Discounting and decision making in the economic evaluation of health care technologies

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Discount rates on costs and health

- Same discount rate for costs and health effects
  - CEA textbooks (eg Gold, 1996)
    - Weinstein & Stason (1977)
    - Keeler & Cretin (1983)
  - Most official bodies (eg NICE)
- Differential discount rate
  - Parsonage & Neuberger (1992);Viscusi (1995); van Hout (1998); Gravelle & Smith (2001); Spackman (2004); Brouwer et al (2005); Gravelle et al (2006)
  - Few official bodies:
    - English Department of Health: costs 3.5%, health effects 1.5%
    - Netherlands Health Insurance Board: costs 4%, health effects 1.5%
    - Belgium KCE: costs 3.5%, health effects 1.5%

The NICE debate

- NICE (2001): costs 6%, health effect 1.5%
- NICE (2004): costs and health effects at Treasury Green Book rate 3.5%
- Brouwer et al (2005) criticised NICE rules
  - Fail to reflect changing value of health
- Claxton et al (2006) defended NICE rules
  - Fixed health care budgets imply all costs are health forgone and require same rate
- Gravelle, Brouwer et al (2007) show differential discounting one way to allow for changing value of health and fixed health care budget
- NICE (2008): costs and health effects at 3.5%
- Claxton, Paulden, Gravelle, Brouwer, Culyer (2009)

This presentation

- Claxton, Paulden, Gravelle, Brouwer, Culyer (2009)
- Debate hinges on assumptions about
  - Objectives of health sector decision makers (health or welfare)
  - Changes in consumption value of health over time
  - Changes in cost-effectiveness threshold over time
  - Time preference rates for health and consumption
- CPGBC disagree on what these assumptions should be
- But CPGBC agree that applying consumption discount rate to both costs and health effects requires a set of assumptions that is hard to defend

Does it matter?

	Cost per unit of health gain	
Subject (outcome)	**Equal discounting**	**Differential discounting**
Public place defibrillators (£/QALY)	47,671	41,146
Meningococcal C vaccine (£/life-year gained)	15,710	3,845
Improved blood pressure control DM2 (£/event-free year gained)	1,049	434
Hip fracture prevention with HRT (£/fracture prevented)	42,374	7,362
Idem with Vitamin D and calcium (£/fracture prevented)	28,022	15,646

Brouwer et al, BMJ, 2005, 331, 446-448

Does differential discounting matter?

- Generally reduces cost per unit of health because applies lower discount rate to health and health gains occur later than costs
  - Hence larger health care sector budget is optimal
- Alters the relative magnitude of costs per unit of health for different interventions
  - Hence alters allocation of given health care budget across activities

Two period example

$\Delta c_1, \Delta c_2$ change in health care costs in periods 1, 2

$\Delta h_1, \Delta h_2$ change in health (QALYs) in periods 1, 2

k_1, k_2 cost effectiveness threshold in periods 1, 2: marginal cost per QALY

$g_k \equiv (k_2 / k_1) - 1$ Growth rate of cost effectiveness threshold

Opportunity cost of new project

Healthcare budget constraint implies that new project displaces other activities in health service

$$\frac{1}{k_t}$$

Reduction in QALYs due to £1 reduction in healthcare buget

$$\frac{\Delta c_t}{k_t}$$

Opportunity cost in period *t* of new project: reduction in QALYs due to other activities displaced by new project

Alternative health care sector objectives

- “Health maximisation”: maximise present value of health stream from given health care budget

- “Welfare maximisation”: maximise present consumption value of health care stream from given health care budget

Health maximisation

- Maximise present value of health stream from given health care budget
  - Narrower NHS health care sector perspective
  - Decision makers do not need to make judgements about relative social values of health and consumption
  - Current health is numeraire

r_h^N Social time preference rate on health:

$1 + r_h^N$ units of period 2 health equivalent to 1 unit of period 1 health

Two period project

Time Period	1	2
Present Value of Health Gained	Δh_1	$\dfrac{\Delta h_2}{(1+r_h)^N}$
Present Value of Health Forgone	$\dfrac{\Delta c_1}{k_1}$	$\dfrac{\Delta c_2}{k_2(1+r_h)^N}$

Health maximising NPV rule

$$\underbrace{\Delta h_1 + \frac{\Delta h_2}{\left(1+r_h^N\right)}}_{\text{Discounted sum of direct health effects}} \quad - \quad \underbrace{\frac{\Delta c_1}{k_1} - \frac{\Delta c_2}{k_2}\frac{1}{\left(1+r_h^N\right)}}_{\text{Discounted sum of health opportunity costs}} > 0$$

Discounted sum of direct health effects

Discounted sum of health opportunity costs

Express all effects in the same units (health) and use health interest rate

Health maximising ICER rule

$$\Delta h_1 + \frac{\Delta h_2}{\left(1 + r_h^N\right)} > \frac{\Delta c_1}{k_1} + \frac{\Delta c_2}{k_2} \frac{1}{\left(1 + r_h^N\right)}$$

$$1 > \frac{\frac{\Delta c_1}{k_1} + \frac{\Delta c_2}{k_2} \frac{1}{\left(1 + r_h^N\right)}}{\Delta h_1 + \frac{\Delta h_2}{\left(1 + r_h^N\right)}}$$

$$k_1 > \frac{\Delta c_1 + \frac{k_1}{k_2} \frac{\Delta c_2}{\left(1 + r_h^N\right)}}{\Delta h_1 + \frac{\Delta h_2}{\left(1 + r_h^N\right)}}$$

Optimal ICER decision rule with health maximisation objective

$$k_1 > \frac{\Delta c_1 + \frac{k_1}{k_2}\frac{\Delta c_2}{\left(1+r_h^N\right)}}{\Delta h_1 + \frac{\Delta h_2}{\left(1+r_h^N\right)}} = \frac{\Delta c_1 + \frac{1}{(1+g_k)}\frac{\Delta c_2}{\left(1+r_h^N\right)}}{\Delta h_1 + \frac{\Delta h_2}{\left(1+r_h^N\right)}}$$

$$\square \frac{\Delta c_1 + \frac{\Delta c_2}{\left(1+r_h^N + g_k\right)}}{\Delta h_1 + \frac{\Delta h_2}{\left(1+r_h^N\right)}}$$

Optimal ICER decision rule with health maximisation objective

$$\text{Accept project iff} \quad k_1 > \frac{\Delta c_1 + \dfrac{\Delta c_2}{\left(1 + r_h^N + g_k\right)}}{\Delta h_1 + \dfrac{\Delta h_2}{\left(1 + r_h^N\right)}}$$

$d_h^N = r_h^N$	discount rate on unadjusted health effects
$d_c^N \,\square\, r_h^N + g_k$	discount rate on unadjusted costs

Differential discount rates are **one** way to take account of $g_k \neq 0$

Health maximisation investment criteria – sample project

t	1	2
Δc_t	£150,000	£150,000
Δh_t	5	10

$$r_h^N = 0.02$$

$$k_1 = £20,000$$

	Case 1	Case 2
	$k_2 = £20,000$ ($g_k = 0$)	$k_2 = £21,000$ ($g_k = 0.05$)
NPVH (QALYs)	$-0.049 < 0$	$0.301 > 0$
ICER	£20,066 $> k_1$	£19,602 $< k_1$

Welfare maximisation

- maximise present consumption value of health care stream from given health care budget
  - Wider societal perspective
  - Decision makers need to make judgements about relative social values of health and consumption
  - Current consumption is numeraire

Social preferences for consumption and health

$$W = W(h_1, h_2, c_1, c_2)$$

$$W_{ht} = \partial W(h_1, h_2, c_1, c_2) / \partial h_t > 0 \quad W_{ct} = \partial W(h_1, h_2, c_1, c_2) / \partial c_t > 0$$

$$-\left.\frac{dc_2}{dc_1}\right|_W = \frac{W_{c1}}{W_{c2}} \equiv 1 + r_c^W$$

discount rate on consumption

$$-\left.\frac{dc_t}{dh_t}\right|_W = \frac{W_{ht}}{W_{ct}} \equiv v_t$$

marginal value of health in period *t* in terms of consumption in period *t*

Optimality of health care budget

$v_t > k_t$ Value of QALY exceeds marginal cost of QALY: budget too small

$v_t < k_t$ Value of QALY less than marginal cost of QALY: budget too large

$v_t = k_t$ Value of QALY equals marginal cost of QALY: budget is optimal

Growth rate of value of health

$$g_v \equiv \frac{v_2 - v_1}{v_1} = \frac{v_2}{v_1} - 1$$

g_v : growth rate in value of health in period t in terms of consumption in period t

Health and cost effects in terms of current consumption

Time Period	1	2
Present Consumption Value of Health Gained	$v_1 \Delta h_1$	$\dfrac{v_2 \Delta h_2}{(1+r_c^W)}$
Present Consumption Value of Health Forgone	$\dfrac{v_1 \Delta c_1}{k_1}$	$\dfrac{v_2 \Delta c_2}{k_2 (1+r_c^W)}$

Welfare maximising NPV rule

$$\underbrace{v_1 \Delta h_1 + v_2 \Delta h_2 \frac{1}{\left(1 + r_c^W\right)}}_{\text{Discounted value of health effects in terms of period 1 consumption}} - \underbrace{v_1 \frac{\Delta c_1}{k_1} - v_2 \frac{\Delta c_2}{k_2} \frac{1}{\left(1 + r_c^W\right)}}_{\text{Discounted value of health opportunity costs in terms of period 1 consumption}} > 0$$

Discounted value of health effects in terms of period 1 consumption

Discounted value of health opportunity costs in terms of period 1 consumption

Express all effects in the same units (consumption) and discount at consumption discount rate

Welfare maximising ICER rule

$$v_1 \Delta h_1 + v_2 \Delta h_2 \frac{1}{\left(1+r_c^W\right)} > v_1 \frac{\Delta c_1}{k_1} + v_2 \frac{\Delta c_2}{k_2} \frac{1}{\left(1+r_c^W\right)}$$

$$1 > \frac{v_1 \frac{\Delta c_1}{k_1} + v_2 \frac{\Delta c_2}{k_2} \frac{1}{\left(1+r_c^W\right)}}{v_1 \Delta h_1 + v_2 \Delta h_2 \frac{1}{\left(1+r_c^W\right)}}$$

$$k_1 > \frac{v_1 \Delta c_1 + v_2 \frac{k_1}{k_2} \frac{\Delta c_2}{\left(1+r_c^W\right)}}{v_1 \Delta h_1 + v_2 \frac{\Delta h_2}{\left(1+r_c^W\right)}} = \frac{\Delta c_1 + \frac{v_2}{v_1} \frac{k_1}{k_2} \frac{\Delta c_2}{\left(1+r_c^W\right)}}{\Delta h_1 + \frac{v_2}{v_1} \frac{\Delta h_2}{\left(1+r_c^W\right)}}$$

Welfare maximising ICER rule

$$k_1 > \frac{\Delta c_1 + \frac{v_2}{v_1}\frac{k_1}{k_2}\frac{\Delta c_2}{\left(1+r_c^W\right)}}{\Delta h_1 + \frac{v_2}{v_1}\frac{\Delta h_2}{\left(1+r_c^W\right)}} = \frac{\Delta c_1 + \frac{(1+g_v)}{(1+g_k)}\frac{\Delta c_2}{\left(1+r_c^W\right)}}{\Delta h_1 + \frac{(1+g_v)\Delta h_2}{\left(1+r_c^W\right)}}$$

$$\approx \frac{\Delta c_1 + \frac{\Delta c_2}{\left(1+r_c^W - g_v + g_k\right)}}{\Delta h_1 + \frac{\Delta h_2}{\left(1+r_c^W - g_v\right)}}$$

Welfare maximising ICER rule

$$\text{Accept project iff} \quad k_1 > \frac{\Delta c_1 + \dfrac{\Delta c_2}{\left(1 + r_c^W - g_v + g_k\right)}}{\Delta h_1 + \dfrac{\Delta h_2}{\left(1 + r_c^W - g_v\right)}}$$

$d_h^W = r_c^W - g_v$	discount rate on unadjusted health effects
$d_c^W = r_c^W - g_v + g_k$	discount rate on unadjusted costs

Differential discount rates are **one** way to allow for

$$g_k \neq 0, \quad g_v \neq 0$$

Welfare maximisation investment criteria – sample project

t	1	2
Δc_t	£150,000	£150,000
Δh_t	5	10

$$r_c^W = 0.035$$

$$k_1 = £20{,}000 \quad v_1 = £50{,}000$$

	Case 1	Case 2
	$k_2 = £20{,}000$ $v_2 = £50{,}000$ $(g_k = 0)$ $(g_v = 0)$	$k_2 = 21{,}000$ $v_2 = £51{,}000$ $(g_k = 0.05)$ $(g_v = 0.02)$
NPV (£s)	– £4227 < 0	£15,787 > 0
ICER	£20,115 > k_1	£19,602 < k_1

ICER criterion: Conventional wisdom

$$\text{Accept iff} \quad \frac{\Delta c_1 + \dfrac{\Delta c_2}{(1+r_c^W)}}{\Delta h_1 + \dfrac{\Delta h_2}{(1+r_c^W)}} < k_1$$

Apply same discount rate to costs and to health

$d_c^{CW} = r_c^W$	discount rate on costs
$d_h^{CW} = r_c^W$	discount rate on health effects

Conventional investment criteria – sample project

t	1	2
Δc_t	£150,000	£150,000
Δh_t	5	10

$$r_c^W = 0.035$$

$$k_1 = £20,000 \quad v_1 = £50,000$$

	Case 1	Case 2
	$k_2 = £20,000 \quad v_2 = £50,000$ $(g_k = 0) \quad (g_v = 0)$	$k_2 = 21,000 \quad v_2 = £51,000$ $(g_k = 0.05) \quad (g_v = 0.02)$
NPV (£s)	– £4227 < 0	£4227 < 0
ICER	£20,115 > k_1	£20,115 > k_1

Three views on discount rates for health sector projects

Health maximisation

$d_h^N = r_h^N$	discount rate on unadjusted health effects
$d_c^N = r_h^N + g_k$	discount rate on unadjusted costs

Welfare maximisation

$d_h^W = r_c^W - g_v$	discount rate on unadjusted health effects
$d_c^W = r_c^W - g_v + g_k$	discount rate on unadjusted costs

Conventional wisdom

$d_c^{CW} = r_c^W$	discount rate on unadjusted costs
$d_h^{CW} = r_c^W$	discount rate on unadjusted health effects

When is conventional wisdom correct?

- Health maximisation viewpoint: conventional wisdom correct only if
  - ICER threshold is constant ($g_k = 0$)
    - g_k determined by
      - growth in health sector budget
      - change in prodcutivity of health care technologies

  - health discount rate equals consumption discount rate $r_c^W = r_h^N$

When is conventional wisdom correct?

- Welfare maximisation viewpoint: conventional wisdom correct only if
  - ICER threshold is constant ($g_k = 0$)
  - Value of health is constant ($g_v = 0$)
    - Studies show increases in value of statistical life over time as consumption increases (eg Viscusi and Aldey, 2003)
    - Health grows more slowly than consumption so its value in terms of consumption increases over time

Derivation of r_c^W, r_h^W from welfare function

$$W = \sum_t \frac{1}{(1+\rho)^{t-1}} \left[\alpha_h \frac{h_t^{1-\varepsilon_h}}{1-\varepsilon_h} + \alpha_c \frac{c_t^{1-\varepsilon_c}}{1-\varepsilon_c} \right]$$

ρ pure time preference rate on future welfare

α_c, α_h weights on welfare from consumption, health

$\varepsilon_c, \varepsilon_h$ elasticity of marginal welfare from consumption, health

g_c, g_h growth rate of consumption, health

$$1 + r_c^W = -\left.\frac{dc_{t+1}}{dc_t}\right|_W = \frac{\partial W / \partial c_t}{\partial W / \partial c_{t+1}} = \frac{(1+\rho)}{(1+g_c)^{-\varepsilon_c}} \qquad \boxed{r_c^W \approx \rho + \varepsilon_c g_c}$$

$$1 + r_h^W = -\left.\frac{dh_{t+1}}{dh_t}\right|_W = \frac{\partial W / \partial h_t}{\partial W / \partial h_{t+1}} = \frac{(1+\rho)}{(1+g_h)^{-\varepsilon_h}} \qquad \boxed{r_h^W \approx \rho + \varepsilon_h g_h}$$

Derivation of r_c^W, r_h^W from welfare function

$$r_c^W \;\square\; \rho + \varepsilon_c g_c \qquad\qquad r_h^W \;\square\; \rho + \varepsilon_h g_h$$

ρ pure time preference rate on future welfare

$\varepsilon_c, \varepsilon_h$ elasticity of marginal welfare from consumption, health

g_c, g_h growth rate of consumption, health

Plausible that $g_c > g_h$, $\varepsilon_c > \varepsilon_h$ so $r_h^W < r_c^W$

UK Treasury assumes $\rho = 1.5\%$, $g_c = 2\%$, $\varepsilon_c = 1$, so

$$r_c^W = 3.5\%$$

If constant marginal welfare from health then $\varepsilon_h = 0$, and so

$$r_h^W = 1.5\%$$

Other arguments for $d_c = d_h$ (1)

- Consistency - Weinstein & Stason (1977)
  - but assume unchanged value of health
- Paralysis paradox – Keeler & Cretin (1983)

Keeler-Cretin paradox

One off project lasting 1 period, can be done once only.

$\Delta h, \Delta c$ Health and cost effects

k threshold ICER in all periods

d_c discount rate on costs

d_h discount rate on health effects

ICER if adopted at period t: $\dfrac{\Delta c / (1+d_c)^t}{\Delta h / (1+d_h)^t}$

K&C argue that since ICER decreases with t if $d_h < d_c$ always postpone even if $k > \Delta c / \Delta h$

But ICER only shows if project worthwhile in period t rather than not done in any period. Cannot identify optimal period. So paradox irrelevant to debate on uniform discounting

Keeler-Cretin paradox rebutted

Welfare increased by postponing from period *t*-1 to period *t* iff

$$\left[\frac{v_1(1+g_v)^t \Delta h}{(1+r_c^W)^t} - \frac{\Delta c}{(1+r_c^W)^t}\right] - \left[\frac{v_1(1+g_v)^{t-1} \Delta h}{(1+r_c^W)^{t-1}} - \frac{\Delta c}{(1+r_c^W)^{t-1}}\right] > 0$$

Or equivalently iff $r_c^W \Delta c > v_1(1+g_v)^t \Delta h \left(r_c^W - g_v\right)$

This is not equivalent to the ICER being smaller in period t + 1 than period t which merely requires

$$\frac{\Delta c / (1+d_c)^{t+1}}{\Delta h / (1+d_h)^{t+1}} < \frac{\Delta c / (1+d_c)^{t}}{\Delta h / (1+d_h)^{t}} \Leftrightarrow d_c > d_h$$

Changes in the ICER over time cannot inform timing decisions

Other arguments for $d_h = d_c$ (2)

- Difficulties in choosing discount rate for consumption: market rates not a guide because of externalities, risk premia, intergenerational allocations.
  - but this does not affect argument for different discount rates when value of health grows over time
- Health is not tradeable
  - but it is possible to change the time stream of health and so the changing value of health must be allowed for
- Public health care sector bodies should ignore effects falling outside health care sector
  - but whether effects falling outside sector are included or not is irrelevant for determining whether value of health is increasing

Other arguments for $d_c = d_h$ (3)

- Intertemporal income distribution: lower discount rate on health implies more investment now by people who are poorer than future beneficiaries of better future health
  - But basing discount rates on explicit welfare function allows for declining marginal welfare from consumption and health

$$r_c^W = \rho + \varepsilon_c g_c \qquad r_h^W = \rho + \varepsilon_h g_h$$

An internal debate: does welfare maximisation imply health maximisation?

Welfare function $W(h_1, h_2, c_1, c_2)$ defines health discount rate r_h^W

$$1 + r_h^W \equiv -\left.\frac{dh_2}{dh_1}\right|_W = \frac{W_{h1}}{W_{h2}} = \frac{W_{c1}}{W_{c2}} \frac{W_{h1}}{W_{c1}} \frac{W_{c2}}{W_{h2}} = (1 + r_c^W) v_1 \frac{1}{v_2} = \frac{(1 + r_c^W)}{(1 + g_v)}$$

$$\boxed{r_h^W \approx r_c^W - g_v}$$

Welfare maximisation discount rates

$d_h^W = r_c^W - g_v = r_h^W$	discount rate on unadjusted health effects
$d_c^W = r_c^W - g_v + g_k = r_h^W + g_k$	discount rate on unadjusted costs

Health maximisation discount rates

$d_h^N = r_h^N$	discount rate on unadjusted health effects
$d_c^N = r_h^N + g_k$	discount rate on unadjusted costs

Should health sector decision makers discount health at $r_h^N \neq r_h^W = r_c^W - g_v$?

Yes: Health sector decision makers (eg NICE) are agents of higher level political authority (principal) which delegate budgets to them to maximise the present value of health. Principal does not have explicit or coherent preferences over health in different periods. Hence also delegates the choice of health discount rate.

No: Without a coherent set preferences over health and consumption in different perods there is no basis on which budgets can be set. Since Treasury uses an explicit welfare function to set public sector discount rate on consumption should apply same approach to set public sector discount rate on health

Welfare maximising investment rules for health care sector

- Regulator must specify
  - discount rate on costs (consumption discount rate)
  - k_1, k_2, …. marginal ICER in health care sector
  - v_1, v_2, … marginal social value of health (QALYs)
- Investment rules must
  - allow for opportunity cost of investment via k_1, k_2,...
  - allow for changing value of health in period t in terms of consumption in period t by
    - **EITHER** adjusting health effects by growth in value of health and costs by growth in ICER and using same consumption discount rate for health and costs
    - **OR** using different discount rates on health $d_h^W = r_c^W - g_v$ and costs $d_c^W = r_c^W - g_v + g_k$

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