simulated market it is difficult to conduct these experiments in practice. As has been previously discussed, most health care goods and services are traded at a zero price. In order to observe revealed preferences in a simulated market, participants must be charged amounts above this price and be prevented from having access to "free" care. Such an experiment would be deemed ethically unacceptable, because it results in participants having access to less care they would otherwise receive.

There is more scope to conduct a simulated market experiment when health care is not subsidised. For example, in Australia many pharmaceutical drugs are subsidised as part of the Pharmaceutical Benefits Scheme (PBS). Drugs listed on the scheme have a fixed front-end deductible to be paid by consumers.[4] However, not all drugs are listed on the scheme and those not listed receive no government subsidy. One way of conducting a simulated market experiment would be to offer participants different levels of subsidy for an unlisted drug and then observe their revealed preferences for *amounts below the market price*. Since all participants in the simulated market (i.e. those being asked to make real payments) gain greater access to the drug, there are not the same kinds of ethical objections that arise when the experiment involves raising the price.[5] Although such an experiment is feasible, it cannot be applied in the current context, because mammographic screening is available to all women more than 40 years of age free of charge in Australia.

9.4. Construct validity

Construct validity examines whether the measure under scrutiny relates to other measures as predicted by theory (Mitchell and Carson 1989, p.191). There are two forms of construct validity—theoretical and convergent.

(i) Theoretical validity

Most tests of whether contingent valuation responses accord with economic theory examine whether WTP is sensitive to changes in the scale or the scope of the good being valued. This test can take on two forms: either respondents can be asked to value different quantities of the same good; or, a split sample design can be employed where different respondents are asked to value different quantities of the same good or multiple goods presented in a different order.

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[4] In 1995 the deductable for the general public was set at $16.80 and the concessional deductible at $2.60 for all drugs listed on the scheme (Commonwealth Department of Human Services and Health 1995).

[5] One of the largest market simulation experiments ever conducted is the RAND health insurance experiment which also had to guarantee no one would be financially worse off by participating in the study (Newhouse 1993, p. 12)

The former is a much weaker test of validity as it merely tests rationality (i.e. that the respondent will prefer more of a good to less). This approach is also known to suffer a number of problems since it is well known that a respondent who is asked multiple questions does not respond to each question independently, but instead is influenced by responses to previous questions (Kartman, Stålhammar and Johannesson 1996). The classic example of interdependence between multiple valuation questions is the "starting point" bias that occurs in a bidding game (see chapter seven).

A stronger test of validity is to ask different subjects to value different quantities of the same good. This is often referred to as a test of scope. Its routine use in contingent valuation studies was recommended by the NOAA panel (Arrow et. al. 1993) and this recommendation has been endorsed by Johannesson, Jönsson, and Karlsson (1996, p.293) as a way of testing the validity of health care contingent valuation studies:

> It is not acceptable to demonstrate [theoretical validity] by giving more than one willingness to pay question with different sizes of the health gain to the same respondent. Instead the size of the health gain should be varied randomly in different subsamples to test that the willingness to pay increases with the health gain. {"theoretical validity" has been added}

However, it is important to recognise the limitations of theoretical tests of validity since they can only examine the internal consistency of responses. It does not provide a test of whether the absolute WTP is an accurate reflection of the benefits. For this, an external test of validity that compares the contingent valuation with methods based on revealed preferences is required.

(ii) Convergent validity

Convergent validity tests whether the measure under evaluation converges with another measure in a way that is consistent with theory. This normally involves comparing the welfare benefits estimated using contingent valuation experiments with those from indirect techniques such as the TCM or the hedonic price method (Bishop, Champ and Mullarkey 1995, p. 642). As these methods are calculated with a similar degree of error, such comparisons cannot be classed as a test of criterion validity. In the case of the TCM, errors arise because of the unobserved nature of travel costs (see chapter five). Hence, 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 absence of a criterion with which to validate the CVM (e.g. a simulated market experiment), comparisons with indirect methods provide one of the only means of assessing the external validity of the method.

Testing the convergent validity by comparing the CVM and the TCM has a long tradition in environmental economics that dates 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 convergent validity of both methods (e.g. Sellar Stoll and Chavas 1985; Smith, Desvousges and Fisher 1986; Loomis, Creel and Park 1991). The results of these and other studies have been pooled using a meta-analysis (Carson et. al. 1996). The results of this meta-analysis suggest that these methods produce roughly comparable values with the CVM generally producing *lower* welfare estimates than TCM.[6] This finding runs counter to the conventional wisdom that stated preference methods produce higher estimates of WTP than revealed preference. However, there is need for more work in this area, because the meta-analysis by Carson et. al. only covers studies that were published prior to 1993 and includes many early studies that differ widely in methodological rigour. There is also a need for similar studies to be undertaken involving health care goods.[7]

9.5 The validity of the mobile mammographic screening experiment

9.5.1 Content validity

In this section the content validity of the contingent valuation study outlined in the previous chapter is assessed. In doing so it provides a rationale for the design and conduct of the contingent valuation survey discussed in the previous chapter, as

[6] The ratio of contingent valuation estimates to single site travel cost models was 0.80 and for multi-site models was 0.70 (Carson et.al. 1996, p. 89)

[7] Interestingly, one of the few previous studies that tested convergent validity also involved breast cancer screening, see Hill (1988) as cited in Carson et. al. (1996).

well as highlighting some of the trade-offs involved in applied research. Because the study uses a hybrid mail-telephone survey, it draws on material included in the information sheet and the survey instrument to assess its content validity (these are reproduced in appendix B)

(i) Description of the good or service

The information sheet provides the respondents with one page of background material on mammographic screening. The telephone survey does not repeat this background material, but provides a shortened two–paragraph description of the service:

> There are two ways mammograms could be provided. They could either be provided locally using a mobile screening van that would visit «Town name» at least once a year or women in «Town name» could travel to a city such as «Subsitute Site» and have a mammogram at any time of the year. In both cases the mammogram is free, but women would have to pay any travel expenses.
>
> To provide a breast cancer screening service locally will cost the Government more money. In the next part of this survey I'm going to ask you a few questions on whether you would be prepared to pay higher taxes to have a mobile breast cancer screening unit located in «Town name».

The field's «Town name» and «Subsitute Site» depend on residential location. Each rural town was defined in terms of a postcode which covers the main town and the surrounding districts. The field «Town name» is the main town within that postcode. The field «Subsitute Site» is the town where the closest alternative mammographic screening unit that operates under the NPEDBC. These details were entered into a database and then "mail merged" using Microsoft Word so that women in different towns received a personalised information sheet and survey.

<u>Reference and target levels</u>

The main WTP question states: "Would you be willing to pay $ «Bid» to have a mobile unit visit «Town name»?" The intended target level is for a mobile unit to visit the town and the reference level is for the town not to be visited. This defines the direction of welfare change, as residents who use the mobile unit gain utility from a visit, because they have to travel a lesser distance to have a mammogram.

The question therefore corresponds to the compensating variation since the WTP represents the amount of money that must be taken from the gainer to reduce her back to her previous level of utility.

Extent and timing

An important attribute of the mobile screening unit is that it visits a town for only a few weeks every two years. Women unable or unwilling to be screened at that time gain no benefits from the unit. This issue is addressed in the information sheet: "A mobile unit usually visits a town for several weeks to allow all women in the area to have access to breast cancer screening."

One of the most difficult elements of the scenario to convey is the timing of the visit by the mobile screening unit. Problems arise because the recommended screening interval is twice as long as the annual cycle of tax payments (the chosen payment vehicle). There are a number of solutions to this problem, none of which are entirely satisfactory. One way is to state that "the mobile breast cancer screening unit visits only once every two years". The problem here is that tax payments are made once a year, so respondents might feel they are paying twice to have access to the screening unit and reduce their WTP accordingly. Another alternative is to state that "the mobile breast cancer screening unit visits once a year". However, this does not overcome the problem, because now respondents might feel that they are paying for the unit on an annual basis, but can only use it every second year. The other way is to link the payment to a single visit: "to have a breast cancer unit visit «Town name»."[8] The last option was used in the survey.

(ii) Role of substitutes

The respondent was informed of a substitute site immediately prior to the initial WTP question: "If there was no mobile screening service women in «Town name»

[8] Unfortunately this question may convey the impression that a unit will be available when the respondent requires it. To try to dispel this impression the information sheet stated that "A mobile unit usually visits a town for several weeks to allow all women in the area to have access to breast cancer screening." However, it is not possible to determine in the present study whether respondents took this information into account when formulating their responses.

you would still be able to use the existing services in places such as «Subsitute Site»."

(iii) Degree of certainty

The aim of the present study is to measure the benefits associated with closer mammographic screening services. Providing the respondent with information on the likelihood of breast cancer and efficacy of mammographic screening (e.g. that provided in figure 9.1) could mislead respondents into thinking they are valuing the total screening program rather than one aspect of provision. As all NPEDBC screening units must meet a minimum standard in order to be accredited, they are likely to have the same efficacy; therefore the only risk differential between using a fixed and mobile unit is that associated with travel to the more distant permanent site.

(iv) The payment mechanism

Currently, mobile screening units are provided as part of the NPEDBC and are funded out of general tax revenue. Phrasing the WTP questions in terms of changes in taxes is a natural payment mechanism. One difficulty with using taxation as a payment mechanism in this survey is that a significant minority of the relevant population (women aged over 40 years) do not pay income tax. To overcome this problem the respondent was asked if they paid income tax (Q 17a). For the 36 per cent of the respondents who had not paid income tax, the WTP question was changed to: "Think of the payment as a levy paid to the local council to provide the service." The WTP questions were then phrased in terms of paying higher local government rates: "Would you be willing to pay «Bid» in a council levy to have a mobile unit visit «Town name»?[9]

[9] Residents in almost all areas of Australia pay annual rates to their local council. While pensioners are offen entitled to discounts, rates are based on property value rather than income and so given the high level of property ownership it is likely to be a more meaningful payment mechanism for respondents not paying income tax.

9.5.2 Theoretical validity

In terms of theoretical validity it was suggested in the previous chapter that welfare benefits of a visit by a mobile unit should increase as the distance to the nearest substitute site increases. This can be regarded as a test of scope since it tests the sensitivity of the respondent's WTP to changes in the size of the reduction in access costs. Since the coefficient on the "distance" variable is significant (at the 10 per cent level) and positive in all specifications the model passes the scope test. It is also worth noting that the income variable in the *ad hoc* log specification is also positive and significant (at the 1 % level) suggesting that WTP may increase with income—which is again consistent with theory. These findings are consistent with some other recent studies that have tested the internal validity of the CVM (e.g. Kartman, Stålhammar and Johannesson 1996; Ryan 1996))

9.5.3. Convergent validity of the contingent valuation method

In the absence of being able to observe changes in market prices, comparisons between the TCM and the CVM provide one of the only means by which to test the (external) validity of both methods. In this section, the contingent valuation estimates are compared with the benefit estimates from the travel cost model. The travel cost model developed in this section is similar to that developed in chapter six. For the sake of brevity, emphasis in this section is placed on detailing assumptions that differ from those adopted in the previous model.

Introduction

All respondents who participated in the contingent valuation survey were asked a series of questions on their screening behaviour. Initially, women were asked how many times they had had a mammogram in the last five years. Those women who had had at least one mammogram were asked additional questions to collect information on the last three occasions on which they had been screened including: (i) the year in which they were screened; (ii) their reasons for having a mammogram; (iii) the type of facility they used; (iv) the name of the town where they had the mammogram; and (v) whether it was the sole reason for their travel. All respondents were also asked if they had received advice from a GP or nurse to have a mammogram in the previous two years and if they intended to have a mammogram sometime within the next two years. This represents a shortened version of the previous travel cost survey (see appendix B).

Descriptive statistics

Table 9.1 lists the subjects' responses to several questions relating to screening behaviour in the previous two years (the recommended interval for mammographic screening). In all, 62 per cent of the sample had been screened in the last two years. The majority of women had had only one mammogram, which lends support to the notion that mammograms are a "binary good".

The rest of the questions listed in table 9.1. were asked of those respondents who had been screened and relate to their most recent mammogram. The majority of these women had had a mammogram under the NPEDBC. Their reasons for attending included: "wanting to make sure they didn't have cancer" (40%) and "receiving a reminder to attend" (30%). (Women who had been screened at a NPEDBC facility are entered on a register and sent a reminder notice after two years inviting them to have another mammogram.) The last question relates to the issue of joint production. Recall from chapter six that women can reduce their access costs by obtaining more than one type of health care or undertaking other activities as part of the same trip. A significant minority (33%) of women stated that they would have gone to the town anyway and hence are engaging in joint production when they are screened (Q10).

Table 9.1. Details of last mammogram

Variable	Value	Number (%)
Number of mammograms in last two years (Q5)		
	One	230 (50%)
	Two	49 (11%)
	Three of more	4 (1%)
	None	175 (38%)
	NR	0
Type of facility they had their most recent mammogram (Q 7)		
	Free screening service as part of NPEDBC	172 (61%)
	Radiologist	74 (6%)
	Public Hospital	21 (8%)
	Private Hospital	3 1%)
	Other	12 (4%)
	NR	1
Reason for having the most recent mammogram (Q8)		
	Had breast cancer in the past	7 (2%)[#]
	Had a breast lump/ breast pain at the time	38 (13%)
	Had breast lump/breast pain in the past	16 (6%)
	Have a family history of breast cancer	15 (5%)
	Heard of a free service	32 (11%)
	Received a reminder	85 (30%)
	GP suggested I go	28 (10%)
	Wanted to may sure they did not have cancer	110 (40%)
If you hadn't been going to have a mammogram would you have still travelled to the town for some other reason? (Q10)		
	Yes	94 (33%)
	No	147 (52%)
	Don't remember	19 (7%)
	NR	23 (8%)

[#]The percentages for this question represents the proportion of all women screened citing this as a reason for having a mammogram. The sum of the percentages is greater than 100% because some women gave more than one reason for having a mammogram.

Travel cost model

The explanatory variables for the travel cost model are listed in table 9.2(a) and 9.2(b). Recall that access cost associated with a mammogram can be divided into three components—medical cost, travel cost and the opportunity cost of time. The later two are a function of travel distance. Again travel distance was estimated by measuring the shortest road distance between their town of residence and the town where they had their mammogram.

> *Medical costs:* The out-of-pocket medical expenses depended on a woman's chosen provider. For the majority of the sample (61%) who had had a mammogram at one of the NPEDBC screening facilities, the mammogram was provided free of charge. For the rest of the sample it was assumed that they had had a mammogram under Medicare (Australia's universal public health insurance system) at a cost of approximately $10.40.[10]
>
> *Travel costs:* Because almost all women (93%) in the previous survey (see chapter six) travelled to the screening unit using a private vehicle, the revised travel cost survey did not ask respondents about their mode of transport. Again, it was assumed that all women travelled by a private vehicle at a cost $0.50 per km (NRMA, 1996).
>
> *Time costs:* Time was assumed to be a function of the adult female marginal wage. Due to difficulties in obtaining wage data from respondents, the average hourly adult female wage of $14.70 (ABS 1996) was used. In order to ascertain the total time taken it has been assumed that all travel is undertaken at 90km per hour and that it takes one hour to be screened.[11]

All three costs are combined to obtain the "access cost" for each woman.

Income share

The survey included a categorical question on the respondent's household income. There were eight categories covering incomes from $0 to $90 000 p.a. (in $15 000 increments). The mid-points of these categories formed the basis of an income

[10] This figure is more accurate than the $13 used in chapter six since it is based on the average out-of-pocket medical expenses incurred by a 10 per cent sample of women having mammograms under Medicare. The datum was provided by the Australian Health Insurance Commission. Comparable datum was not available when the previous study was undertaken.
[11] Screening time includes time spent finding the screening unit and waiting time.

variable. The variable "access cost" was divided by "income" to form "income share".[12] Again the variable formed the basis of "access cost" and "income share" equation that was used to predict the access costs of each woman in the sample (see table 9.6).

Other explanatory variables

The current model includes all the explanatory variables from the previous model (i.e. "age", "marital status", "advice", and dummies representing levels of education). It also includes two additional variables. The first dummy denoted as "CART" is to control for whether a woman was resident in a CART intervention or control town. This was included because the CART intervention may have increased the demand for mammographic screening. The second factor that might influence behaviour is whether women had had a mammogram more than two years ago. Not only would this increase her familiarity with the procedure, but women screened under the NPEDBC are sent reminder notices after two years. Both these factors are likely to increase the probability that she has had a mammogram within the last two years.

After purging incomplete observations and subjects that did not intend to use the mobile unit, there were 319 women in the sample which included women engaged in joint production and 241 women in the sample that excluded these women.

[12] The definition of income differs from that used in the previous travel cost model (see chapter six). In this study "household income" is defined as the combined income of *all* individuals living in the household.

Table 9.2(a) Descriptive statistics (excluding women engaged in joint production) (n=241)

Variable	Description	No (S.D.)
Mammogram	Women who have had a mammogram in the previous two years (Dependent variable)	0.54
Travel cost	Travel cost of women after removing women engaged in joint production (value of time is equal to the average wage).	$65.05($69.21)
Income share	Income share (travel cost divided by income) after removing women engaged in joint production (the value of time is equal to the average wage).	0.0019(00.16)
Advice	Equals one if she had received advice from a GP or nurse to have a mammogram, 0 else.	0.19
Screened before	Equals one if she had been screened three or four years before the current survey, 0 else.	0.48
Married	Equals one if respondent is married, 0 else.	0.70
Senior high school	Equals one if respondent's highest level of education was senior high school, 0 else.	0.08
Technical College	Equals one if respondent's highest level of education was technical college, 0 else.	0.07
University	Equals one if respondent's highest level of education was university, 0 else.	0.06
Age	Respondent's age.	56.94
CART	Equals one if a CART intervention town, 0 else.	0.64

Range of assumptions regarding the valuation of time and joint production

The two areas of greatest imprecision in measuring access costs are the monetary valuation of time and allocation of costs when a woman is undertaking multiple activities (i.e. joint production). It is therefore necessary to adopt a range of assumptions and examine the sensitivity of the results. 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). Secondly, three assumptions were adopted regarding the allocation of joint costs for women engaged in joint production: (i) removing all women in joint production from the sample; (ii) including these women and attributing 50 per cent of access costs to mammographic screening ; (iii) including these women and attributing 100 per cent of the access costs to mammographic screening. The joint effect of these factors yields nine potential combinations of assumption that are listed in table 9.3. The descriptive statistics for the variables used in all models are listed in table 9.2(a) and 9.2(b).

The 14 travel cost models estimated in the next section are also listed in table 9.3 The even numbered models (e.g. model 2; model 4 etc) are those that apply the income share specification (see chapter six) and the odd numbered models (model 1 ; model 3 etc) apply the linear specification.

Table 9.2(b) Descriptive statistics for all women (n=319)

Variable	Description	Mean (S.D)
Mammogram	Women who have had a mammogram in the previous two years (Dependent variable)	0.60
Access cost		
Model 3	Travel cost including women engaged in joint production (VT=100 per cent; JC=100 per cent).	$70.98(69.36)
Model 5	Travel cost including women engaged in joint production (VT=100 per cent; JC=50 per cent).	$62.38(66.86)
Model 7	Travel cost including women engaged in joint production (VT=50 per cent; JC=100 per cent).	$62.33(60.84)
Model 9	Travel cost including women engaged in joint production (VT=50 per cent; JC=50 per cent).	$53.73(58.51)
Model 11	Travel cost including women engaged in joint production (VT=150 per cent; JC=100 per cent).	$79.63(77.25)
Model 13	Travel cost including women engaged in joint production (VT=150 per cent; JC=50 per cent).	$71.03(75.25)
Income share		
Model 4	Income share including women engaged in joint production (VT=100 per cent; JC=100 per cent).	0.0021(0.0019)
Model 6	Income share including women engaged in joint production (VT=100 per cent; JC=50 per cent).	0.0018(0.0014)
Model 8	Income share including women engaged in joint production (VT=50 per cent; JC=100 per cent).	0.0019(0.0014)
Model 10	Income share including women engaged in joint production (VT=50 per cent; JC=50 per cent).	0.0016(0.0017)
Model 12	Income share including women engaged in joint production (VT=150 per cent; JC=50 per cent).	0.0023(0.0021)
Model 14	Income share including women engaged in joint production (VT=150 per cent; JC=50 per cent).	0.0020(0.0016)
Other variables		
Age	Respondents age.	56.94(9.498)
GP Advice	Equals one if she had received advice from a GP or nurse to have a mammogram, 0 else.	0.19
Screened before	Equals on if she had been screened three or four years before the current survey, 0 else.	0.53
Married	Equals one if respondent is married, 0 else.	0.71
Senior high school	Equals one if respondent's highest level of education was senior high school, 0 else.	0.09
Technical College	Equals one if respondent's highest level of education was technical college, 0 else.	0.08
University	Equals one if respondents highest level of education was university, 0 else.	0.07
CART	Equals one if a CART intervention town, 0 else.	0.63

	Assumptions regarding the nature of joint production		
Assumptions regarding the value of time	Remove women who undertook other activities when they had a mammogram	Include women who undertook other activities and attribute 100 per cent of the access costs to mammographic screening (JC=100 %)	Include women who undertook other activities and assume travel cost and 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** (Linear specification) **Model 2** (Income share specification)	**Model 3** (Linear specification) **Model 4** (Income share specification)	**Model 5** (Linear Specification) **Model 6** (Income share specification)
Assume the value of time is equal to 50 per cent of the marginal wage (VT= 50 per cent)	No models estimated	**Model 7** (Linear specification) **Model 8** (Income share specification)	**Model 9** (Linear Specification) **Model 10** (Income share specification)
Assume the value of time is equal to 150 per cent of the marginal wage (VT=100 per cent)	No models estimated	**Model 11** (Linear specification) **Model 12** (Income share specification)	**Model 13** (Linear Specification) **Model 14** (Income share specification)

Table 9.3. Assumptions regarding the value of time and the allocation of costs for women undertaking joint production

Results

Table 9.4 presents the results for models 1–4. These models include all variables described in the previous section. In the first two models, women engaging in joint production have been removed from the sample. In these two models the access cost variable was not significant at the 10% level and so there is little point in proceeding further with this approach.

Models 3 and 4, assume that women who are engaging in joint production have the same costs as those who's sole purpose was to have a mammogram (i.e 100 per cent of access costs of these women are attributed to mammographic screening). In contrast to the first two models, the access cost variable is highly significant and has a sign consistent with expectations. The only variables significant at the five per cent level were "GP advice" and "screened before". Although the "university" education variable was significant at the 10 per cent level, a likelihood ratio test (χ^2= 4.05) of the joint significance of all three education variables was not significant at the five per cent level and so all three were dropped from the specification.

The rest of the results are displayed in tables 9.4(a) and 9.4(b). In all, 10 models were estimated reflecting various combinations of assumptions relating to the value of time and the allocation of costs for women engaged in joint production. For the sake of brevity, only final specifications are reported. The model appears to be robust, in that, the same coefficients remained significant under a wide range of assumptions. The mean estimated WTP based on each of the specifications is also reported at the bottom of Table 9.4(a) and 9.4(b).

The estimates of the welfare gain are higher than those estimated using the previous model (see chapter six). This is most likely due to a increase in demand for mammographic screening that has accompanied the introduction of the NPEDBC.

Variable	**Model 1** Linear model	**Model 2** Income share	**Model 3** Linear	**Model 4** Income share
Constant	-0.662(1.008)	-0.747(1.168)	-0.348 (0.600)	-0.634(1.140)
Travel cost	-0.003 (0.222)		-0.003(2.509)[b]	
Income share		21.34 (0.345)		-101.75(2.594)[b]
GP Advice	0.618(2.538)[b]	0.576(2.180)[c]	0.535(2.647)[b]	0.619 (2.875)[b]
Screened before	1.194(6.538)[b]	1.194(6.565)[b]	0.859(5.635)[b]	0.773 4.996)[b]
Married	0.002 (0.009)	0.004 (0.020)	0.007 (0.039)	-0.027 (0.156)
Senior high school	-0.145 (0.455)	-0.160 (0.511)	0.359 (1.295)	0.230 (0.855)
Technical College	-0.053 (0.135)	-0.105 (0.281)	0.385 (1.292)	0.2286 (0.786)
University	-1.179(2.963)[b]	-1.153 (2.917)[b]	-0.567(1.849)[d]	-0.371 (1.157)
Age	0.001 (0.092)	0.014 (0.146)	0.002 (0.202)	0.010 (1.122)
CART	0.233 (1.123)	0.249 (1.288)	0.235 (1.468)	0.138 (0.808)
No. Observations	241	241	319	219
LLF(β) Full model	-134.12	-134.08	-186.29	-186.22
LLF(0) Intercept only	-166.29	-166.29	-214.44	-214.44

[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 9.4: Estimation results for the initial specification for the multivariate probit models[a]

Variables	Model 3 Linear	Model 4 Income share	Model 5 Linear	Model 6 Income share	Model 7 Linear	Model 8 Income Share
	(VT= 100 %; JC=100%)		(VT= 100 %; JC=50%)		(VT=50%;JC=100%)	
Constant	-0.068(0.484)	0.010(0.066)	-0.115(1.022)	0.016(0.104)	-0.068(0.480)	0.010(0.069)
Travel cost	-0.003(2.363)[b]		-0.003(2.093)[c]		-0.003(2.367)[b]	
Income share		-101.0(2.726)[b]		-120.66(2.708)[b]		-125.52(2.728)[b]
GP Advice	0.509(2.444)[b]	0.577(2.703)[b]	0.5140(2.497)[b]	0.589(2.743)[b]	0.509(2.446)[b]	0.578(2.705)[b]
Screened before	0.849(5.365)[b]	0.766(4.740)[b]	0.880(5.595)[b]	0.770(4.760)[b]	0.849(5.364)[b]	0.766(4.737)[b]
LLF(β) Full model	-191.35	-190.07	-192.10	-190.10	-191.34	109.06
LLF(0) Intercept only	-214.44	214.44	-214.44	-214.44	-214.44	214.44
LRI	0.11	0.11	0.11	0.11	0.11	0.11
Mean WTP	$76.89	$52.98	$64.02	$46.87	$64.42	$48.60

[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 9.5(a): Final specifications for travel cost model

Variables	Model 9 Linear	Model 10 Income share	Model 11 Linear	Model 12 Income share	Model 13 Linear	Model1 I4 Income Share
	(VT= 50 %; JC=50%)		(VT=150%; JC=100%)		(VT=150%;JC=50%)	
Constant	-0.076(0.544)	0.014(0.093)	-0.069(0.487)	0.010(0.063)	-0.133(1.025)	0.017(0.111)
Travel cost	$-0.003(2.341)^{b}$		$-0.003(2.360)^{b}$		$-0.003(2.090)^{c}$	
Income share	--	$-132.29(2.720)^{b}$		$-98.06(2.725)^{b}$		$-110.70(2.697)^{b}$
GP Advice	$0.510(2.456)^{b}$	$0.582(2.728)^{b}$	$0.508(2.443)^{b}$	$0.577(2.702)^{b}$	$0.514(2.495)^{b}$	$0.593(2.756)^{b}$
Screened before	$0.854(5.403)^{b}$	$0.768(4.747)^{b}$	$0.849(5.365)^{b}$	$0.767(4.742)^{b}$	$0.880(5.595)^{b}$	$0.772(4.772)^{b}$
LLF(β) Full Model	-192.43	-190.07	-191.36	-190.07	-192.11	190.13
LLF(0) Intercept only	-214.44	-214.44	-214.44	-214.44	-214.44	-214.44
LRI	0.11	0.11	0.11	0.11	0.11	0.11
Mean WTP	$60.22	$43.42	$83.10	$57.39	$72.68	$50.33

[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 9.5(b): Final specifications for travel cost model

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. Again, bootstrapping methods are used to calculate confidence intervals for the mean WTP (see chapter eight).

Figure 9.2 is divided into two parts: the left-hand side shows the predicted mean WTP and the 95 per cent confidence interval for models 9–12. These models were selected from table 9.3, because they produced the highest and lowest mean WTP and so provided a range for all 14 models. The highest predicted mean WTP was $83.10, with a confidence interval that ranged from $99.06 to $68.53, this was estimated using model 11. In contrast, the lowest predicted mean WTP was $43.42 (C.I $53.63–$33.38) which was estimated using model 9. The confidence intervals for the other two models are illustrated in the figure 9.2.

The comparable WTP estimated using the CVM is shown on the right–hand side of figure 9.2. These are based on the confidence interval reported in chapter eight. The predicted mean WTP and confidence intervals for the linear and income share specifications (see chapter eight). These results show that the confidence intervals for the mean WTP estimated using either of the contingent valuation models do not overlap with those estimated using the travel cost method. Hence, the TCM produces a significantly lower mean WTP.

9.6 Discussion

On the basis of this test of convergent validity, the CVM produces a higher predicated mean WTP than estimating welfare benefit using the TCM. At this point it is useful to examine the survivor function for WTP (figure 8.5) presented in the previous chapter. The striking feature of this function is that approximately 50 per cent of respondents rejected bids of $50, $75 and $100, while a significant minority accept bid values of $150 or more (e.g. approximately 20 per cent accepted a bid of $300). This pattern responses is typical of many CVM studies.

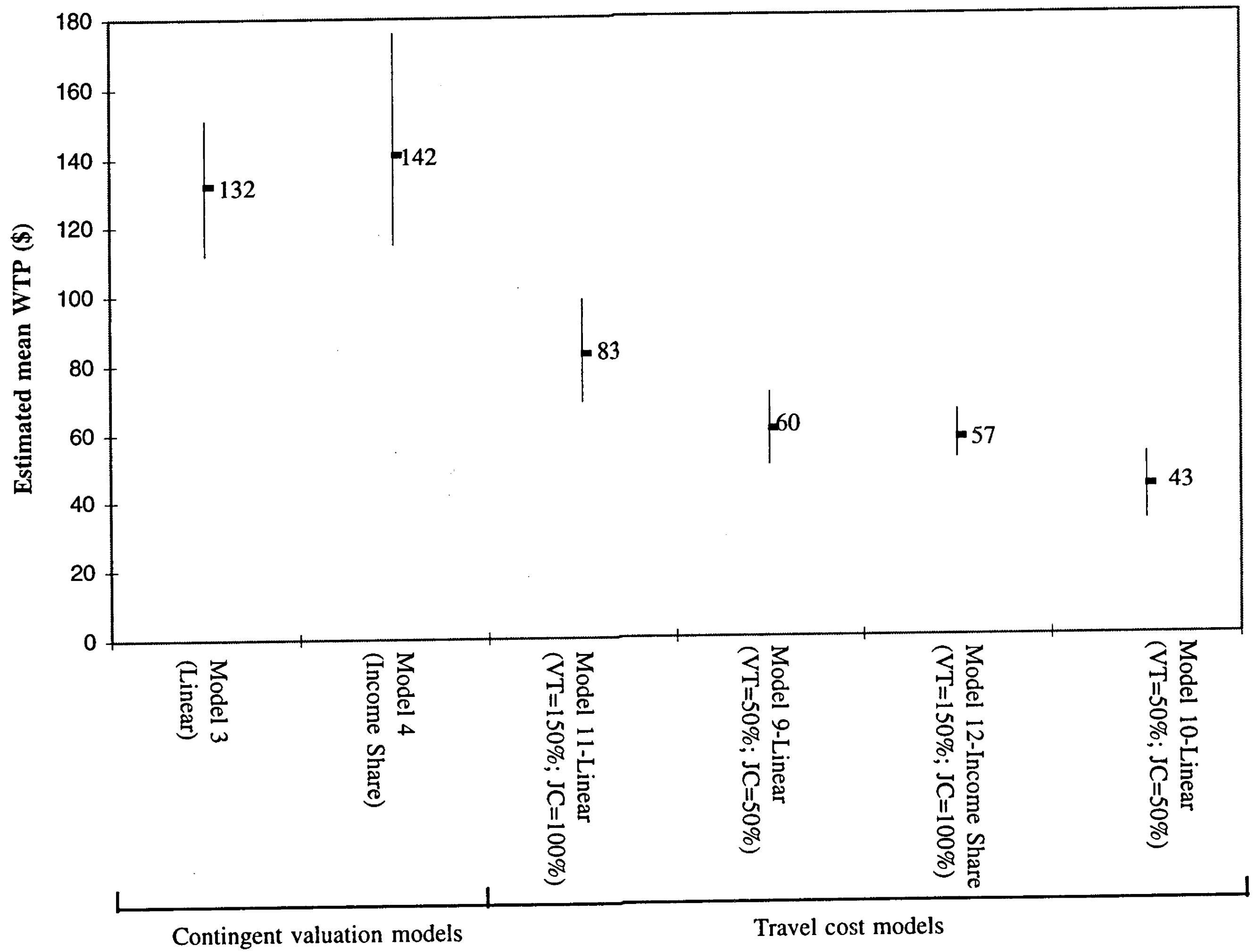


Figure 9.2. Comparison between the contingent valuation and travel cost estimates of mean WTP (95 per cent confidence intervals)

Some researchers (e.g. Kenkel, Berger and Blomquist, 1984) have suggested using the median rather mean WTP as a summary measure to reduce the influence of respondents stating high WTP values. However, it is difficult to justify such an approach within an applied welfare economic framework. As Johanssson Kristom and Maler (1989) note the advantage of the mean over the median is that it can be converted into a measure of the total benefits simply by multiplying it by the number of individuals in the population. This is equivalent to the aggregate of compensating variations which, in almost all circumstances, is consistent with the criterion of potential Pareto improvement.

Why does this minority express such high WTP values while the majority of the sample have a WTP that is similar to that estimated in the travel cost model? There are number of explanations for this phenomenon:

(i) The travel cost method does not capture the true access costs associated with attending a permanent screening site.

As previously stressed, the TCM involves the researcher making assumptions concerning the value of time, the unit cost of travel, and the proportion of common costs attributed to screening for those women that undertook other activities when having a mammogram. These assumptions might not accurately reflect the access costs of some respondents. For example, women may place an even higher value on their time than the 150 per cent of the marginal wage assumed in models 11–14.

(ii) When responding to contingent valuation questions, some subjects may be engaging in strategic behaviour or expressing moral satisfaction

Respondents might be overstating their true values believing that provision of the good is positively related to the amount they state. This form of strategic behaviour is the opposite of the more common form of "free-rider" behaviour that occurs when respondents believe they can gain an advantage by understating their true WTP. It is important to recognise that the payment mechanism has an influence on the extent and nature of strategic behaviour. Recall from chapter seven that incentives to "free ride" are minimised if a respondent perceives they will pay the amount offered and that the provision of the good depends on their stated preference. In this respect, a change in the level of tax is not an ideal payment mechanism because consumption is not directly linked to payment. However, it difficult to employ an alternative payment mechanism such as a "user-fee", because the NPEDBC is currently financed from general taxation revenue. The adoption of an unfamiliar payment mechanism is likely to lead to protest responses as well as draw criticism from providers because it could be interpreted as spreading false information about potential changes to the system of financing.

(iii) Contingent valuation responses reflect altruism as well as use values.

It is important to note that the TCM can only measure the use value of a mobile unit, whereas, the CVM measures both use and altruistic values. There are two grounds for suspecting that altruism is the motivation behind some of the responses. Firstly 47 per cent of women who stated they would not use a mobile unit still accepted positive WTP bids. These altruistic values may be substantial, as table 8.8 in the previous chapter suggests that women who would not use a unit but were prepared to contribute towards the service had a mean WTP of $100.60 if they were married and $75.99 if they were not married. Interestingly, if these amounts are deducted from the total WTP of $132 (see table 8.7) the use component *maybe* in the order of $32 to $57 which is well within the range of use values based on the TCM.

Johansson (1995) has suggested that the cost–benefit practitioner collect information on both people's total WTP and their WTP for their own safety. In the context of the present study, it is difficult to elicit the later without altering the payment vehicle since the tax payment for a visit by a mobile unit by its nature corresponds to the total WTP.

To summarise, the estimates of mean WTP from the TCM and the CVM fail to converge. This does not mean that the CVM is not valid, but it does mean that that further work needs to be undertaken before *either* method can be considered reliable enough to be used in the evaluation of health programs. The work should take place along the lines suggested above.

Appendix 9A

9.6 Parameter estimates of the access cost/ income share equation

Variable	Access cost equation Mean (S.D)	Income share equation Mean(S.D)
Constant	153.25(1.637)	0.0071(0.341)
Town Dummy Variables		
Town 1	-45.27(0.880)	-0.0014 (1.087)
Town 2	41.91(0.628)	0.0036 (2.111)
Town 3	-17.32(0.373)	-0.0012 (0.994)
Town 4	43.26(0.981)	-0.0012 (1.032)
Town 5	-48.97(0.580)	-0.0021 (0.945)
Town 6	-64.84(1.623)	-0.0009 (1.236)
Town 7	-43.82(0.931)	-0.0008 (0.721)
Town 8	31.75(0.588)	0.0007 (0.550)
Town 9	-44.89(0.810)	-0.0015 (0.493)
Town 10	-38.17(0.806)	-0.0059 (1.201)
Town 11	89.53(1.208)	0.0016 (3.170)
Town 12	-14.67(0.247)	-0.0001 (1.069)
Town 13	3.19(0.050)	0.0013 (0.024)
Town 14	-9.79(0.143)	-0.0002 (0.760)
Town 15	-15.90(0.335)	-0.0002 (0.139)
Town 16	66.80(3.646)[b]	0.0036 (1.393)
Town 17	-83.02(1.241)	-0.0013 (0.751)
Variables from Equation 1		
GP Advice	10.38(0.424)	0.0060(0.947)
Screened before	7.71(0.302)	-0.0002(0.254)
Married	-5.60(0.236)	-0.0050(0.820)
Senior high school	62.18(1.806)[d]	0.0001(0.123)
Technical College	47.30(1.280)	0.0001(0.041)
University	24.465(0.501)	0.0020(1.644)
Age	-1.70(1.248)	0.0001(0.922)
No. of observations	192	192
R^2	0.20	0.21

t-ratios are reported in brackets.
[b] Significant at 1 per cent level.
[c] Significant at 5 per cent level
[d] Significant at 10 per cent level

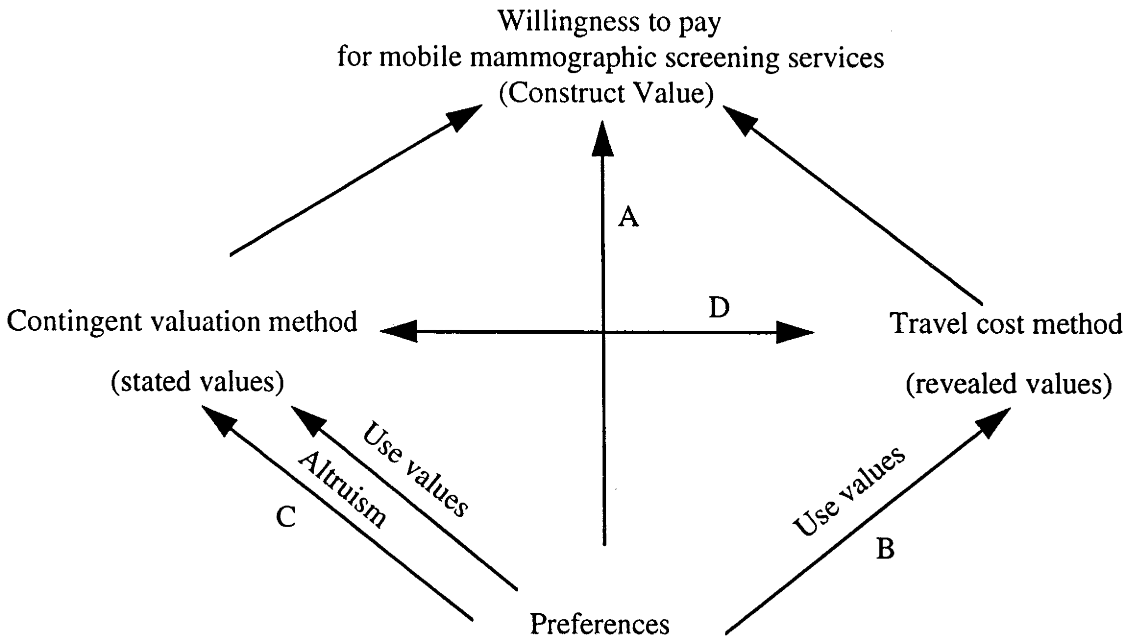
Chapter 10

Concluding remarks

> We cannot discuss the valuation of things without knowing what it is that is being valued. (Frank H. Knight, 1921)

In order to summarise 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 which are illustrated in figure 10.1. At the bottom of the figure are individual preferences which, within a welfare economic framework, are the source of all value. These preferences generate a "construct value" (ray A) which, in this case, is 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 measure this construct are the travel cost method (TCM) (ray B) and the contingent valuation method (CVM) (ray C). The final relationship explored in the study is the relationship between the TCM and CVM (ray D). Each of these relationships is discussed in turn.

Figure 10.1. The relationship between the main elements of the study



10.1 The relationship between preferences and economic values

The relationship between preferences and construct values is the focus of chapters two to four. These chapters not only address the technical issue of how preferences are transformed into construct values, but also highlight the special characteristics of mammographic screening.

It has been argued that the preferences for goods and services are likely to be built up over time through a process of "trial and error" learning, and so it is likely to be difficult for an individual to value unfamiliar goods or commodities. In this regard, individuals are likely to find it easier to value health care that is purchased on a regular basis (such as a mammogram) than the direct valuation of changes in health status. For this reason, the empirical work of the study focuses on the direct valuation of mammographic screening services rather than valuing the potential health benefits of such a service.

An important feature of mammographic screening is that it produces information on a patient's disease status. Arrow (1962) has argued that the demand for a "piece" of information is indivisible in the sense that consumption is restricted to whole quantities. It has been argued that the most fundamental form of indivisibly arises when preferences are defined only for discrete quantities of a good or service (i.e. indivisibility in preferences). Most of chapter three focused on "binary goods" which are demanded in only one quantity. This special case has important implications for the measurement of welfare change. In particular, it is shown that the Marshallian consumer surplus is equal to the compensating variation when the price of such a good declines, but not when it rises.

The fourth chapter examines the potential outcomes of mammographic screening. The outcomes of a screening test are uncertain, so welfare measures that take risk into account have to be developed. Two different types of welfare measure were considered: (i) a measure in which women must decide on the value of the test prior to knowing its outcome; and (ii) a measure which values a change in the probability of achieving a specified outcome. It was argued that the former is reflected in revealed preferences for screening tests since a woman must commit herself to "purchasing" a mammogram without knowing its outcome.

10.2 The measurement of revealed preferences

In this study, the TCM was applied to value the benefits of improving access to mammographic screening services through the use of mobile units in rural areas of New South Wales. In chapter six, it was employed in an indicative cost–benefit analysis of a hypothetical program to use these units to screen women in 10 randomly selected rural towns. The results suggested that the level of welfare benefits associated with such a program depends on the distance of a town from the nearest fixed (permanent) screening unit. In the 10 towns considered the average compensating variation ranged from $1.46 per visit (for a town 15km from a fixed screening unit) to $48.20 per visit for town 10 (for a town 160km from a fixed screening unit). The benefits were greater than the cost in the six towns that were 50km or more from a fixed site.

What is scope for applying the TCM in the evaluation of other types of health care? As Johansson (forthcoming) suggests, the most obvious condition that must be met is that other market goods must be necessary for the production of health care (e.g. petrol used on the trip to a screening facility). When health care does not require the input of these goods, it cannot be valued using the method. Even when it is necessary to travel to a medical facility there are many instances where it is very difficult to impute costs from observed behavior. For example, it may be more difficult to apply the traditional travel cost model in an urban context, because intra-city access costs are not normally linearly related to the distance traveled. Instead they depend on factors such as congestion on different routes and the modes of transport available to the user. In these circumstances it may be preferable to focus on travel time rather than travel costs if the method is to be used in the evaluation of health services in urban areas.

The valuation of time poses a significant problem for the travel cost model. In most applied work the value of time is assumed to be a function of the marginal wage. However, the conditions under which the value of time is equal to the marginal wage are limited and there is great uncertainty surrounding the value of time involved in the consumption of medical care. For this reason a wide range of values was used in the empirical work (50% to 150% of the marginal wage). Future travel cost research should examine ways of refining this range.

Joint production also created difficulties for the travel cost model. Joint production arises whenever an individual consumes more than one type of health care or undertakes other activities as part of the same trip. Such behaviour enables individuals to reduce the costs incurred when seeking health care in the same way that a firm can reduce costs by producing several outputs simultaneously and thereby gain from the scope of its operations (Baumol, Panzar and Willig 1982, p. 71). This leads to a proportion of the costs being common to more than one activity. Hof et al. (1985) demonstrate that it is not possible to assign these common costs to any one activity. In practice, the problem of joint production can be addressed by collecting information on whether an individual engages in joint production as part of the travel cost survey, and then attributing different proportions of the common costs to the health care good or service under investigation.[1]

In summary, the TCM provides an alternative to CVM in the evaluation of health care service especially in rural areas. The real strength of the method is that it is based on observed behaviour and so the criticism often leveled at stated preference methods, that it is not what people say but what they do that counts, does not apply. However, more basic research is required to further develop the method if it is to be used in the evaluation of other types of medical care.

10.3 The measurement of stated preferences

Chapter eight reports on a contingent valuation experiment to measure the benefits of using mobile mammographic screening units in rural towns in New South Wales. Depending on the specification, the mean WTP (across all 19 towns) for a visit by a mobile unit ranged from $128.70 to $150.81. These values reflect both the "use value" associated with improving an individual's access and the altruistic value an individual might place on others gaining access to the service. Unlike "use value", altruism is not reflected in market behaviour and so only stated preference methods provide the means by which to measure it.

What scope is there for applying the CVM to other types of health care? Unlike the TCM, which is constrained by the need to observe behaviour, the CVM can potentially be applied in the valuation of any type of health care. As Johannesson (1996, p. 239) notes, the main advantage of CVM "is its flexibility and ability to directly get at the desired WTP". However, the main challenge is not finding new applications for the method, but in developing valid and reliable measures of preferences that can be used in the evaluation of health care services.

In order to develop the method further, additional research should be conducted. This could involve: (i) conducting experiments to separate the various components

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[1] Another potiential problem for the travel cost model is endogenous location since people who choose to live in rural areas may hold atypical values for health care goods and services. Parsons (1991) has

of value (i.e. use values and altruism); (ii) exploring how the information presented in the scenario affects valuation; (iii) developing methods to identify and minimise protest bids and strategic behaviour; and (iv) examining further the effects of question order, anchoring and the framing effects associated with multiple contingent valuation questions. Although this list is far from comprehensive it represents a starting point for further research.

10.4. Comparisons between revealed and stated preferences

Comparisons between values based on revealed preferences and on stated preferences is one of the strongest means by which to test the validity of the CVM, the rationale being that revealed preferences represent a willingness to make real economic commitments and this is the standard by which stated preferences should be measured (Bjornstad and Kahn 1996). In this study, the contingent valuation experiment was compared with a travel cost model. 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 travel cost model. The highest predicted mean WTP estimated using the travel cost model was \$83.10 (C.I. \$99.06–\$68.53), which is significantly less than comparative estimates produced by the CVM. The mean WTP using the CVM was \$132.03 (95 % C.I \$112.4–\$151.1) for the linear specification and \$141.75 (95% C.I: \$115.0–\$176.47) for the income share specification.

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

considered this issue in the context of the recreational travel cost model.

What implication can be drawn about the validity of use of the CVM or the TCM in the valuation of other types health care? Before drawing any conclusions, it is worthwhile to emphasise an important qualification. The results of a single empirical study do not represent a basis for accepting or rejecting the validity of either method, as Randall (1996, p.202) notes:

> No particular study comparing CV and RP welfare measures is likely to be definitive. There is no crucial experiment. Conceptual problems and matters of detail in implementation, on both sides of the comparison, will provide a plethora of Duhemian escape clauses.

Caution should therefore be exercised in relying upon the results of this study, since the failure of the two methods to converge does suggest that further work needs to be undertaken before either method can be considered superior to the other in the evaluation of health care programs. Nevertheless, both have provided plausible estimates of the WTP for mobile screening units, providing some confidence that WTP for health services can meaningfully be measured, thus enabling the normative significance of cost–benefit analysis in comparison with cost-effectiveness or cost-utility analysis to be exploited.

Appendix A: Travel cost survey questions

Section 1: General Questions

1. What is your date of birth?_______________

2. What type, if any, of educational institution are you currently attending?

Secondary School	1
TAFE College	2
University	3
Other	4
Not attending	5

3. Which of the following best describes your highest education level?
(Read out each response below. Circle one number only)

Primary school only	1
Some secondary school	2
School Certificate	3
High School Certificate	4
Technical College	5
C.A.E/ University	6
Other	7

4. Which of the following best describes your present marital status?
(Read out each response below. Circle one number only)

Never married	1
Married	2
Separated	3
Divorced	4
Widowed	5

5. What is your main occupation?_______________
If they are not presently employed, ask for the most recent occupation.

6. *(Ask only if married or living with someone)* **What is your partner's occupation?**_______________

7. *(Ask only if partner is not presently employed)*
Which of the following best describes your partner's work situation?

Unemployed	1
Student	2
Pensioner	3
Home duties	4
On sickness benefits	5
Other	6

8. Which of the following best describes your work situation?
(Read out each response below. Circle one number only)

Unemployed	1
Student	2
Pensioner	3
Home duties	4
On sickness benefits	5
Other	6

Section 2: Mammographic Screening Questions

9. Have you had a mammogram in the last 2 years?

Yes	1 *(Ask questions 10. to 17.)*
No	2 *(Go to question 17.)*

10. Where did you go to have your last mammogram?

Free screening service provided by health service	1
Radiologist	2
Public Hospital	3
Private Hospital	4
Other	5

11. Did your GP refer you for your last mammogram?

Yes	1
No	2
Don't remember	3

12. Can you tell me why you attended for your last mammogram?

	Yes	No
Had breast cancer in the past	1	2
Had a breast lump/ breast pain at the time	1	2
Had a breast lump/ breast pain in the past	1	2
Have a family history of breast cancer	1	2
Heard of free service	1	2
Wanted to make sure I didn't have breast cancer	1	2
Got a reminder to attend from a doctor	1	2
Got a reminder to attend from a Cancer Registry	1	2
My GP referred/ suggested I go	1	2
Other	1	2

13. How far (in kilometres) was the town where you had your mammogram?

____

14. Did you travel by:

Car	1
Bus	2
Train	3
Aeroplane	4
Other	5

15. What was the name of the town where you had your mammogram?

____

16. If you hadn't been going to have a mammogram would you still have travelled to {town name Q16} **on that day?**

Yes	1
No	2
Don't remember	3

17. *(Ask all women):* **Has a doctor or nurse advised you to have a mammogram in the last two years?**

Yes	1
No	2
Don't remember	3

Section 3: Question concerning the valuation of time

18. How many hours a week do you work?

____

19. Do you work a flexible number of hours per week. i.e. Do have a choice as to the number of hours a week you work?

Yes	1 *(Go to question 22)*
No	2 *(Continue)*

20. Do you undertake any other paid employment besides your main job on a casual or part time basis on a regular basis (i.e Work at least once per week)?

Yes	1
No	2

21. How would you describe your part-time or casual job?__________________
Ask for the full title. For example, Bar attendant, Fast food Cook, etc

22. *(Ask all women):* **Did you have your mammogram during what would normally be considered your work time.**

Yes	1
No	2
Can't recall	3

23. Do you think you would be able to take time off work to have a mammogram?

Yes	1
No	2
Don't Know	3

Appendix B: Combined contingent valuation and travel cost survey

1. Contact letter
2. Information sheet
3. Reply paid card included with the letter
4. TCM/CVM survey questions

NCEPH

RN: «M__TownCode»
«M__PersonCode» («Merge Record #»)

«Title» «Initial». «Last name»
«Street»
«Town name»
NSW «Post code»

26th November 1996

Dear «Title» «Last name»,

Three years ago the *Cancer Education and Research Project* phoned you and asked you questions on whether you smoked and if you had been screened for breast and cervical cancer. One of the researchers has since moved to the *National Centre for Epidemiology and Population Health* at the *Australian National University.* We are now undertaking a follow-up survey on breast cancer screening. In the next week or so we will be telephoning you to ask you some questions on this issue. If you don't want to be interviewed just let one of our telephone interviewers know when they contact you.

As part of the survey we are seeking your opinions on where you think breast cancer screening facilities should be located. To help you answer this section of the survey we have enclosed an information sheet and two questions that you will be asked in our telephone survey. These are not the only questions we will ask, but they form an important part of our survey. Could you please read the information and answer the questions. Please do not send us your answers as we will be asking you the same questions in our phone survey. We are giving you this information to give you time to think about this issue before we contact you.

We will be contacting you on the following telephone number (Ph: «Phone No.»). If your phone number has changed, could you please fill out the enclosed card and return it to us. If you have any questions about the survey please contact the *National Centre for Epidemiology and Population Health* on (06) 2492378.

This is university research which is independent of Government and the *NSW Program for Mammographic Screening* and will therefore not directly influence current policy.

Thank you for your time.

Yours sincerely,

Philip Clarke
Health Economics Researcher, NCEPH

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Email: Executive.Officer@nceph.anu.edu.au

Breast Cancer Screening Survey

Background information

To help you answer our questions we have provided you with some background information on breast cancer screening. Please 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 that are 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?

The Federal and State Governments have combined to set up the *NSW Program for Mammographic Screening*. The program aims to make mammograms available to all women over 50 years of age. Women aged between 40-49 years may also have a mammogram if they request it. This program involves setting up mammographic screening units in larger towns and cities and using mobile screening units to provide mammograms in smaller towns. Under the program mammograms are provided free of charge.

What is a mobile breast cancer screening unit?

Mammograms can be provided through a mobile screening unit 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. A mobile unit usually visits a town for several weeks to allow all women in the area to have access to breast cancer screening.

P.T.O

No postage stamp required
if posted in Australia

REPLY PAID 790
Philip Clarke
National Centre for Epidemiology and Population Health
GPO BOX 4
CANBERRA ACT 2601

My phone number has changed.
Here are my details:

Name: ______________________ (Please print)

Address: ______________________

____

New phone number: (   ) ______________________

ONLY SEND THIS CARD IF YOUR PHONE NUMBER HAS CHANGED

«TownCode» «PersonCode» («Merge Record #»)

BREAST CANCER SCREENING SURVEY
CVM/TCM SURVEY

Name: **«Title» «Fname» «Lname»** Address:**«Street» «Town Name» «pcode»** Ph Number: **(«STD») «phone»** Date of Birth:**«bday»/«bmonth»/«byr»** Initial amount offered for mobile service:**$«Assigned bid 1»**	
Consent status : 1 **Consent** 2 **Non consent**	**Interview:** 1 **Yes** 2 **No**
New Contact Details: **New postal Address:**______________________________ ____________________________________ ____________________________________ **New phone number:**________________________	

Contact Record	**Call Back Date**
1.____________________	**1.**____________________
2.____________________	**2.**____________________
3.____________________	**3.**____________________
4.____________________	**4.**____________________
5.____________________	**5.**____________________

SECTION 1 TO THE PERSON THAT ANSWERS THE PHONE:

Hello, my name is ________ . Your household should have received a letter from the Australian National University addressed to _______ telling her about a health survey we are conducting. Could I speak to _______?

YES *goto "2. TO SELECTED RESPONDENT"*
NO *goto "3. TO ANOTHER HOUSEHOLD MEMBER"*

SECTION 2. TO SELECTED RESPONDENT:

Three years ago the Cancer Education Research Project contacted you and asked some questions on cancer and other health issues. One of the researchers has since moved to the National Centre for Epidemiology and Population Health in Canberra. We are now conducting a follow-up survey on breast cancer screening. This study should take no longer than a few minutes. Is now a convenient time to answer a few questions?

YES *Go to "4. START OF SURVEY:"*
NO *Continue*

Would you like to do the survey some other time?

YES What time would be a good time to contact you?

Write time on "Call Back Date" section of cover sheet.

NO Thank the respondent for her time **and** *record on cover sheet "Non Consenter"*

SECTION 2a. TO ANOTHER HOUSEHOLD MEMBER:

Do you know when ______ will be home so I can call and talk to her then? How about I call back on ____ at _____? *{Record on cover sheet}*

IF NO LONGER LIVING AT ADDRESS

Three years ago we surveyed ______ to find out her attitudes to cancer. At that time she said that she was willing to under take a follow-up survey on this issue.

Do you have a contact address and phone number for _________?

{Write information on cover sheet}

SECTION 3. START OF SURVEY:

I would like to start by asking you some general questions:

1. Could you tell me your date of birth? ______________*{check with birthday on cover sheet}*

2. What is your current occupation? ________________

Unemployed	**1**
Home Duties	**2**
Pensioner	**3**

{Circle if not employed}

3. Do you know anyone who has had breast cancer in the last 5 years?

YES *goto* **Q4**	**1**
NO *goto* **Q5**	**2**

4. How was this person related to you?
{Unprompted }

Self	**1**
Mother	**2**
Daughter	**3**
Sister	**4**
Cousin /Aunt	**5**
Other relative	**6**
Friend	**7**
Acquaintance	**8**

{If they know more than one person circle as many as apply}

5. I would now like to ask you some questions about mammograms. A mammogram is an X-ray of your breasts. It is used to detect breast cancer while it's still small.

How many mammograms have you had in the last five years (since Jan 1992)?

One	**1** *goto* Q6
Two	**2** *goto* Q6
Three or more	**3** *goto* Q6
None	**4** *goto* Section 5.

SECTION 4. QUESTIONS FOR WOMEN WHO HAVE HAD MAMMOGRAM IN LAST THREE YEARS

6. How long ago did you have your {most recent mammogram / mammogram before that/ etc}?

	Most recent	2nd most recent	3rd most recent
Was it :			
{Read out list}			
This year (1996)	**1**	**1**	**1**
Last year (1995)	**2**	**2**	**2**
In 1994	**3**	**3**	**3**
In 1993	**4**	**4**	**4**
In 1992	**5**	**5**	**5**

7. ***If had a mammogram:*** Where did you go to have your {most recent mammogram/ mammogram before that/ etc}?
{Read out list}

	Most recent	2nd recent	3rd recent
Free screening service by health Dept	**1**	**1**	**1**
Specialist Doctor (Radiologist)	**2**	**2**	**2**
Public Hospital	**3**	**3**	**3**
Private Hospital	**4**	**4**	**4**
Other	**5**	**5**	**5**

8. ***If had a mammogram:*** Can you tell me why you had your {most recent mammogram / mammogram before that/etc}?
{Unprompted}

	Most recent	2nd recent	3rd recent
Had breast cancer in the past	**1**	**1**	**1**
Had a breast lump/breast pain at the time	**2**	**2**	**2**
Had a breast lump/breast pain in the past	**3**	**3**	**3**
Have a family history of breast cancer	**4**	**4**	**4**
Heard of a free service and decided to attend	**5**	**5**	**5**
Received a reminder to attend	**6**	**6**	**6**
My GP suggested I go	**7**	**7**	**7**
Wanted to make sure they didn't have breast cancer	**8**	**8**	**8**
{circle as many as apply}			
Other	______		

9. ***If had a mammogram:*** What was the name of the town where you had your {most recent mammogram / mammogram before that/ etc}?

Most Recent	**2nd most recent**	**3rd most recent**

10. ***If had a mammogram:*** If you hadn't been going to have a mammogram would you still have travelled to ***{town name Q9}*** on that day for some other reason?

	Most recent	**2nd recent**	**3rd recent**
Yes	1	1	1
No	2	2	2
Don't remember	3	3	3

{Repeat questions in Section 4 if they have had more than one mammogram}

SECTION 5. GENERAL QUESTIONS ON MAMMOGRAMS (ASK ALL WOMEN):

11. In the last two years, has a doctor or nurse asked or suggested you have a mammogram?

Yes	**1**
No	**2**
Don't remember	**3**
Have not seen a doctor/ nurse in that time	**4**

12. Do you intend to have a mammogram sometime in the next two years?

Yes	**1** ***goto* Q14**
No	**2** ***goto* Q13**
Don't Know	**3** *goto Section 6*

13. ***If not intending to have mammogram:*** What would you say are your reasons for not having a mammogram?
{Unprompted}

Discomfort of procedure	**1**
Do not think they are effective	**2**
Will not have an x-ray	**3**
Cannot afford to travel to have a mammogram	**4**
Too young	**5**
Too old	**6**

Other____________________________________

{After asking Q13 goto Section 6}

14. ***If they are intending to have a mammogram:*** If you couldn't have the mammogram in «Town Name» to what town would you go?

________________________ ***{write response} goto Q15***

Don't Know **1** *{Circle* **1** *and goto* **Section 6***}*

15. ***If they know the town for next mammogram:*** Do you think you would be likely to combine a trip to {response from Q14} to have a mammogram with other activities (e.g. business/ social visit/ or shopping.)

Yes	**1**
No	**2**
Don't Know	**3**

SECTION 6. CONTINGENT VALUATION SECTION (FOR ALL WOMEN)

I'm now going to ask you some questions on whether you think mammograms should be provided locally. We recently sent you some information on this issue through the mail.

16. Have you received this information from us?

Yes	**1**
No	**2**
Don't know	**3**

If No or Don't Know: Don't worry I'll repeat this information over the phone.

READ THIS TO ALL WOMEN:

There are two ways mammograms could be provided. They could either be provided locally using a mobile screening van that would visit «Town Name» at least once a year or women in «Town Name» could travel to a city such as «Substitute site» and have a mammogram at any time of the year. In both the cases the mammogram is free, but women would have to pay any travel expenses.

17. Would you use a mobile screening unit to have a mammogram if it visited «Town Name»?

Yes	**1**
No	**2**
Don't know	**3**

To provide a breast cancer screening service locally will cost the Government more money. In the next part of this survey I'm going to ask you a few questions on whether you would be prepared to pay higher taxes to have a mobile breast cancer screening unit located in «Town Name».

17.a Do you currently pay tax?

Yes	**1** ***goto*** **Q18**
No/ refused to answer	**2** ***continue***

If respondent doesn't pay tax: Think of the payment as a levy paid to the local council to provide the service.

18. Would you be willing to pay $«Assigned bid 1» in {tax/council levy} to have a mobile unit visit «Town Name»?

Yes	**1** ***goto*** **Q19**
No	**2** ***goto*** **Q20**
Don't know	**3** ***goto*** **Q20**

19. *If willing to pay $«Assigned bid 1»:* Lets suppose providing a mobile screening unit is more expensive. Are you willing to pay $«Assigned bid 3»?

Yes	**1** ***goto*** **Q23**
No	**2** ***goto*** **Q23**
Not sure	**3** ***goto*** **Q23**

(*After answering Q19 goto Q23*)

20. *If not willing to pay $«Assigned bid 1»:* **Lets suppose providing a mobile screening unit is cheaper. Are you willing to pay $«Assigned bid 2»?**

Yes	**1** ***goto*** **Q23**
No	**2** ***continue***
Don't know	**3** ***goto*** **Q23**

21. *If not willing to pay $«Assigned bid 2»:* **Would you be willing to pay something (i.e. an amount below $«Assigned bid 2») to have a mobile unit located in «Town Name»?**

Yes	**1** ***goto*** **Q23**
No	**2** ***continue***

22. *If not willing to pay anything:* Why don't you want to pay any more {tax/council levy} to have a service located in your town?

{Unprompted}

Don't believe I should pay for other peoples health	**1**
Money should come from existing taxes/less waste	**2**
Would not use the service	**3**
Other______________________________	

{write response}

READ THIS TO ALL WOMEN:

23. The final question relates to your household's income (i.e. the combined income of all people currently living in your household).

Could you tell me if your household income is:

Less that $15,000 per year	**1**
Between $15,000-$30,000 per year	**2**
Between $30,000-$45,000 per year	**3**
Between $45,000-$60,000 per year	**4**
Between $60,000-$75,000 per year	**5**
Between $75,000-90,000 per year	**6**
Greater than $90,000 per year	**7**
Refused to answer/don't know	**8**

That concludes the survey, thank you very much for your time.

END

FOR THE INTERVIEWER:

Did the respondent understand the willingness to pay questions (Q18-Q20):

Yes	**1**
No	**2**

On a scale of 1 to 5 how certain/ sure was the respondent of their answers to the willingness to pay questions:

1	**2**	**3**	**4**	**5**
Not at all		**Moderately**		**Very sure**

Appendix C: Responses to Question 22

Below are listed some selected responses to Q22, that asked women their reasons for having a zero willingness to pay. These are listed by category. The interviewers were asked to record their response verbatim. In some cases, the respondent gave a long answer and so the interviewer para-phrased it. When two or more women offered the same or a very similar answer only one example has been included.

1. Problems with the payment vehicle

(i) "We pay enough tax as it is."

(ii) "I already pay $2500 in health insurance and the Medicare levy. I feel I pay enough.".

(iii) "Worked until 60 years of age and paid tax, mammograms should be free for pensioners at this time of life."

(iv) "If people in city have free service, country people should not have to pay tax for a free service."

(v) "We pay private health insurance as well as the Medicare levy. We both work and pay high taxes. I don't want to pay any more tax."

(vi) "I paid taxes all my working life. I should get it free".

(vii) "All women should be treated the same whether or not they live in city or country areas."

2. "Can't Afford it"

(i) "I'm a pensioner, I can hardly manage as it is."

(ii) "Can't afford it- I think it's worthwhile to pay for it, but the money is not there."

(iv) Respondent does believe in user pays system, but because of financial situation is unable to pay.

(v) On a pension, depends on circumstances, can't really afford extra things

3. Previously donated to a charity to provide the service

(i) "We have raise a lot of money for a mobile unit so I feel we have already paid."

(ii) "Have paid money to charity have a mobile unit."

(iii) "Respondent was heavily involved in fund raising for a mobile van. After raising thousands of dollars the van has not been provided. Will not pay any more in taxes for a mobile van."

(iv) "There has been fund raising in the area to provide the service. I donated $250 and should not be asked to pay more money now."

(v) "We were involved in fundraising for a mobile unit. It seems Canberra has taken the money and nothing has happened. Would not pay any more money."

(vii) "Women in the area have already raised money for a mobile screening unit and I would not pay any more."

4. Prefer a substitute site

(i) "I can get a free service in Lismore."

(ii) "Lismore service is excellent and has all the facilities."

(iii) "I would go to private radiologist."

(iv) "Find Lismore service excellent and feel confident in using their service."

(v) "More confident having it done at a private radiologist."

(vi) "I prefer to go to my doctor who would have my previous x-rays."

(viii) "I have a business and have to travel to Tamworth (nearest fixed site) anyway."

(ix) "Don't feel that service is as good as a specialist. When I first approached the mobile service they refused to give me a mammogram because I was only 40."

(x) "Would use a private radiologist. Two friends had mammograms at mobile units then got breast cancer within six months."

5. No difficulty in using the fixed site

(i) "Rather combine a mammogram with a trip to Coffs Harbour."

(ii) "I would rather travel elsewhere and combine the trip with other activities than paying more taxes."

(iii) "I have to go to Port Macquarie (nearest fixed site) to do the shopping. Would rather combine having a mammogram with a shopping trip."

(iv) "I would just go to Echuca to do other things and have my mammogram then."

(v) "Just as easy to travel to Armidale (nearest fixed site)."

(vi) "I travel to Tamworth regularly and it a waste to have a screening van visit, because all the local women travel to Tamworth regularly."

(vii) "Because there a volunteer car pool people can easily get to Canberra to have a mammogram."

(viii) "There is a screening centre at Orange (nearest site) and would be happy to travel."

6. Would not use it.

(i) "Would not use the service. I need a special screening tests due to thickening of the breast tissue."

(ii) "Being disabled, a mobile unit has no access for me."

(iii) "Don't believe in mammograms- would not have one."

(iv) "MRI is a better method for detecting breast cancer and should be used instead"

7. Other reasons

(i) "Not enough information given on who would receive the mammograms. Would be willing to pay if mammograms were available to women of all ages."

(ii) "Mobile units should be for all types of cancer. Would be willing to pay if benefited the whole community"

Bibiography

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