Discounting

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Which lottery ticket would you prefer?

- Lottery A: $50,000 check every year for 20 years
- Lottery B: $1,000,000 check immediately

Qualifiers:
- Probability of winning two lotteries is identical
- Equally priced
- Tax free winnings

Outline

1. Mechanical relationship between present value and discount rate
2. What discount rate should be used for CEA and CBA?
   - Theoretical
   - Practical
3. Should a different discount rate be used for costs and QALYs?
Present Value

\[ \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t} \]

where:

- \( B_t \) and \( C_t \) = benefits and costs that accrue at time \( t \)
- \( r \) = discount rate

Fundamental Concepts

- **Present value**: Because a dollar today has a different value as a dollar tomorrow, if all dollars are converted to their present value, we can make apples to apples comparisons.
- **Discount rate**: The rate used to convert money received in the future into its present value.

Mechanical issue:

- **Formula starts at year 0**
  - If a project starts and ends in the first year, we do not, in practice, use discounting. This implies that:
    - The first year in the present value formula = 0
    - All costs and benefits happen on the first day of the year
  - For consistency, start counting years from 0 (like your age) when discounting future years as well
    - [Or if you really want to make year 1 = 1 then think of the formula as \( t-1 \)]
discount rate

different from inflation rate

• Both rates are used to create apples to apples comparisons
  – Costs and outcomes in different time periods are not directly comparable
• But rates used for different purposes:
  – Inflation rate: adjusts for changes in purchasing power of dollar over time
    • e.g., consumer price index
    • “A dollar is not worth a dollar any more”
  – Discount rate: adjusts for changes in value of cost or outcome based on when it occurs
    • Use a “real” discount rate (not nominal) to discount “real” dollars. This is equivalent to using a nominal discount rate to discount nominal dollars.

• Inflation adjustment converts nominal dollars to REAL DOLLARS. Real dollars represents the same level of purchasing power over time
• Discount rate is applied to value real dollars over time into their PRESENT VALUE.

Inflation mechanics

• Inflation accounts for fact that purchasing power of a dollar changes over time
  – Stream of dollars without inflation adjustment: Nominal $
  – Stream after inflation adjustment: Real $
• 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 so includes more of the economy
• Which measure should be used when adjusting dollars?
  – Between 1990 and 2006, difference between 2 within +5%.

“When” to Discount
(vs. inflation adjust) in economic evaluation applications

• 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 (II)

• You enroll people in 2013 and follow them for 4 years (from 2013-2016); at the end of follow-up you estimate costs using values obtained in 2016: Discount? Inflation adjust?
• Your enroll people in 2013 and follow them for 4 years (from 2013-2016); you use their billing claims to estimate costs: Discount? Inflation adjust?
• You enroll people on a rolling basis during a 4-year period, but follow each for only 1 year; you collect bills to estimate costs: Discount? Inflation adjust?

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The choice of discount rate matters!

<table>
<thead>
<tr>
<th>Year</th>
<th>Project A</th>
<th>Project B</th>
<th>Project C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-80</td>
<td>-80</td>
<td>-80</td>
</tr>
<tr>
<td>1</td>
<td>25</td>
<td>80</td>
<td>0</td>
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<tr>
<td>2</td>
<td>25</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>10</td>
<td>140</td>
</tr>
<tr>
<td>NPV (r=2%)</td>
<td>37.8</td>
<td>35.8</td>
<td>46.8</td>
</tr>
<tr>
<td>NPV (r=10%)</td>
<td>14.8</td>
<td>21.5</td>
<td>6.9</td>
</tr>
</tbody>
</table>
What discount rate should be used for CBA / CEA?

- **Social Discount Rate (SDR):** The rate that determines the part of a dollar society is willing to give up tomorrow to have use of that dollar today.

- To determine this rate, let's start with the reasons why a dollar tomorrow is worth less than a dollar today.

Why is a dollar tomorrow worth less than a dollar today?

- **Time preference to consume today (Marginal rate of time preference)**
  - We tend to prefer to consume immediate benefits to those occurring in the future.

- **Investment today could produce more in the future (Marginal rate of return on private investment)**

- Given these two reasons, shouldn’t market interest rates be sufficient to quantify the appropriate magnitude for the social discount rate?

Social discount rate

- the social discount rate (SDR) (under certain conditions)
  - Marginal rate of time preference (p)
  - Marginal rate of return on private sector investments (r)

- These conditions require perfect markets
  - No taxes
  - No transaction costs associated with making loans
  - You can borrow as much as you like
  - No market failures including no externalities and information asymmetry
Social discount rate with taxes and transaction costs

- marginal rate of time preference \( (p) \) < marginal rate of return on private sector investments \( (r) \)
- because a greater private return is needed to cover taxes and transactions
- In this case, base SDR on the relative contributions that investment \( (r) \) and consumption \( (p) \) would make towards funding the project
  - Criticism: project specific

What is a good proxy for Marginal rate of time preference \( (p) \)

- Use real, after-tax return on savings to proxy for earnings in exchange for postponing consumption
  - Return to holding government bonds
  - Average monthly yields on one-year U.S. gov’t Treasury notes
  - Convert nominal, pre-tax average to real, after-tax rate
  - Result: between 1 and 2%
- Criticisms
  - Individuals differ in their preferences and opportunities
  - Some are savers and some are borrowers
  - Individuals do not act in a way that would imply they hold a single rate of time preference
- Use \( p \) if a project is funded by domestic taxes and taxes reduce consumption and not investment

What is a good proxy for Marginal rate of return on private sector investments \( (r) \)

- Use real, before-tax rate of return on corporate bonds
  - A good proxy for marginal pretax return
  - AAA-rated corporate bonds - real rate of return between 4 and 5%
- Return on equities would give an estimate that is too high
  - Based on average returns rather than marginal returns
  - They contain a risk premium for holding equities
- Criticisms – too high
  - Negative externality: ignores the wishes of future generations
  - Market prices exceeding social marginal costs
  - Contains default risk premium
  - If financed by taxes rather than by loans then costs crowd out consumption rather than investment which implies the rate of time preference should be considered
- Rationale: Before the gov’t takes resources out of the private sector, it should show that society will receive more than if those resources remained in the private sector.
What Discount Rate?
Consider conceptual foundations
- Underlying theory for determination of a discount rate for public investment:
  - Consider the source of the funds (are they coming from investment or consumption?) Is the public investment crowding out an opportunity to make a private rate of return on an investment?
  - Consider how the results of the public investment will be used (will they go to investment or consumption?)
- The discount rate may vary depending on:
  - a program’s financing mechanism
  - the nature of its benefits and costs
  - the state of the economy

What Discount Rate?
Estimate shadow price of capital
- If all resources used in a project displace current consumption and benefits provide additions to future consumption then no need to estimate \( \theta \) because SDR=marginal rate of time preference
  - But if project also changes investment, inflate investment flow to represent its consumption equivalent using estimate of 0.
- Steps to execute Shadow Price of Capital solution:
  - Step 1: weigh investment flows by a parameter
    - Shadow price of capital: \( \theta \) It is >1 because \( r > p \).
    - This converts investment flows into its consumption equivalent
  - Step 2: Discount everything at social rate of time preference \( p \).
- Criticisms:
  - Difficult to explain calculation to policy makers
  - Requires more information and judgment (i.e., potential for manipulation)

What discount rate?
Practical Solution
- Use 3%:
  - Recommended by U.S. Panel
  - Current practice in US and most other developed countries
  - Approximate rate on return on long-term US treasury notes
  - Should test sensitivity analysis at 5%
- NICE uses 3.5% (accept sensitivity at 1.5%)
- What about developing countries?
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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

Arguments

• Health effects cannot be traded
  – What about a health tradeoff over time such as abstaining from smoking?
• health effects are not affected by the future generations being richer
  – But if richer, they can spend more on health and technological advances in the future increase health
Rationales for Discounting Health

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

(All three seem to be variations on example)

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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>

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

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Summary of Programs 1 and 2

<table>
<thead>
<tr>
<th>Stats for calculation</th>
<th>Program 1</th>
<th>Program 2</th>
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<tbody>
<tr>
<td>Discounted costs</td>
<td>1000</td>
<td>970.9</td>
</tr>
<tr>
<td>Discount QALYs</td>
<td>100</td>
<td>97.1</td>
</tr>
<tr>
<td>Undiscounted QALYs</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CALCULATIONS</th>
<th>Program 1</th>
<th>Program 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CER (Undiscounted Benefits)</td>
<td>10.0</td>
<td>9.7</td>
</tr>
<tr>
<td>CER (Discounted Benefits)</td>
<td>10.0</td>
<td>10.0</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
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

Consistency

- If costs and benefits are in monetary terms, everyone agrees to discount both benefits and costs.
- Why should it matter if effects are in non-monetary terms?
- It shouldn’t