Future costs in cost effectiveness analysis

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Abstract

This paper resolves several controversies in CEA. Generalizing [Garber, A.M., Phelps, C.E., 1997. Economic foundations of cost-effectiveness analysis. Journal of Health Economics 16 (1), 1–31], the paper shows accounting for unrelated future costs distorts decision making. After replicating [Meltzer, D., 1997. Accounting for future costs in medical cost-effectiveness analysis. Journal of Health Economics 16 (1), 33–64] quite different conclusion that unrelated future costs should be included in CEA, the paper shows that Meltzer’s findings result from modeling the budget constraint as an annuity, which is problematic. The paper also shows that related costs should be included in CEA. This holds for a variety of models, including a health maximization model. CEA should treat costs in the manner recommended by Garber and Phelps.

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1. Introduction

Economists have debated whether future medical costs should be incorporated in cost effectiveness analyzes for a number of years. Indeed, the Panel on Cost-Effectiveness in Health and Medicine was unable to reach consensus on this issue (Russell, 1986; Mushlin and Fintor, 1992; Weinstein et al., 1996). Meltzer (1997) has subsequently advanced theoretical arguments that, in his view, showed that “cost-effectiveness analysis must include the total change in future expenditures which results from a medical intervention, regardless of whether those expenditures are medical or non-medical (Meltzer, 1997, p. 41).” Garber and Phelps (1997) demonstrate that less general models imply that unrelated future costs should be excluded, but do not directly contest Meltzer’s conclusions. Indeed, Garber (2000), p. 203, subsequently conjectures that generalizing their model by allowing for “intertemporal reallocation of income and consumption” might yield Meltzer’s results. This is not a point of emphasis, however, because they stress that, at the margin, interventions should have the same cost per quality adjusted life year whether or not future costs are included. From this they infer that “the inclusion of future costs is without consequence so long as the practice is consistent (Garber and Phelps, 1997, p. 25).”
There is general agreement that cost effectiveness analyzes should account for related costs. The controversy is primarily about the treatment of unrelated future costs, but it is important to understand that both terms have non-colloquial meanings in this context. In cost effectiveness analysis future costs are termed unrelated if they are independent of current spending, apart from the effects of that spending on survival. Of course, if an intervention has significant effects on survival, it can have a major impact on spending, but such spending would be considered unrelated. For example, compared to bypass surgery, angioplasty appears to reduce mortality for high-risk patients with cardiovascular disease (Stroupe et al., 2006). Patients who live longer obviously use more medical care, but these costs would be considered unrelated to angioplasty. Costs of other cardiac care that do not appear to be affected by the choice of angioplasty or bypass surgery (e.g., treatment of aneurisms) would also be considered unrelated. In contrast, patients who choose angioplasty are more likely to require revascularization than patients who choose bypass surgery, and these added revascularization costs are considered related to angioplasty. In practice, as Weinstein and Manning (1997) note, teasing apart related and unrelated costs can be quite challenging. Nonetheless, the core issue for this paper is whether changes in spending that are solely due to changes in survival – i.e., unrelated costs – should be included in cost effectiveness analyzes.

Meltzer argues that cost effectiveness analyzes should incorporate related and unrelated future costs. He also argues that these costs should be measured as the present value of the difference between labor earnings and total spending weighted by the change in survival probabilities. And applied researchers appear to be taking note, as Meltzer’s paper has been cited over 90 times. Although I have found no instances in which including unrelated future costs has fundamentally changed an analyst’s assessment of an innovation, adhering to Meltzer’s protocol has changed a number of cost effectiveness ratios. For example, in a study of adding a beta blocker to standard therapies for congestive heart failure, Ekman et al. (2001) found that including future costs increased the cost per life year from $1717 per life year to $22,137. Likewise, in an analysis of adding an angiotensin-converting enzyme inhibitor to the therapy of patients at high risk of cardiovascular events, Bjorholt et al. (2002) found that accounting for unrelated future costs increased the cost per life year gained from $2244 to $28,703. Meltzer et al. (2000) found that counting unrelated future costs decreased the cost per quality adjusted life year of adding intensive therapy for patients with type 1 diabetes mellitus from $22,576 to $9626. And Almbrand et al. (2000) found that recognizing unrelated future costs increased the cost per quality adjusted life year of intense insulin treatment for diabetic patients who had experienced a heart attack from $1772 to $28,467. Similarly, Johannesson et al. (1997) found that adding unrelated future costs in an assessment of the treatment of hypertension increased the cost per quality adjusted life year by at least $26,000 for older patients.

All of these calculations, which are based on earnings, suggest that accounting for unrelated future costs is important. Yet this paper argues that this is unlikely to be correct for two reasons. First, earnings-based estimates significantly overstate unrelated future costs. Second, a compelling case for including unrelated future costs in cost effectiveness analysis has yet to be made.

The remainder of paper rigorously examines the treatment of future costs in cost effectiveness analysis. Section 2 analyzes Meltzer’s expected utility model using the Garber–Phelps budget constraint. This analysis finds, as did Garber and Phelps, that optimality is inconsistent with inclusion of unrelated future costs. Section 3 extends this by showing that consistency is not enough. Incorrectly calculating opportunity costs will distort decision making except in special cases. Section 4 reassesses the Meltzer model. This analysis shows that the present value of Meltzer’s measure of future costs is approximately zero. It also shows that his budget constraint is problematic. Section 5 analyzes related costs, showing that their treatment should be quite different from unrelated costs. Section 6 shows that expected health maximization gives decision rules that parallel those of Garber and Phelps. Section 7 concludes.

2. A model with a Garber–Phelps budget constraint

This section analyzes a model that uses Meltzer’s objective function. It starts using a Garber–Phelps budget constraint and replicates their result that an expected utility maximizer need not consider unrelated future costs. The section goes on to show that this is also the case with a more general budget constraint that allows borrowing and lending. Meltzer examines an expected utility framework for a representative consumer. Utility in each period depends on consumption \([c']\) and health status \([H']\). Preferences satisfy the axioms of expected utility, so \(U'(c', H(M'))\) is strictly increasing and concave. Health status depends on medical consumption to date, which is defined by the vector \(M' = (m^0, m^1, m^2, \ldots , m^r)\). So, \(H' = H(M')\). Utility is discounted by a time discount factor \([\beta']\) and a probability of survival that
depends on the entire vector of medical care consumption \[ S'(M') \]. Eq. (1) defines lifetime expected utility:

\[
EU = \sum_{t} \beta^{t} S'(M') U^{t}(c^{t}, H(M^{t})).
\]

(1)

In a model without capital markets the representative consumer cannot borrow or lend. In each period \( c^{t} = y^{t} - pm^{t} \). This is precisely the model that Garber and Phelps analyze. Incorporating the budget constraint via substitution yields the objective function and first-order condition with respect to \( m^{0} \), Eqs. (2) and (3), respectively.

\[
EU = \sum_{t} \beta^{t} S'(M') U^{t}(y^{t} - pm^{t}, H(M^{t})).
\]

(2)

\[
\sum_{t} \beta^{t} \left[ S'(M') \left( \frac{\partial U^{t}}{\partial H^{t}} \right) \left( \frac{\partial H^{t}}{\partial m^{0}} \right) + U^{t} \left( \frac{\partial S'}{\partial m^{0}} \right) - \left( \frac{\partial U^{0}}{\partial c^{0}} \right) \right] - \left( p \beta^{0} S^{0}(M^{0}) \right) = 0.
\]

(3)

Eq. (4) simplifies and rearranges (3) to get the traditional link between expected utility maximization and cost utility analysis. The simplifications are inessential. Eq. (4) gives full weight to the initial period, so \( \beta^{0} = S^{0}(M^{0}) = 1 \). Relaxing these assumptions adds complexity, but no insight. The result that \( m^{0} \) should be chosen so that the cost per QALY \( [p/\Delta^{0}] \) is just equal to \( 1/(\partial U^{0}/\partial c^{0}) \), reproducing the finding of Garber and Phelps:

\[
\gamma^{0} = \frac{p}{\Delta^{0}} \quad \text{with} \quad \gamma^{0} = \frac{1}{(\partial U^{0}/\partial c^{0})}.
\]

(4)

Throughout the paper a leading \( * \) or \( ** \) denotes an optimal value or an expression evaluated at the optimum. For example, \( * \Delta^{0} \) represents \( \sum_{t} \beta^{t} U^{t}(S^{t}/m^{0}) + \sum_{t} \beta^{t}(\partial U^{t}/\partial H^{t})(\partial H^{t}/\partial m^{0}) \) when the optimal values of \( c^{t} \) and \( m^{t} \) have been chosen. Here \( * \Delta^{0} \) is just the change in quality adjusted life years that the optimal \( m^{0} \) generates, an expression that will appear unchanged several times.

Eq. (4) sharpens our inquiry. It implies that an expected utility maximizer who uses the Meltzer objective function and the Garber–Phelps budget constraint need not consider unrelated future costs. The opportunity cost, \( p \), does not include any unrelated future costs. Meltzer’s different conclusion must be due to his different budget constraint or hidden assumptions in his analysis.

In addition, repeating this analysis for different periods helps fine tune a question about unrelated future costs. Consider optimal future medical consumption, \( *m^{t} \), for some unspecified future time period. The first-order conditions for \( *m^{t} \) are \( *\gamma^{t} = p/*\Delta^{t} \). The implication is that \( *m^{t} \) will take full account of the opportunity costs of consuming it. The reader can verify that all optimal values for all \( *c^{t} \) will also fully account for opportunity costs. It is hard to understand, therefore, why these costs need to be factored into other decisions as well.

Furthermore, one can add capital markets to the Garber–Phelps model without changing its implications (except that doing so means that the marginal utility of income should be equalized over time). Let the consumer borrow (\( s^{t} > 0 \)) or lend (\( s^{t} < 0 \)), so the budget constraint becomes \( c^{t} = y^{t} + (1 + r)d^{t-1} + s^{t} - pm^{t} \). In this constraint \( r \) is the (assumed constant) rate of return and \( d^{t} \) is assets, meaning that \( rd^{t-1} \) might represent income or expense. The consumer’s assets are defined by \( d^{t} = (1 + r)d^{t-1} + s^{t} \). Taken together, these imply a lifetime budget constraint of \( \sum_{t} (y^{t} - c^{t} - pm^{t}) (1 + r)^{t-1} = 0 \), assuming that the consumer has no starting assets and plans to have no ending assets. (Here \( \tau \) denotes the final date in the planning problem. To maximize \( \sum_{t} \beta^{t} S'(M') U^{t}(c^{t}, H(M^{t})) \) subject to the constraint that \( \sum_{t} (y^{t} - c^{t} - pm^{t})(1 + r)^{t-1} = 0 \), the consumer should choose \( m^{0} \) so that \( *\gamma^{0} = p/*\Delta^{0} \). Adding intertemporal reallocation of income and consumption to the Garber–Phelps model does not change its implications.

3. Consistency

Garber and Phelps (1997) show that an expected utility maximizer ought to be consistent in applying cost utility analysis. By consistent they mean that an individual should allocate resources so that the cost per QALY will be the same for all possible interventions. I will replicate that result below. They go on to prove that including unrelated future costs in an intervention’s opportunity cost should still lead an expected utility maximizer to equate the cost per QALY across interventions. I will also replicate this result below. They then infer from these results that “the inclusion of unrelated future costs is without consequence so long as the practice is consistent (p. 25).” I will show why that conclusion is incorrect.
To make these points I will examine an example in which the optimum entails positive levels of consumption of two medical interventions, $x^0$ and $m^0$. As in the case that Garber and Phelps explore, the consumer must choose $x^0$ and $m^0$ to maximize expected utility, which is given by $\sum_{t\in T} \beta^t S'(M,X) U'(y^t - pm^t - qx^t) H(M^t, X^t)$. I will continue to follow Garber and Phelps in assuming that capital markets do not exist. The first-order conditions for $*x^0$ and $*m^0$ are

$$\sum_{t\in T} \beta^t \left[ S'(M,X) \left( \frac{\partial U'}{\partial m^0} \right) + U' \left( \frac{\partial S'}{\partial m^0} \right) \right] - \left( \frac{\partial U'}{\partial c^0} \right) \frac{p \beta^0}{\theta} S^0 = 0. \tag{6}$$

$$\sum_{t\in T} \beta^t \left[ S'(M,X) \left( \frac{\partial U'}{\partial H^t} \right) + U' \left( \frac{\partial S'}{\partial H^t} \right) \right] - \left( \frac{\partial U'}{\partial c^0} \right) q \beta^0 S^0 = 0. \tag{7}$$

Again noting that $\beta^0 = S^0 = 1$, I find that optimality requires

$$*y^0 = \frac{p}{*\Delta^0} = \frac{q}{*\theta^0}. \tag{8}$$

Here $*\theta^0 = \sum_{t\in T} \beta^t [S'(M,X)(\partial U'/\partial H^t)(\partial H^t/\partial x^0) + U'(\partial S'/\partial x^0)]$, the number of QALYs produced by $*x^0$. Eq. (8) implies that the cost per QALY should be the same for $*m^0$ and $*x^0$, so the consumer should display consistency in the sense of Garber and Phelps. Now I will repeat the analysis, mistakenly including the present value of unrelated future costs in the opportunity costs of $m$ and $x$. Let $\mu$ represent a forecast of the present value of unrelated future costs for $m^0$, and let $\xi$ represent a forecast of the present value of unrelated future costs for $x^0$. As a result, I act as though $m^0$ costs $(p + \mu)$ per unit and $x^0$ costs $(q + \xi)$ per unit. At the resulting optimum the cost per QALY will again be equated:

$$\frac{(p + \mu)}{*\Delta^0} = \frac{(q + \xi)}{*\theta^0}. \tag{9}$$

So, my decision making will be consistent in the sense of Garber and Phelps, but will my choices of $m^0$ and $x^0$ remain unchanged? To answer this question it is helpful to write $*m^0$ and $*x^0$ as the Marshallian demand functions $m(p, q, y)$ and $x(p, q, y)$, and then examine under what circumstances $(\partial m/\partial p)\mu + (\partial m/\partial q)\xi = 0 = (\partial x/\partial q)\xi + (\partial x/\partial p)\mu$. This can be rearranged to show that errors in forecasting future costs will not affect $*m^0$ or $*x^0$ in two cases. In one trivial case $*m^0$ and $*x^0$ are zero with and without errors in estimating opportunity costs. In the other case all of the price and cross-price elasticities of demand are zero. Nothing in the Garber–Phelps model (or in standard models of consumer demand) rules out non-zero elasticities. Garber–Phelps consistency does not imply invariance of $*m^0$ and $*x^0$.

Erroneously treating the present value of future cost as a part of the opportunity cost of a product will not change the form of the decision rules. But, except in special cases, doing so will alter the resulting choices. There are consequences to incorrectly measuring opportunity costs.

An example in the spirit of Weinstein and Manning (1997) illustrates this. Suppose that two treatments are effective for a condition. Analysts calculate that the cost per quality adjusted life year is $10,000 for treatment $M$ and $15,000 for treatment $X$. However, inappropriately including the present value of unrelated future costs increases the cost per quality adjusted life year to $22,000 for $M$. This mistake reverses the rankings of the treatments and reduces use of $M$.

Such a reversal could not occur for Garber and Phelps, as they focus on optima in which the representative consumer adjusts consumption to equate the cost per quality adjusted life year. The consumer will do this (i.e., will be consistent) whether he gets the opportunity costs right or wrong. If he mistakenly incorporates unrelated costs, he will consume less $M$ by limiting its use to situations in which its costs are lower or its benefits are greater. Furthermore, it will be interventions with significant effects on survival (such as intensive treatment for diabetic patients or treatment of hypertension) that will be most affected.

4. Reassessing the Meltzer model

Meltzer constrains expected lifetime spending to equal expected lifetime income, meaning that the consumer can costlessly shift consumption between periods. No mechanism for doing this is spelled out, but the budget constraint functions like a life annuity that uses the individual’s survival probabilities. This budget constraint is defined by Eq. (10), which replicates Meltzer’s budget constraint except for two minor notation simplifications. Eq. (10) writes the discounting function as $\delta^r$ rather than $(1+r)^{-r}$ and deflates all expenditures by the price of the composite consumption.
commodity:

\[ 0 = \sum_{T} \delta^t S'(M^t)(y^t - c^t - pm^t). \]  

(10)

In the rest of this section I will demonstrate that this formulation of the budget constraint distinguishes Meltzer’s results from those of Garber and Phelps.

Maximization of (1) subject to (10) yields the first-order conditions (11)–(13). We seek to evaluate current medical spending, so now I will examine only the results for optimal \( c^0 \) and \( m^0 \). This allows me to simplify by taking advantage of the fact the \( \beta^0 = \delta^t = S'(M^0) = 1 \).

\[
\frac{\partial U^0}{\partial c^0} - \lambda = 0. 
\]  

(11)

\[
\sum_{T} \beta^t \left[ S'(M^t) \left( \frac{\partial U^t}{\partial H^0} \right) \left( \frac{\partial H^0}{\partial m^0} \right) + U^t \left( \frac{\partial S^t}{\partial m^0} \right) \right] - \lambda p + \lambda \sum_{T} \delta^t \left( \frac{\partial S^t}{\partial m^0} \right) (y^t - c^t - pm^t) = 0. 
\]  

(12)

\[
\sum_{T} \delta^t S'(M^t)(y^t - c^t - pm^t) = 0. 
\]  

(13)

As did Meltzer, I rearrange (11) and (12) to link optimal medical care consumption to cost utility analysis. Eq. (14) implies that \( m^0 \) should be chosen so that the adjusted cost per QALY is just equal to the inverse of the marginal utility of consumption. The presence of the Meltzer effect, \( \varphi^0 \), distinguishes this from the Garber–Phelps result of Section 2:

\[ * \gamma^0 = \frac{p - \varphi^0}{* \Delta^0}, \]  

(14)

with \( \varphi^0 = \sum_{T} \delta^t (\partial S^t / \partial m^0) (y^t - c^t - pm^t) \).

What is \( \varphi^0 \)? It is the present value of optimal savings multiplied by the change in survival probabilities. Below I will point out a theoretical difficulty with this formulation, but an empirical question needs to be raised first.

The effect of \( \varphi^0 \) could still be negligible if savings are small. Recognizing that it represents an imperfect guide to the savings plans of consumers who are contemplating various medical interventions, Meltzer draws on the Consumer Expenditure Survey to approximate \( \gamma^t - c^t - pm^t \) for the general population. In doing so, though, he makes an important change from the model outlined above. Rather than looking at population values for income minus expenditure for individuals in households with heads of different ages, he tabulates values for earnings minus expenditure. This is the case even though Meltzer specifically notes that insurance (e.g., social security and life annuities) is a common feature of retirement. Of course income from other assets (such as housing, certificates of deposit, or stocks) is also an important component of pre- and post-retirement income. Nonetheless, Meltzer focuses solely on earnings.

The paper offers no compelling rationale for this modification, even though one of its central features is the representative consumer’s ability to reallocate income over time. In the context of this model, the case for only considering earnings is very difficult to make. Especially for the elderly, focusing on earnings rather than income has a major impact on the value of \( \varphi^0 \). As households age both income and earnings fall, but earnings fall much more than income. Fig. 1, which draws on the 2003 Consumer Expenditure Survey, shows that earnings equal 77% of income for households with a respondent between 55 and 64. But, for households with a respondent between 65 and 74, earnings represent only 35% of income, and this falls to 10% for households with a respondent over 74.

In addition, the average propensity to consume among the elderly is close to unity, averaging 1.03. Because incomes tend to be lower in retirement, these average propensities to consume give rise to average \( per \ capita \) annual dissaving of only $481 (Bureau of Labor Statistics, 2005). This equals 2.7% of Meltzer’s earnings-based estimate. This pattern of very small levels of saving or dissaving has been found by Nieswiadomy and Rubin (1995) using the 1972–1973 and 1986–1987 Consumer Expenditure Surveys.

In short, savings by the elderly are approximately zero. Even if one accepted the Meltzer model, ignoring \( \varphi^0 \) in empirical work should have little or no effect on cost effectiveness ratios for the elderly and should modestly bias up the cost effectiveness ratios for everyone else.

A closer look at the theoretical underpinnings of Meltzer’s model is now in order. It should be clear that Meltzer’s budget constraint, which is \( 0 = \sum_{T} \delta^t S'(M^t)(y^t - c^t - pm^t) \), drives his results. In particular, it is the weighting of annual budgets by \( S'(M^t) \) that generates \( \varphi^0 \).
There are two ways of modeling budget constraints for uncertain lifetimes in the literature. These approaches, which I call the Annuity and Conditional models, have differing implications, yet I am aware of no rigorous comparison of them.

Meltzer’s budget constraint is an example of an Annuity model. Other authors, including Blomqvist (2002) and Barro and Friedman (1977), have also used Annuity models. In rationalizing this approach, Meltzer and Blomqvist explicitly make an analogy with a life annuity. The analogy cannot be exact, however, as death does not cancel all cash flows. Taxes still have to be paid, the house still exists, the car payment remains due, mutual fund dividends still accrue, and so forth. Thus, the first criticism of an Annuity approach is that it does not accurately describe the consumer’s financial circumstances. A related criticism is that the Annuity approach understates the consumer’s resources. What constrains spending on consumption goods and medical care in period $t$ is $y_t$, not $S_t(M_t)$. A consumer with $100,000 to spend in the next period and a probability of survival of 90% is not limited to spending $90,000. Although $y_t$ can be a lottery, it needs to be a lottery that is well defined if the consumer lives, and this is not true for Annuity budget constraints.

In writing down the budget constraint that will hold if the consumer survives, Garber and Phelps use a Conditional budget constraint. Representative examples include Johansson (2001), Caballero (1991) and Abel (1986). In addition to correctly characterizing the resources available to consumers, Conditional budget constraints lack some of the problematic features of Annuity budget constraints.

A simple two-period model helps make this clear. We seek to maximize $U(c_0, H(M_0)) + S_1(M_1)U(c_1, H(M_1))$. (Note that $H(M_0)$, $H(M_1)$, and $S_1(M_1)$ were defined in Section 2). As in Barro and Friedman (1977), $U(\cdot)$ is time invariant, income is the same in both periods, $\partial U/\partial c > 0$, $\partial^2 U/\partial c^2 \partial c^\prime < 0$, and there is no interest or discounting.) To set up a Conditional model, let $y - c_0 - s - pm_0 = 0$ be the constraint in year 0 and $y - c_1 + s - pm_1 = 0$ be the constraint in year 1. The opportunity to save or borrow in period 0 ensures the equality of the marginal utility of income. Substituting these constraints into the objective function yields

$$U(y - s - pm_0, H(M_0)) + S_1(M_1)U(y + s - pm_1, H(M_1)).$$

First, note that this is a well-formed objective function for expected utility maximization. This is not a trivial point. Accepting an Annuity approach, as Meltzer and Blomqvist (2002) recommend, means rejecting the Conditional approach, and the basis for doing so needs to be clear. In particular, there is no reason why $y$ could not be an annuity payment. Recognizing that social security and many other pensions are structured like annuities does not mean that one must reject a Conditional budget constraint. Second, the implications of this model are straightforward. Solving for $*m_0$ implies that $*y_0 = p/*A_0$. Solving for $*s$ gives $\partial U/\partial c_0 = S_1(M_1)\partial U/\partial c_1$, which implies that consumption plans will depend on the probability of survival. As we will see, an Annuity model makes a very different and very counter-intuitive prediction about consumption patterns. Finally, the results are identical if the problem is set up by substitution or using a Lagrangian. Again, this is not trivial, as it will not be true for the Annuity approach.
Setting up an Annuity model is more complex, as $S^1(M^1)(y - c^t + s - pm^t) = 0$ is the constraint in year 1. Because expected utility is defined with respect to $c^t$, not $S^1(M^1)c^t$, substitution is not straightforward. (This is also an example of the earlier point that Annuity budget constraints do not describe the budget set accurately.) However, assuming that $S^1(M^1) \neq 0$, the year 1 constraint implies that $y - c^t + s - pm^t = 0$, so one can replicate (15). Manipulating the constraint like this leads to the same results as the Conditional budget constraint: $*v^0 = p^t * \Delta^0$ and $\partial U/\partial c^0 = S^1(M^1) \partial U/\partial c^0$. However, setting this up as a Lagrangian gives different results: $*v^0 = (p - \varphi^0) * \Delta^0$ and $\partial U/\partial c^0 = \partial U/\partial c^1$. In addition to generating Meltzer’s result, using a Lagrangian to analyze an Annuity model implies that consumers will choose consumption without regard for survival probabilities, which seems quite counter-intuitive. It implies that a patient with Stage 3 ovarian cancer (who has a 75% chance of being alive next year) would not be interested in shifting consumption from next year to this year (perhaps by taking that once-in-a-lifetime trip to the Orient).

Thus, this section has shown that the Meltzer effect is unlikely to have any meaningful empirical impact. It has also argued that the budget constraint that generates $\varphi^0$ is problematic. At a minimum, the case for including the Meltzer effect in cost effectiveness ratios has not been made.

5. Related costs

Weinstein and Manning (1997) note that Meltzer and Garber–Phelps do not explicitly analyze how to deal with related costs. A reader might conjecture that Section 4, in suggesting that $\varphi^0$ need not be considered, also implies that related costs should not be considered. A counterexample demonstrates that this conjecture is false. I focus on a case suggested by Garber and Phelps in which $m^t$ is conditionally dependent on $m^0$, because this produces the simplest counterexample.

Conditional dependence means that $\partial m^t/\partial m^0 \neq 0$, given the baseline probability of survival and income in period $t$. This includes cases with multi-period treatment protocols, so choosing an initial intervention determines subsequent medical spending plans. It also includes some of the more ambiguous cases that Weinstein and Manning (1997) raise.

I will begin by examining the Meltzer model, despite my reservations about its budget constraint. Maximizing $\sum_n \beta_t S^t(M^t)U^t(c^t, H(M^t)) + \lambda \sum \delta^t S^t(M^t)(y^t - c^t - pm^t)$ with respect to $c^0$, $m^0$, and $\lambda$ gives us the following first-order conditions:

$$\beta^0 S^0 \left( \frac{\partial U^0}{\partial c^0} \right) - \lambda \delta^0 S^0 = 0. \tag{16}$$

$$\sum_t \beta^t \left[ S^t(M^t) \left( \frac{\partial U^t}{\partial H^t} \right) \left( \frac{\partial H^t}{\partial m^0} \right) + S^t(M^t) \left( \frac{\partial H^t}{\partial m^0} \right) \left( \frac{\partial m^1}{\partial m^0} \right) + U^t \left( \frac{\partial S^t}{\partial m^0} \right) \right] = \frac{\partial H^t}{\partial m^0} = 0. \tag{17}$$

$$\sum_t \delta^t S^t(M^t)(y^t - c^t - pm^t) = 0. \tag{18}$$

Eq. (19) rearranges and simplifies these results. It shows clearly that related costs should be treated quite differently from unrelated costs. Related costs are represented by the term $p \sum \delta^t S^t \partial m^t / \partial m^0$. Although they should be discounted for elapsed time, the probability of survival, and the degree of relatedness, related future costs should enter cost effectiveness calculations:

$$*v^0 = \frac{p + p \sum \delta^t S^t \partial m^t / \partial m^0 - \varphi^0}{* \Delta^0}. \tag{19}$$

As before, $\sum_t$ denotes summation over all $t$ except 0, $* \Delta^0 = \sum_t \beta^0 [S^t(M^t)\partial U^t/\partial H^t(\partial H^t/\partial m^0) + S^t(M^t)(\partial U^t/\partial H^t)(\partial H^t/\partial m^0)] + \sum \delta^t (\partial S^t/\partial m^0) + U^t(\partial S^t/\partial m^0)(\partial m^t/\partial m^0)$, and $\varphi^0 = \sum \delta^t ((\partial S^t/\partial m^0)(y^t - c^t - pm^t) + (\partial S^t/\partial m^0)(\partial m^t/\partial m^0)) = 0$. 

A very similar result emerges for the Garber–Phelps model of Section 2. It differs in that \( \varphi^0 \) is explicitly equal to zero and in that the absence of capital markets means that the decision maker may not be able to allocate consumption optimally across periods:

\[
* \gamma^0 = \frac{p + p \sum_\Delta \zeta \frac{\partial m^t}{\partial m^0}}{* \Delta^0}.
\]

(20)

Here \( \zeta \) represents \( \beta^t S'(M^t)(\partial U^t/\partial y^t)/(\partial U^0/\partial y^0) \). Both models imply that the present value of related costs should be taken into account.

6. Extension to an expected health maximization model

Some analysts base cost effectiveness analysis on a health maximization model, in which quality adjusted life years are defined solely in terms of health status. This section shows that the results for the Garber–Phelps model apply to health maximization models as well (Williams, 1997). In such models unrelated future costs should be excluded and related future costs should be included.

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Focusing on \( H^t(M^t, X^t) \) has no empirical consequences. This represents just an elaboration of why

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\text{Related costs again appear in the numerator if they exist:}
\]

\[
\text{A very similar result emerges for the Garber–Phelps model of Section 2. It differs in that}
\]

\( \varphi^0 \) is explicitly equal to zero and in that the absence of capital markets means that the decision maker may not be able to allocate consumption optimally across periods:

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* \gamma^0 = \frac{p + p \sum_\Delta \zeta \frac{\partial m^t}{\partial m^0}}{* \Delta^0}.
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future costs or excluding the present value of related future costs will distort opportunity costs (hence cost effectiveness ratios). Under quite general conditions this will distort decision making and fail to maximize expected health.

7. Conclusions

Using cost effectiveness analysis to support health- or utility-maximizing decisions demands getting opportunity costs right. Consistency is not enough. This paper has shown that how one treats future costs matters.

At issue is whether unrelated future costs need to be considered in calculating cost effectiveness ratios. This paper has shown that the controversy in the literature is due to differences in modeling budget constraints. Analyzes that use a Conditional budget constraint, as Garber and Phelps do, imply that unrelated future costs need not be considered. Analyzes that use an Annuity budget constraint, as Meltzer does, imply that future savings (which are affected by a wide range of unrelated future costs) need to be considered. Having identified the source of the dispute, the paper goes on to argue that Conditional budget constraints are preferable. Conditional budget constraints accurately describe the budget set, are robust to differences in how the analysis is set up, have plausible predictions in other domains, and would apply even if all income took the form of a life annuity.

Even if one were to rely on an Annuity model, this paper has demonstrated that the consequences are likely to be minimal. The present value of future saving (weighted by the change in survival probabilities that a therapy induces) will much smaller than Meltzer’s earnings-based estimates suggest. Furthermore, Annuity models, like Conditional models, imply that the present value of related future costs should be accounted for.

This paper has also demonstrated that the same rules apply to health maximization and utility maximization. Both require accounting for the present value related future costs and ignoring unrelated future costs. Failure to do so will bias cost effectiveness calculations.

Although they clarify the task of the cost effectiveness analyst, these results do not simplify it. As Weinstein and Manning (1997), 126, note, it is difficult to disentangle “related” costs from “unrelated” costs. In such cases it is perfectly appropriate to include costs that are related in a colloquial sense to calculate an upper bound on the cost per quality adjusted life year.

References


