Counting the cost of effective health policy

1. Introduction
In this case study, you can practise your maths skills in a way which resembles their professional use to inform policy-making for services we all depend on from time to time, and also to inform their public regulation. The case will indicate how a study of economics is used to inform decision making specifically in *health services*.

The resources at stake are huge; for example, estimated UK public spending committed to these services in 2007-08 exceeds £100billion (about 18% of total government spending). The sequence of calculations described here is often used to consider *which* services to provide over the coming years.

After studying this case study successfully, you can expect to be able to describe cost calculations made to obtain estimates of cost effectiveness (CE) of new investments in services. You will improve your ability to calculate: marginal costs; discounted present values, percentages and aggregated effects, and to interpret probability distributions. You will also gain experience in identifying and describing limitations of the data and the mathematical techniques when used in their real-world context.

2. Applied economics of investments in services
Any successful study of the economics of services to enhance human well-being requires an extensive, sensitive analysis. It also requires contributions from a broad range of people.

Increasingly, however, policy makers demand a very brief summary of evidence predicting the impact of investments in these services, for ready application to the decision making process.

For a leading UK example of how the estimates are used and which services have been studied in this way, see the National Institute for Health and Clinical Excellence (NICE) website.[1]

Use of CE estimates remains limited and controversial, for various technical and philosophical reasons. This reminds us to consider not only the techniques used to develop them but also the care with which they are devised, generated, interpreted and used in a real human context. Services such as education and health are vastly more complex than any figures alone can convey.

3. Measures of cost effectiveness
Many people have been known to utter the words `cost effective' but a clear idea of how to use the term is needed if we want to be clear what our estimates indicate for practical decision making.

Many economists define `cost effective' use of resources as meaning the least costly way possible to achieve a stated outcome. One example would be the least costly way possible to increase awareness of all the risks known to be associated with smoking.

Note that the rather modest outcome to be measured in this example is 'awareness': it would take a more ambitious analysis to establish the effect of increased awareness on people's health. Many other examples, of course, do tackle just such an ambitious challenge.

To indicate whether a cost effective activity is also a worthwhile activity requires evidence that cannot be included in any measure of CE itself: evidence that the value of the outcome achieved outweighs the lowest possible cost of achieving it.

We assume from the outset that the costs and outcomes of an economic activity are measurable. Each CE figure is presented as cost divided by outcome quantity (i.e. one cost figure for each relevant quantity).

V*arying* the size of the investment will change the total cost of that investment. These *differences* in total cost are called *marginal costs (of outcomes)*.

We must be careful to measure the costs of achieving *outcomes* (such as health improvements), not merely the costs of employing more inputs. These two cost concepts are linked by the productivity of the inputs in achieving the outcomes required.

4. Marginal cost of outcomes

In Table 1, we see a typically incomplete set of data with which an economist might have to work. The gaps in data might arise for technical, confidentiality or cost reasons. We can fill in the gaps by manipulating the data we do have, by a process known as interpolation which is described in a paragraph below.

Table 1 contains data on the total cost (in the right hand column) of generating three different quantities of health gain (listed in the left hand column) by investing in a particular health service (for example, hip replacement surgery).

Table 1

Health gain units	Data on total cost of health gains
100	£100,000
101	Not available
102	Not available
103	Not available
104	Not available
105	£150,000
106	Not available
107	Not available
108	Not available
109	Not available
110	£250,000

A unit of health gain here just means a quantifiable improvement in health, so a higher quantity of units indicates more improvement. Note that a total of units might include improvements experienced by different patients.

Another case study in this series, called *Measuring Health Improvements for a Cost Effectiveness Analysis*, includes an introduction to ways in which such units are compiled and used.

Our first task is to calculate the difference between the different total cost figures (between 100 - 105 units of health gain, then between 105 - 110 units). Now we have estimates of marginal cost for two different five-unit variations in health gain. The marginal cost of 105 units compared with 100 is £50,000, whereas it is £100,000 for 110 units compared with 105.

Estimates of marginal cost for single-unit increments can be obtained by dividing the five-unit ones by five. For example, the marginal cost estimate for 104 units, compared with 103, is £10,000. This method is called linear interpolation, because it assumes total costs rise at a constant rate: possibly an oversimplification of the truth but likely to make little difference over the small margins in this case.

Table 2

Health gain units	Data on total cost of health gains	Marginal cost estimates	Total cost estimates with interpolations
100	£100,000		£100,000
101	Not available	£10,000	£110,000
102	Not available	£20,000	£120,000
103	Not available	£30,000	£130,000
104	Not available	£40,000	£140,000
105	£150,000	£50,000	£150,000
106	Not available	£20,000	£170,000
107	Not available	£40,000	£190,000
108	Not available	£60,000	£210,000
109	Not available	£80,000	£230,000
110	£250,000	£100,000	£250,000

Columns 3 and 4 of Table 2 indicate marginal cost estimates generated in this way and aggregated for total gains of 2, 3, 4 and 5 health units between

100 and 105. We repeat this process but use total cost of 105 units as the base figure and apply multiples of £20,000 to each 1-unit increment up to 110 units.

It is only having done all the preceding calculations that we can now quote a full sequence of cost effectiveness figures as in Table 3, column 3. The figures represent cost divided by outcome quantity (one cost figure for each relevant quantity).

In this simple example, we note that total cost per unit of health gain increases continuously for increased total quantities of health gain across the range considered.

That might not always be true. In any case, it is more important to know the size of any cost increases. Decision makers can then judge how much is worth spending to achieve more health gains, by investing more in this particular health service, especially if different services could achieve those gains instead were that sum to be spent on them.

Table 3

Health gain units	Total cost estimates with interpolations	Cost per health gain unit (CE)
100	£100,000	£1,000
101	£110,000	£1,089
102	£120,000	£1,177
103	£130,000	£1,262
104	£140,000	£1,346
105	£150,000	£1,429
106	£170,000	£1,604
107	£190,000	£1,776
108	£210,000	£1,944
109	£230,000	£2,110
110	£250,000	£2,273

In this example, the smallest quantity of this health service we have considered seems to incur the lowest total cost (as would be expected) but it is also the cost effective quantity among them in that it minimises cost incurred per health gain unit achieved.

It might be that £100,000 is the cost effective way to achieve 100 health gain units but also that a 101st unit could be achieved at a cost less than £1,089 by investing in a different type of health service; a 102nd one for less than £1,177, and so on.

5. Limited data: sensitivity analysis
Apart from the usual difficulties of obtaining and working with adequate data, other complications are often encountered in calculating a useful set of CE estimates.

In particular, CE estimates are affected by any significant uncertainties about how much an activity will cost or what outcomes there will be. A standard way to take these uncertainties into account is called *sensitivity analysis*, which can take a variety of forms.

The mathematics of conducting a sensitivity analysis can be simply to vary one key cost component by a small percentage, according to a chosen probability distribution.

For example, suppose we have information suggesting that either all our original total cost estimates were correct or there is a 20% chance we underestimated them all by 10%.

That then defines two very simple probability distributions for our cost estimates: either `original estimates with 100% confidence; all other cost levels 0% chance of being correct' or 'originals 80% chance that they are correct; 20% chance of an underestimate by 10%; 0% chance that any other cost levels are correct'.

We can compare our original estimates (compiled as if we had 100% confidence in them) with revised ones. The revisions take a 20% chance of a 10% underestimate into account, along with an 80% chance of the original estimates being correct. This is called a weighted average (of two quantities

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each adjusted by, in this case, their probability of occurring).

We can then calculate the impact the difference between these two levels of confidence has on the total cost estimates included within our cost effectiveness figures. We will observe whether the cost increases (or decreases) by enough to affect our indication of which is the cost effective investment option.

In reality, more probability distributions, and more cost variations, might be worth including in the sensitivity analysis but we will keep things simple.

First, we calculate an increase of 10% on the total cost figures in Table 2 above between 100 and 105 units of health gain. These revised estimates appear in Table 4, column 3 below.

Table 4

Health gain units	Total cost of health gains (original estimates)	Total cost of health gains (+10%)	80% of column 2 + 20% of column 3
100	£100,000	£110,000	102,000
101	£110,000	£121,000	112,200
102	£120,000	£132,000	122,400
103	£130,000	£143,000	132,600
104	£140,000	£154,000	142,800
105	£150,000	£165,000	153,000

We now have to combine our new information on total cost levels (the possibility that they are 10% higher than originally thought) with our new information about the probability that these higher cost figures are the accurate ones.

We begin by multiplying each of the original total cost estimates by 80% (= 0.8) and each of the correspondingly revised estimates by 20%, reflecting their probabilities of occurring. Next, for each quantity of health gain, we add the two probabilistic figures together. These figures are presented in Table 4, column 4.

To complete this sensitivity analysis, we calculate revised cost per health gain unit (CE) figures and compare them with the original estimates. See Table 5, column 3 and column 2.

Table 5

Health gain units	Cost per health gain unit (CE)	Revised Cost per health gain unit (CE)
100	£1,000	£1,020
101	£1,089	£1,111
102	£1,177	£1,200
103	£1,262	£1,287
104	£1,346	£1,373
105	£1,429	£1,457

The cost differentials in this case do not seem large, although they would be more significant if the same investment were to be repeated many times.

6. Tasks
(i) Recalculate the marginal cost and interpolated total costs in Table 2 if the information we have about the total cost of achieving 100, 105 and 110 units of health gains is £100,000, £200,000 and £350,000 respectively.
(ii) Recalculate the cost per health unit.
(iii) Undertake a sensitivity analysis on the assumption that there is a 10% probability of our new costs being 50% higher than expected.

7. End note
Well done for completing this case study and improving both your mathematical skills and your awareness of how they can be used by economists for practical policy purposes.

The companion case study in this series called *Measuring Health Improvements for a Cost Effectiveness Analysis* extends this policy application to include calculations which take the timing of costs into account, together with ways in which indicators of health improvement are compiled and used.