Discounting in Economic Evaluation

Henry A. Glick, Ph.D.
Pharmacoeconomics
March 26, 2012
www.uphs.upenn.edu/dgimhsr

Which Lottery?
- Suppose you decided to buy a single lottery ticket
- You have a choice between equally priced tickets for 2 tax free lotteries
- The probability of winning the two lotteries is identical
- One lottery pays out $50,000 per year for 20 years; the other pays out $1,000,000 immediately
- For which lottery would you buy a ticket? Why?

Time Preference
- We have time preferences for costs incurred and outcomes obtained in different periods (i.e., our valuation depends upon when we incur the costs or obtain the outcomes)
  - We tend to prefer to consume immediate benefits to those occurring in the future (Marginal rate of time preference)
  - Investment today could produce more in the future (Marginal rate of return on private investment)
  - Market interest rate
Time Preference (II)

- Because costs and outcomes in different time periods are not directly comparable, their comparison requires conversion to a common time period
  - Inflation (consumer price index)
    - Inflation is not the same as time preference
  - Time preference (social discount factor)
    - Discount streams of cost and outcome because we value them differently depending upon when they occur

Social Discount Factor

- Represents the amount that future streams of cost and benefit must be discounted to account for the fact that society values them less than if these streams were available today

Discounting Formula

\[ \sum_{t} \frac{B_t}{(1+R)^t} \]

where \( B_t \) equals the net benefits (benefits minus costs) in time \( t \) and \( R \) equals the discount rate

- What assumption about the relative discount rates for costs and effects does this notation incorporate?
Discounting And Inflation

• What is the relationship between inflation and discounting?
  – Real rate of discount (1+r), where r = real rate of time preference
  – Nominal rate of discount [(1+r) (1+i)], where i equals the rate of inflation

Discounting And Inflation (II)

• In what cases are the different rates used?
  – Real rate: Costs are already inflation-adjusted (i.e., constant $)
  – Nominal rate: Costs incorporate inflation
    • If sectors have relatively different inflation rates, need to use sectoral rates of inflation to evaluate changes in costs over time
    • Corollary: Should we discount costs if the inflation rate equals 0?

What Discount Rate?

• Current practice, U.S. (and most, but not all, other developed countries): 3% (U.S. Panel recommendation)
• Appropriate rate for less developed countries?
• Adjust for risk separately in the analysis
Underlying Theory for Determination of a Discount Rate for Public Investments

• Consider the source of the funds
  – Are the funds coming from investment (higher rate) or consumption? (lower rate)

• How will the results of the public investment be used?
  – Will they go to investment (lower rate) or consumption (higher rate)?

• The discount rate may vary depending on:
  – A program’s financing mechanism
  – The nature of its benefits and costs
  – The state of the economy

Implications of Discounting

• Treatment vs prevention
  – Why do those trying to justify childhood vaccination sometimes argue against discounting?

• Old vs young
  – Does it make sense for the elder’s associations to argue against discounting?

Discount Rate Can Matter...

<table>
<thead>
<tr>
<th>Year</th>
<th>Therapy 1</th>
<th>Therapy 2</th>
<th>Therapy 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>QALY</td>
<td>Cost</td>
</tr>
<tr>
<td>1</td>
<td>2000</td>
<td>.8</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
<td>.8</td>
<td>1000</td>
</tr>
<tr>
<td>3</td>
<td>1000</td>
<td>.8</td>
<td>1000</td>
</tr>
<tr>
<td>4</td>
<td>1000</td>
<td>.8</td>
<td>1000</td>
</tr>
<tr>
<td>5</td>
<td>1000</td>
<td>.87</td>
<td>1000</td>
</tr>
</tbody>
</table>

0% discount rate: 50,000/QALY
3% discount rate: 82,000/QALY
5% discount rate: 131,800/QALY
...But It Doesn’t Always

<table>
<thead>
<tr>
<th>Year</th>
<th>Therapy 1 Cost</th>
<th>Therapy 1 QALY</th>
<th>Therapy 2 Cost</th>
<th>Therapy 2 QALY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2315</td>
<td>0.9550</td>
<td>1400</td>
<td>0.95</td>
</tr>
<tr>
<td>2</td>
<td>2107</td>
<td>0.869</td>
<td>1260</td>
<td>0.855</td>
</tr>
<tr>
<td>3</td>
<td>1917</td>
<td>0.7908</td>
<td>1134</td>
<td>0.7695</td>
</tr>
<tr>
<td>4</td>
<td>1745</td>
<td>0.7197</td>
<td>1021</td>
<td>0.6926</td>
</tr>
<tr>
<td>5</td>
<td>1587</td>
<td>0.6549</td>
<td>918</td>
<td>0.6233</td>
</tr>
</tbody>
</table>

0% discount rate: 39,737/QALY
3% discount rate: 40,727/QALY
5% discount rate: 41,394/QALY

2-state Markov model; 10% conditional annual mortality; RR= 0.9; $RX = 1000/yr; $OMC=1000/yr; $Death=5000; all costs inflation-adjusted

"When" to Discount

• The need to discount is not a function of the duration of the study; it is a function of the duration of follow-up per participant
  – For example, if you randomize over a 4 year period, but only follow participants for 60 days, you would adjust across the 4 years for inflation (i.e., use real dollars), but would not discount
  – Only if you followed each participant for more than a year would you both adjust for inflation and discount

When Example #1

• You follow people for 4 years; at the end of follow-up you obtain price weights from the Federal government for the year 2012
  – Discount?
  – Inflation adjust?
When Example #2

- You enroll people during a 6 month period and follow each of them for 6 months; either you collect bills or obtain price weights from the government for the year 2012 to estimate costs
  - Discount?
  - Inflation adjust?

When Example #3

- You enroll people during a 3-year period, but follow each for only 1 year; you collect bills to estimate costs
  - Discount?
  - Inflation adjust?

When Example #4

- You follow people for 4 years; you collect bills to estimate costs
  - Discount?
  - Inflation adjust?
Inflation
- Inflation is not the same as discounting
- Inflation accounts for the fact that the purchasing power of a dollar changes over time
- Common measures of inflation
  - Consumer price index
    - Defined for a market “basket” of goods and services
  - Gross domestic product deflator
    - Not based on a fixed basket of goods and services
    - Between 1990 and 2006, difference between the 2 within ±5%

---

### Inflation: U.S. Consumer Price Index

<table>
<thead>
<tr>
<th>Year</th>
<th>All Items</th>
<th>Medical Care</th>
<th>Medical Care Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>130.7</td>
<td>162.8</td>
<td>162.7</td>
</tr>
<tr>
<td>1995</td>
<td>152.4</td>
<td>220.5</td>
<td>224.2</td>
</tr>
<tr>
<td>2000</td>
<td>172.2</td>
<td>260.8</td>
<td>266.0</td>
</tr>
<tr>
<td>2005</td>
<td>195.3</td>
<td>323.2</td>
<td>336.7</td>
</tr>
<tr>
<td>2007</td>
<td>207.342</td>
<td>351.054</td>
<td>369.302</td>
</tr>
<tr>
<td>2008</td>
<td>215.303</td>
<td>364.065</td>
<td>384.943</td>
</tr>
<tr>
<td>2009</td>
<td>214.537</td>
<td>375.613</td>
<td>397.299</td>
</tr>
<tr>
<td>2010</td>
<td>218.056</td>
<td>388.436</td>
<td>411.208</td>
</tr>
<tr>
<td>2011</td>
<td>224.939</td>
<td>400.258</td>
<td>420.802</td>
</tr>
</tbody>
</table>

* http://bls.gov/data [Inflation & prices | All urban consumers | multiscreen]
US avg, not seasonally adjusted, MC=drugs+supplies+MCS; MCS=professional+hospital services

---

### Sectoral Price Indices

<table>
<thead>
<tr>
<th>Year</th>
<th>Hospital Services</th>
<th>Physician Services</th>
<th>Prescript Drug</th>
<th>Nursing Home</th>
<th>Homecare</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>100</td>
<td>216.4</td>
<td>242.9</td>
<td>100.0</td>
<td>--</td>
</tr>
<tr>
<td>2000</td>
<td>115.9</td>
<td>244.7</td>
<td>285.4</td>
<td>117.0</td>
<td>--</td>
</tr>
<tr>
<td>2005</td>
<td>161.6</td>
<td>287.5</td>
<td>349.0</td>
<td>145.0</td>
<td>100</td>
</tr>
<tr>
<td>2006</td>
<td>172.1</td>
<td>291.9</td>
<td>363.9</td>
<td>151.0</td>
<td>101.8</td>
</tr>
<tr>
<td>2007</td>
<td>183.551</td>
<td>303.242</td>
<td>369.157</td>
<td>159.592</td>
<td>103.164</td>
</tr>
<tr>
<td>2008</td>
<td>197.186</td>
<td>311.342</td>
<td>378.284</td>
<td>165.343</td>
<td>107.882</td>
</tr>
<tr>
<td>2009</td>
<td>210.731</td>
<td>320.831</td>
<td>391.055</td>
<td>171.630</td>
<td>109.872</td>
</tr>
<tr>
<td>2010</td>
<td>227.227</td>
<td>331.330</td>
<td>407.824</td>
<td>177.003</td>
<td>111.280</td>
</tr>
<tr>
<td>2011</td>
<td>241.213</td>
<td>340.301</td>
<td>424.981</td>
<td>182.188</td>
<td>113.133</td>
</tr>
</tbody>
</table>
### Inflation: GDP Deflator

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP Deflator</th>
<th>GDP % Increase</th>
<th>CPI % Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>0.7882</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1995</td>
<td>0.9120</td>
<td>15.7%</td>
<td>16.6%</td>
</tr>
<tr>
<td>2000</td>
<td>1.0000</td>
<td>9.6%</td>
<td>13%</td>
</tr>
<tr>
<td>2001</td>
<td>1.0236</td>
<td>2.4%</td>
<td>2.8%</td>
</tr>
<tr>
<td>2002</td>
<td>1.0432</td>
<td>1.2%</td>
<td>1.8%</td>
</tr>
<tr>
<td>2003</td>
<td>1.0643</td>
<td>2.0%</td>
<td>2.3%</td>
</tr>
<tr>
<td>2004</td>
<td>1.0920</td>
<td>2.6%</td>
<td>2.7%</td>
</tr>
<tr>
<td>2005</td>
<td>1.1270</td>
<td>3.2%</td>
<td>3.4%</td>
</tr>
<tr>
<td>2006</td>
<td>1.1643</td>
<td>3.3%</td>
<td>3.2%</td>
</tr>
</tbody>
</table>

http://www.gpoaccess.gov/usbudget/fy09/sheets/hist10z1.xls

### Per Capita National Health Expenditures

<table>
<thead>
<tr>
<th>National Health Exp*</th>
<th>Medical Care CPI</th>
<th>&quot;Technology&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>356</td>
<td>34</td>
</tr>
<tr>
<td>1980</td>
<td>1102</td>
<td>74.9</td>
</tr>
<tr>
<td>1993</td>
<td>3469</td>
<td>201.4</td>
</tr>
<tr>
<td>1997</td>
<td>4104</td>
<td>234.6</td>
</tr>
<tr>
<td>2000</td>
<td>4790</td>
<td>260.8</td>
</tr>
<tr>
<td>2003</td>
<td>5952</td>
<td>297.1</td>
</tr>
<tr>
<td>2004</td>
<td>6322</td>
<td>310.1</td>
</tr>
<tr>
<td>2005</td>
<td>6697</td>
<td>323.2</td>
</tr>
</tbody>
</table>


### (International) Purchasing Power Parity (PPP)

- "Market basket" index used to translate costs in one country into comparable costs in another based on purchasing power in the countries
- PPP preferred over exchange rates because PPP provides a comparative measure of buying power and not a reflection of the supply of the currency in international markets
- Common measures:
  - OECD PPP
  - "Big Mac" index
Purchasing Power Parity, 2009

<table>
<thead>
<tr>
<th>Country</th>
<th>OECD</th>
<th>Big Mac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>1.19</td>
<td>1.18</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>13.7</td>
<td>18.6</td>
</tr>
<tr>
<td>Denmark</td>
<td>8.17</td>
<td>8.33</td>
</tr>
<tr>
<td>Euro Zone</td>
<td>.803</td>
<td>.96</td>
</tr>
<tr>
<td>Hungary</td>
<td>132</td>
<td>192</td>
</tr>
<tr>
<td>Mexico</td>
<td>7.68</td>
<td>9.32</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1.50</td>
<td>1.38</td>
</tr>
<tr>
<td>Poland</td>
<td>1.85</td>
<td>1.98</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.53</td>
<td>1.84</td>
</tr>
<tr>
<td>Turkey</td>
<td>.917</td>
<td>1.45</td>
</tr>
<tr>
<td>US</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

http://www.maxi-pedia.com/Big+Mac+Index+2009

Discounting Life-saving and Other Nonmonetary Effects

- Debate -- generally among noneconomists -- exists in the literature about whether or not years of life or QALYs need to be discounted, and if so, if they need to be discounted at same rate as costs

"Years of Life Obtained at the End of Life"

- Not true of the "QA" of QALYs; is it true for expected years of life?
- Actuarially, we can gain years at different points in life
- Can we have preferences between the following 2 treatments?

<table>
<thead>
<tr>
<th>Years of life</th>
<th>Treatment 1 (Prob)</th>
<th>Treatment 2 (Prob)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.50</td>
<td>0.25</td>
</tr>
<tr>
<td>5</td>
<td>0.00</td>
<td>0.25</td>
</tr>
<tr>
<td>10</td>
<td>0.00</td>
<td>0.25</td>
</tr>
<tr>
<td>15</td>
<td>0.50</td>
<td>0.25</td>
</tr>
<tr>
<td>Exp Value</td>
<td>7.50</td>
<td>7.50</td>
</tr>
</tbody>
</table>
“End of Life” (cont.)

- Cumulative probabilities

<table>
<thead>
<tr>
<th>Years of life</th>
<th>Treatment 1</th>
<th>Treatment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>0.50</td>
<td>0.75</td>
</tr>
<tr>
<td>10</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>15</td>
<td>0.50</td>
<td>0.25</td>
</tr>
</tbody>
</table>

- Differences between the treatments are due to probability of living 5 vs. 15 years
- May be a number of sources of preference (including risk or variance), but one may be time preference
- Empirical rather than theoretical question?

Evaluation of Programs 1 And 2 *

<table>
<thead>
<tr>
<th>Variable</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costs</td>
<td>1000</td>
<td>0</td>
</tr>
<tr>
<td>QALYs</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Program 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costs</td>
<td>0</td>
<td>1000</td>
</tr>
<tr>
<td>QALYs</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

- Program benefits might be due to one-year shifts in the survival curve, or they might be due to, for example, providing wheelchairs for one year to different cohorts of quadriplegic patients

Evaluation of Programs 1 And 2 (cont.)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costs</td>
<td>1000</td>
<td>0</td>
</tr>
<tr>
<td>QALYs</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Program 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costs</td>
<td>0</td>
<td>1000</td>
</tr>
<tr>
<td>QALYs</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

- Should program 2 have a smaller (better) cost-effectiveness ratio than program 1?
Summary of Programs 1 and 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Program 1</th>
<th>Program 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discounted Costs (3%)</td>
<td>1000.00</td>
<td>970.87</td>
</tr>
<tr>
<td>Undiscounted QALYs</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Discounted QALYs (3%)</td>
<td>100.00</td>
<td>97.087</td>
</tr>
<tr>
<td>CER (Undisc Ben)</td>
<td>10.00</td>
<td>9.7087</td>
</tr>
<tr>
<td>CER (Disc Ben)</td>
<td>10.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>

• IMPLICATION: Failure to discount both costs and outcomes (at an equal rate), given a set of programs that are identical in all features except for their timing, leads later programs to have more favorable ratios than earlier ones.

Rationales for Discounting Health

• Consistency (Weinstein and Stason)
• Discounting paradox (Keeler and Cretin)
• Horizontal equity

(All three seem to be variations on the previous example)

Consistency (1)

• When costs and benefits are both expressed in monetary terms, there is little debate about whether the 2 should be discounted
• Why should it matter if we wait until after we construct the cost-effectiveness ratio to translate the effects into money terms (e.g., by comparing the CER to W or by calculating NMB)
Consistency (2)

• [In economic assessment, years of life] "...are being valued relative to dollars and, since a dollar in the future is discounted relative to a present dollar, so must a year of life in the future be discounted relative to a present dollar." (assumed steady state relationship between dollars and health benefits)

• Williams: "because it is possible, at the margin, to transform health into wealth, and vice versa, at any point in time, and since "wealth" is (ideally) allocated through time with reference to the rate of social time preference, then it would be inconsistent to apply a different rate of discount to "health" from that being applied to "wealth."

Discounting Paradox: Keeler and Cretin

• Statistically identical cohorts (that differ only in their position in time) vie for dollars from a budget that must be allocated (once and for all) at the current moment

• Paradox: If discount rate for costs is higher than that for effects, the cost effectiveness ratio for any program will be improved by delaying its implementation (see prior example)
  – i.e., those with later positions in time can argue that health expenditures should be targeted disproportionately at them, because the cost effectiveness ratios for these expenditures will be lower

Horizontal Equity

• If discount rate for costs equals the discount rate for effects, potential program beneficiaries who are identical in every respect except for their positions in time relative to the moment the decision maker must act will receive equal treatment