An Introduction to Cost-Effectiveness and Benefit-Cost Analyses in Education Research

Natalie A. Koziol, Ph.D.
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Outline

• Overview and Motivation
• Cost Analysis
• Cost-Effectiveness Analysis
• Benefit-Cost Analysis
• Additional Considerations
Acknowledgement

• The Center for Benefit-Cost Studies of Education (CBCSE; cbcse.org) is at the forefront of economic evaluation in education research
  – Tons of resources and examples on their website
  – IES-funded methods training program (now closed)
• Content and organization of presentation is based on their textbook (Levin, et al., 2018)
Overview and Motivation
Economic Evaluation/Analysis

• “Broad set of techniques for evaluation and decision-making” (Levin et al., p. 3)
  – Cost Analysis or Cost Feasibility Analysis (CA/CF)
  – Cost-Effectiveness or Cost-Utility Analysis (CEA/CU)
  – Benefit-Cost Analysis (BCA)
<table>
<thead>
<tr>
<th>Type</th>
<th>Procedure</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA/CF</td>
<td><strong>Estimate</strong> average annual cost of program implementation per participant (or total or marginal cost)</td>
<td>Fully explicate program resources and who finances resources Rule out unaffordable alternatives</td>
<td>No consideration of program outcomes</td>
<td>Bowden et al. (2017)</td>
</tr>
<tr>
<td>CEA</td>
<td><strong>Estimate</strong> incremental cost to achieve 1-unit increase in effectiveness, relative to an alternative program with common goals</td>
<td>Consider costs &amp; outcomes “Straightforward” extension to traditional effectiveness studies</td>
<td>Effectiveness must be represented by a single measure Limited to relative conclusions Alternatives must target (&amp; identically measure) the same outcome</td>
<td>Hollands et al. (2013)</td>
</tr>
<tr>
<td>CU</td>
<td><strong>Estimate</strong> incremental cost to achieve 1-unit increase in utility, relative to an alternative program with common goals</td>
<td>Consider costs &amp; outcomes Allow for multiple effectiveness measures Account for stakeholder preferences</td>
<td>Must determine how to define, weight, &amp; combine utilities Limited to relative conclusions Alternatives must target (&amp; identically measure) the same outcomes</td>
<td>Lewis et al. (1994)</td>
</tr>
<tr>
<td>BCA</td>
<td><strong>Estimate</strong> a program’s monetized effects (benefits) relative to its monetized costs</td>
<td>Consider costs &amp; outcomes Provide absolute information Capture all benefits and for as long as they last Compare diverse alternatives</td>
<td>Difficult to monetize some impacts Long-term benefits generally require projection</td>
<td>Belfield et al. (2015) Bowden et al. (2015) Levin &amp; Garcia (2013)</td>
</tr>
</tbody>
</table>

Based in part on Table 1.1 (p. 22; Levin et al., 2018)
Motivation

• Optimize scarce resources and maximize educational outcomes
• Improve education policy via evidence-based decision-making
• Meet the requirements of funding agencies
• Justify use of a particular program
Example Research Questions

- Is the program affordable? (CA/CF)
- Who primarily bears the costs? (CA/CF)
- How scalable is the program? (CA/CF)
- Given a fixed budget, which program (among those with a common goal) is most effective (CEA)?
- Given a minimum level of effectiveness, which program (among those with a common goal) is least costly? (CEA)?
- Do the returns on the program justify its costs? (BCA)
- Among alternatives targeting the same OR different outcomes, which program is the most “socially desirable investment”? (BCA)
Key Considerations

- Purpose
- Audience
- Perspective
- Relevant alternatives
- Timespan of evaluation
- Analytic method
Cost Analysis
Purpose

• Fully explicate program resources and financing of resources
• Rule out unaffordable alternatives
• First step of larger evaluation (CEA or BCA)
Defining Costs

• “All the resources that are involved in ‘making the intervention work’” (p. 51; Levin et al., 2018)
  – Costs directly tied to program implementation
  – Induced costs (Bowden et al., 2017)
• Opportunity cost (value is next best use)
• Incremental vs. total costs
• Costs vs. who finances costs
• Budgets and expenditure reports ≠ cost analysis
Estimating and Reporting Costs: The Ingredients Method

1) Determine program “ingredients”
2) Assign a value (price) to each ingredient
3) Calculate costs
4) Identify optimal presentation of costs
Determining Ingredients (Step 1)

• Identify all resources needed to replicate effects, e.g.,
  – Personnel (e.g., teachers, volunteers, coaches)
  – Facilities (e.g., classroom space)
  – Equipment/materials (e.g., software, textbooks)
  – Other program inputs (e.g., scholarship funds)
  – Client inputs (e.g., parents’ time but usually not children’s time)

• Fully detail resources, e.g.,
  – Qualifications (e.g., certifications, experience)
  – Dimensions/Characteristics (e.g., sq ft, special features)
  – Dosage/Quantity (e.g., % of usable time allocated to program)
Sampling Procedures

• Existing program descriptions are generally insufficient
  – Lack precise information about ingredients’ characteristics
  – Fail to capture site-by-site variability
  – Describe *intended* resources which may not correspond to the *actual* resources tied to observed impacts

• Need to sample information from implementation sites
  – Use traditional data collection methods
  – Perform concurrently with program implementation
Assigning Prices (Step 2)

- Local (site-specific) prices vs. national (expected) prices
  - Local prices are subject to greater sampling error and are less generalizable, but may be more meaningful to primary stakeholders
  - National prices are more generalizable and thus may be more meaningful to secondary audience(s)
- Market prices vs. shadow prices
  - Market prices can be drawn from national databases (e.g., see Hollands et al., 2015) or site-specific documents (e.g., for local prices)
  - Shadow prices are needed in the absence of market prices and are estimated as the value of the ingredient’s next best use
- Account for characteristics of ingredients when identifying prices
Adjusting Prices
Hollands, Hanisch-Cerda, Menon et al. (2015)

- Inflation
  – Convert prices to the same time period
  – \( AP = P \times (IE/IP) \)
- Geographic location
  – (Potentially) convert national prices to local prices
  – \( GP = P \times \left( \frac{RPP_e}{RPP_p} \right) \)
- Amortization/Depreciation
  – Calculate adjusted annual costs for assets with lifetime > 1 year (e.g., training, owned facilities)
  – \( AC = P \times \left[ R \times (1 + R)^L \right]/[(1 + R)^L - 1] \)
- Discounting
  – Compute present value (prefer future cost [immediate benefit] to immediate cost [future benefit])
  – \( PV = P \times e^{D \times (1 - Y)} \)
- Personnel Benefits
  – Adjust salary/wage estimates to account for fringe benefits
  – \( TC = W \times (1 + B) \)

\( AP \) = inflation-adjusted price; \( P \) = unadjusted price; \( IE \) = inflation index for year in which prices will be expressed; \( IP \) = inflation index for year of unadjusted price. \( GP \) = geographically-adjusted price. \( RPP_e \) = geographical index for location in which prices will be expressed. \( RPP_p \) = geographical index for location of unadjusted price. \( AC \) = annual cost; \( R \) = interest rate; \( L \) = lifetime of asset; \( PV \) = present value; \( D \) = discount rate; \( Y \) = year of cost or impact; \( TC \) = total compensation; \( W \) = wages; \( B \) = benefits rate (% of wages)
Calculating Costs (Step 3)

- Cost of ingredient = $C_i = P_i \times Q_i$
- Total cost of program implementation = $\sum_i C_i$
- Average cost per program participant = $\sum_i C_i / N$
- Marginal cost (less straightforward)

$C_i$ = cost of $i^{th}$ ingredient;
$P_i$ = price of $i^{th}$ ingredient;
$Q_i$ = quantity of $i^{th}$ ingredient;
N = number of program participants
Reporting Costs (Step 4)

- Report annual (per intervention year) cost
- Provide aggregate-level information (e.g., average cost)
- Disaggregate information where meaningful, e.g., by
  - constituency (e.g., highlight who finances the costs)
  - site (e.g., identify site-by-site variability)
  - ingredient (e.g., inform scalability questions)
  - year (e.g., identify savings due to increased efficiency)
  - demographic group (e.g., highlight impact of dosage)
Table 3. Distribution of Core Costs of City Connects in Boston.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Total Cost (PV)</th>
<th>Cost to City Connects</th>
<th>Cost to School</th>
<th>Cost to Parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central program staff</td>
<td>US$174,580</td>
<td>US$174,580</td>
<td>US$0</td>
<td>US$0</td>
</tr>
<tr>
<td>School site coordinators</td>
<td>US$900,040</td>
<td>US$900,040</td>
<td>US$0</td>
<td>US$0</td>
</tr>
<tr>
<td>School staff</td>
<td>US$93,140</td>
<td>US$0</td>
<td>US$93,140</td>
<td>US$0</td>
</tr>
<tr>
<td>Parental involvement</td>
<td>US$4,990</td>
<td>US$0</td>
<td>US$0</td>
<td>US$4,990</td>
</tr>
<tr>
<td>Materials</td>
<td>US$5,040</td>
<td>US$2,870</td>
<td>US$2,170</td>
<td>US$0</td>
</tr>
<tr>
<td>Facilities</td>
<td>US$16,410</td>
<td>US$0</td>
<td>US$26,760</td>
<td>US$0</td>
</tr>
<tr>
<td>Total</td>
<td>US$1,204,560</td>
<td>US$1,077,490</td>
<td>US$122,070</td>
<td>US$4,990</td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td>89.5</td>
<td>10.1</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Note. Core costs averaged across sites and weighted for site size in 2013–2014. Present value (PV) based on 6 years participation (K–5), discounted back to kindergarten using 3.5% discount rate, expressed in constant 2013 dollars using Boston average prices.
CostOut – the CBCSE Cost Tool Kit
Hollands, Hanisch-Cerda, Levin et al., 2015

• Free online tool developed by CBCSE to facilitate cost analyses
• Includes a multi-source database with national market prices
• Automatically makes price adjustments
• Automatically calculates costs given ingredient quantities and prices
• Disaggregates costs across ingredients and constituencies
• Incorporates effectiveness information for CEA
• Offers simple comparative reports
• For more detail see Hollands, Hanisch-Cerda, Menon et al. (2015)
Hypothetical Example (HYPE!)

• HYPE! is a 9-wk afterschool intervention aimed at decreasing aggression in K-3rd graders with behavior concerns

• Ingredients of intervention (100 kids across 20 schools)
  – Personnel
    • 20 teachers (no special qualifications), each 3 hrs/wk
    • 20 coaches, each 1 hr/wk
  – Facilities
    • 20 classrooms, each 900 sq ft with lifetime of 30 years, 3 hrs/wk
  – Client Inputs
    • 100 parents, each 1 hr/wk for meetings, 12 mi/wk and .5 hr/wk for transportation
# HYPE! Costs

Expressed in constant 2016 dollars using national prices and inflation rate of 3.5%, and assuming 1440 hrs/academic year

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Unit</th>
<th>Quant</th>
<th>% Use</th>
<th>Unadj. Price</th>
<th>Price Year</th>
<th>Price Source</th>
<th>Benefit Rate</th>
<th>Adjust. Price</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>Hour</td>
<td>540</td>
<td>100</td>
<td>40.00</td>
<td>2015</td>
<td>CostOut: Elementary school teacher grades K-6</td>
<td>0.50</td>
<td>60.24</td>
<td>32531.91</td>
</tr>
<tr>
<td>Coach</td>
<td>Hour</td>
<td>180</td>
<td>100</td>
<td>31.91</td>
<td>2011</td>
<td>CostOut: Teacher (education specialist) grades K-12</td>
<td>0.50</td>
<td>50.64</td>
<td>9115.49</td>
</tr>
<tr>
<td>Classroom</td>
<td>Unit</td>
<td>20</td>
<td>=1.88</td>
<td>314232.21</td>
<td>2015</td>
<td>CostOut: Elementary classroom (900 sq ft)</td>
<td></td>
<td></td>
<td>6434.06</td>
</tr>
<tr>
<td>Parent</td>
<td>Hour</td>
<td>1350</td>
<td>100</td>
<td>24.14</td>
<td>2016</td>
<td>Independent Sector (value of volunteer time, includes fringe benefits)</td>
<td></td>
<td>24.14</td>
<td>32589.00</td>
</tr>
<tr>
<td>Transport</td>
<td>Mile</td>
<td>10800</td>
<td>100</td>
<td>0.54</td>
<td>2016</td>
<td>IRS (standard mileage rate)</td>
<td>0.54</td>
<td>0.54</td>
<td>5832.00</td>
</tr>
</tbody>
</table>

Total Cost

86502.46

Cost/Student

86502.46/100

= 865.02
Cost-Effectiveness Analysis
Purpose

• Identify, among alternatives with common goals, the program that optimizes educational resources with respect to maximizing educational outcomes
Performing a CEA

1) For all relevant alternatives, concurrently estimate *incremental* program costs and impacts (effects) relative to those of a baseline group

2) Calculate cost-effectiveness ratios (CERs)

3) Compare and rank alternatives programs
Measuring Effectiveness (Step 1b)

- Program impact as indicated by the theory of change
- Strength of evidence depends on the study design
- Standardized effects facilitate interpretation
- Same effectiveness measure needed for all alternatives
- Discounting needed if programs vary in timing of effect
- Programs often target multiple domains at multiple time points but CEA requires a single measure of effectiveness
Calculating CERs (Step 2)

• CERs indicate the *incremental* cost per participant needed to achieve a 1-unit increase in effectiveness per participant, relative to an alternative program with common goals.

• \[
\text{CER} = \frac{(C_T - C_C)}{(E_T - E_C)} = \frac{(\Delta C)}{(\Delta E)}
\]

\[C_T = \text{Average cost per participant for target program}\]
\[C_C = \text{Average cost per participant for alternative program}\]
\[E_T = \text{Average effectiveness per participant for target program}\]
\[E_C = \text{Average effectiveness per participant for alternative program}\]
Comparing Alternatives (Step 3)

• Generally prefer alternative with smallest CER but consider
  – sign of $\Delta C$ and $\Delta E$
  – relative magnitude of $\Delta C$ and $\Delta E$ in relation to budget restrictions or minimum required level of effectiveness
  – heterogeneity in CERs
Example Cost-Effectiveness Map

- Origin represents baseline comparison group
- Southeast quadrant is optimal (more effective and less costly)
- Northeast quadrant is more likely (more effective and more costly)
HYPE! Hypothetical CEA

• An RCT was performed to evaluate the impact of HYPE! on aggression as measured by the BASC-3 TRS Aggression scale

• The mean aggression score for HYPE! students was .13 SDs lower than the score for BAU students

• $CER = 865.02/(-.13) = -6654$, i.e., it takes an additional $6654 per student to decrease aggression by 1 SD unit (relative to BAU)
Multiple Measures of Effectiveness

• The CER necessitates one effectiveness measure
• Options for handling multiple measures include
  – calculating multiple CERs to either (a) reveal a clear “winner,” or (b) highlight program tradeoffs
  – conducting a CU
  – conducting a BCA
Performing a CU

• Similar to CEA but denominator represents utility ($U$)
• Use Multiattribute Utility Theory as a guiding framework
  – Choose method for determining individual utilities, $U_i(x_i)$ (e.g., proportional scoring, direct method, variable probability method)
  – Choose method for determining individual importance weights, $w_i$ (e.g., direct method, variable probability method)
  – Choose function for combining $U_i(x_i)$, e.g., $U = \sum_{i=1}^{M} w_i U_i(x_i)$
• Rarely performed in education research
  – Requires sampling preference data from relevant populations
  – Relies heavily on judgment and makes strong assumptions
Benefit-Cost Analysis
Purpose

• Determine, in an absolute sense, whether a program is a “socially desirable investment”

• Determine whether a program is a more “socially desirable investment” than alternative programs, including
  – education programs with common goals
  – education programs with different goals
  – non-education programs with different goals
Performing a BCA

1) Estimate immediate program costs and impacts, and predict long-term impacts
2) Monetize costs and impacts using appropriate price adjustments
3) Calculate economic metrics to combine monetized costs and impacts
4) Evaluate program
Measuring Impacts (Step 1b)

• Consider ALL (ideally causally-linked) program impacts as soon as they occur and for as long as they last
  – Immediate impacts (e.g., decrease in externalizing behaviors)
  – Intermediate impact (e.g., decrease in HS dropout rate)
  – Long-term impacts (e.g., increase in wages, improved health)
• Immediate impacts are directly observed
• Longer-term impacts are typically predicted, e.g., via
  – secondary analyses of large-scale federally-funded datasets
  – published meta-analytic findings (e.g., see WSIPP, 2017)
<table>
<thead>
<tr>
<th>Estimated causal links between outcomes</th>
<th>Number of effect sizes</th>
<th>Meta-analytic results before adjusting effect sizes</th>
<th>Adjusted effect size and standard error used in the benefit-cost analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fixed effects model</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weighted mean effect size &amp; p-value</td>
<td>Homogeneity test (p-value to reject homogeneity)</td>
</tr>
<tr>
<td>Cannabis use &lt;18 years of age, leading to...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crime</td>
<td>1</td>
<td>0.271 0.130 0.038 0.000</td>
<td>0.000 0.000</td>
</tr>
<tr>
<td>High school graduation</td>
<td>13</td>
<td>-0.180 0.016 0.000 0.000</td>
<td>109.830 0.000</td>
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<tr>
<td>Crime (non-offender pop), leading to...</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>High school graduation</td>
<td>6</td>
<td>-0.421 0.029 0.000 0.000</td>
<td>23.957 0.000</td>
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<tr>
<td>Crime (offender pop), leading to...</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>High school graduation</td>
<td>4</td>
<td>-0.174 0.043 0.000 0.000</td>
<td>6.516 0.089</td>
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<td>Depression, leading to...</td>
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<td></td>
<td></td>
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<tr>
<td>Employment</td>
<td>11</td>
<td>-0.296 0.018 0.000 0.000</td>
<td>97.244 0.000</td>
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<tr>
<td>Earnings given employment</td>
<td>3</td>
<td>-0.022 0.021 0.000 0.000</td>
<td>1.083 0.582</td>
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<tr>
<td>High school graduation</td>
<td></td>
<td>see internalizing composite</td>
<td></td>
</tr>
<tr>
<td>Grade retention</td>
<td></td>
<td>see internalizing composite</td>
<td></td>
</tr>
<tr>
<td>Diabetes, leading to...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>5</td>
<td>-0.210 0.012 0.000 0.000</td>
<td>26.193 0.000</td>
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<tr>
<td>Earnings given employment</td>
<td>3</td>
<td>-0.027 0.030 0.000 0.000</td>
<td>0.417 0.812</td>
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<tr>
<td>Nursing home</td>
<td>8</td>
<td>0.212 0.008 0.000 0.000</td>
<td>20.497 0.005</td>
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<tr>
<td>Disruptive Behavior Disorder, leading to...</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>High school graduation</td>
<td>5</td>
<td>-0.429 0.029 0.000 0.000</td>
<td>6.063 0.195</td>
</tr>
<tr>
<td>Grade retention</td>
<td>4</td>
<td>0.273 0.055 0.000 0.000</td>
<td>1.155 0.764</td>
</tr>
<tr>
<td>Test scores-academic</td>
<td></td>
<td>see Externalizing composite</td>
<td></td>
</tr>
<tr>
<td>Special education</td>
<td></td>
<td>see Externalizing composite</td>
<td></td>
</tr>
<tr>
<td>Crime</td>
<td></td>
<td>see Externalizing composite</td>
<td></td>
</tr>
<tr>
<td>Drug Disorder, leading to...</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Employment</td>
<td>5</td>
<td>-0.270 0.033 0.000 0.000</td>
<td>12.470 0.014</td>
</tr>
<tr>
<td>Crime</td>
<td>2</td>
<td>0.304 0.056 0.000 0.000</td>
<td>0.072 0.788</td>
</tr>
<tr>
<td>Externalizing behavior symptoms, leading to...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school graduation</td>
<td>3</td>
<td>-0.225 0.029 0.000 0.000</td>
<td>1.261 0.532</td>
</tr>
</tbody>
</table>
Monetizing Impacts (Step 2)

- A benefit \((B_i)\) is a monetized impact \((P_i \times E_i)\)
  - \(P_i\) is typically a shadow price
  - Benefits may be positive or negative
  - Some benefits are ignored because they cannot be monetized

- Total benefits \(B = \sum_{y=1}^{L} \sum_{i=1}^{M} B_{yi} = \sum_{y=1}^{L} \sum_{i=1}^{M} P_{yi} \times E_{yi}\)
  - Avoid double-counting benefits
  - Adjust prices as previously discussed (e.g., for inflation, discounting)
  - Adjust effects via ratchet and fadeout functions to capture growth and decay (e.g., see WSIPP, 2017; Belfield et al., 2015)

\(L = \text{Number of years impact persists}\)
\(M = \text{Number of impacts}\)
<table>
<thead>
<tr>
<th>Outcome</th>
<th>ES at time 2</th>
<th>SE at time 2</th>
<th>Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child abuse &amp; neglect</td>
<td>ES1</td>
<td>SE1</td>
<td>Age 17</td>
</tr>
<tr>
<td>Out-of-home placement</td>
<td>ES1</td>
<td>SE1</td>
<td>Age 17</td>
</tr>
<tr>
<td>Substance abuse prevention outcomes</td>
<td>ES1</td>
<td>SE1</td>
<td>Age at Time 1 + 10</td>
</tr>
<tr>
<td>Substance abuse treatment outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For most programs</td>
<td>0</td>
<td>0.187</td>
<td>Age at Time 1 + 3</td>
</tr>
<tr>
<td>Contingency management (higher-cost)</td>
<td>0</td>
<td>0.125</td>
<td>Age at Time 1 + 1</td>
</tr>
<tr>
<td>Contingency management (lower-cost)</td>
<td>0</td>
<td>0.075</td>
<td>Age at Time 1 + 1</td>
</tr>
<tr>
<td>Substance abuse outcomes</td>
<td>ES1 * 0.137</td>
<td>√(SE1^2 * 2.25)</td>
<td>Age at Time 1 + 2</td>
</tr>
<tr>
<td>Crime</td>
<td>ES1</td>
<td>SE1</td>
<td>Age at Time 1 + 10</td>
</tr>
<tr>
<td>Adult depression, adult anxiety</td>
<td>ES1 * 0.52</td>
<td>(SE1^2 * 1.5)^0.5</td>
<td>Age at Time 1 + 2</td>
</tr>
<tr>
<td>Adult PTSD</td>
<td>ES1</td>
<td>SE1</td>
<td>Age at Time 1 + 1</td>
</tr>
<tr>
<td>Adult psychosis</td>
<td>ES1 * 0.743</td>
<td>(ES1^2 * 0.569^2 + 0.743^2 SE1^2 + SE1^2 * 0.569^2)^0.5</td>
<td>Age at Time 1 + 1</td>
</tr>
<tr>
<td>Child PTSD</td>
<td>ES1</td>
<td>SE1</td>
<td>Age at Time 1 + 1</td>
</tr>
<tr>
<td>Child ADHD</td>
<td>0</td>
<td>(ES1^2 * 0.048^2 + 0.00317^2 SE1^2 + SE1^2 * 0.048^2)^0.5</td>
<td>Age at Time 1 + 1</td>
</tr>
<tr>
<td>Child depression</td>
<td>ES1 * 0.00099</td>
<td>(ES1^2 * 0.0811^2 + 0.00099^2 SE1^2 + SE1^2 * 0.0811^2)^0.5</td>
<td>Age at Time 1 + 1</td>
</tr>
<tr>
<td>Child anxiety</td>
<td>ES1* 0.4623</td>
<td>(ES1^2 * 0.0992^2 + 0.4623^2 SE1^2 + SE1^2 * 0.0992^2)^0.5</td>
<td>Age at Time 1 + 1</td>
</tr>
<tr>
<td>Child internalizing</td>
<td>ES1 * 0.72848</td>
<td>(ES1^2 * 0.2803^2 + 0.7285^2 SE1^2 + SE1^2 * 0.2803^2)^0.5</td>
<td>Age at Time 1 + 2</td>
</tr>
<tr>
<td>Child externalizing, child disruptive behavior</td>
<td>ES1 *0.47646</td>
<td>(ES1^2 * 0.2012^2 + 0.47646^2 SE1^2 + SE1^2 * 0.2012^2)^0.5</td>
<td>Age at Time 1 + 3</td>
</tr>
</tbody>
</table>
Exhibit 4.7.9 (p. 122; WSIPP, 2017)

Exhibit 4.7.9
Fadeout Multipliers for Test Scores:
Estimates of Effect Size Decay Based on Longitudinal Evaluations of Early Childhood Education

<table>
<thead>
<tr>
<th>Age at measurement</th>
<th>Grade level</th>
<th>Fadeout: Later test score effect size as a % of pre-K effect size</th>
<th>Fadeout multiplier: Multiply the effect size by the % below to estimate end-of-high school effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Pre-K</td>
<td>100%</td>
<td>21%</td>
</tr>
<tr>
<td>5</td>
<td>K</td>
<td>66%</td>
<td>31%</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>52%</td>
<td>40%</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>44%</td>
<td>47%</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>38%</td>
<td>54%</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>34%</td>
<td>60%</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>31%</td>
<td>66%</td>
</tr>
<tr>
<td>11</td>
<td>6</td>
<td>29%</td>
<td>72%</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>27%</td>
<td>77%</td>
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<tr>
<td>13</td>
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<td>25%</td>
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</tr>
<tr>
<td>14</td>
<td>9</td>
<td>24%</td>
<td>87%</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>23%</td>
<td>91%</td>
</tr>
<tr>
<td>16</td>
<td>11</td>
<td>22%</td>
<td>96%</td>
</tr>
<tr>
<td>17</td>
<td>12</td>
<td>21%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Shadow Pricing Methods

• Market analogy method
  – Use market prices for comparable goods (e.g., cost of hiring a tutor to increase test scores; cost of hiring someone to perform volunteer’s services)

• Defensive expenditure method
  – Use estimates of how much society is willing to pay to avoid negative outcomes (e.g., cost-of-illness approach; cost of additional school security)

• Hedonic method
  – Use estimates of how much people are willing to pay to live in a good school district (e.g., via unique variability in home prices predicted by test scores)

• Trade-off method
  – Variation of defensive expenditure and hedonic methods

• Contingent valuation method
  – Survey people about how much they are willing to pay
Existing Shadow Prices

• Many shadow prices have been derived for use in economic analyses, e.g.,
  – Lifetime earnings via educational attainment (Table 9.3; Levin et al., 2018)
  – Value of outcomes tied to the labor market, crime, child abuse and neglect, ATOD, teen birth, public assistance, K-12 and higher education, mental health, health care (WSIPP, 2017)
  – Quality-adjusted life years (QALYs) via educational attainment (e.g., Muennig et al., 2010; Schoeni et al., 2011)
  – Value of social and emotional learning outcomes (Belfield et al., 2015)
  – Value of a statistical life (e.g., EPA, 2017)

• Advantages and disadvantages of using existing prices
  – Greater credibility by using prices that are well-established and causally-linked
  – Requires “benefit transfer” step
Calculating Metrics (Step 3)

• Net Present Value
  \[ NPV = B_{PV} - C_{PV} \]
  – Extent to which total benefits exceed total costs

• Benefit-Cost Ratio
  \[ BCR = \frac{B_{PV}}{C_{PV}} \]
  – “For every dollar invested in this...program, there will be a return of [$$]” (p. 225; Levin et al., 2018)

• Internal Rate of Return (IRR)
  – Discount rate that results in \( NPV = 0 \)
Evaluating Programs (Step 4)

• Programs are evaluated positively when
  – $NPV > 0$
  – $BCR > 1$
  – No real threshold for a “good” IRR but $\geq .1$ is a rough guideline (Levin et al., 2018)

• Use caution when comparing programs due to
  – differences in their scale of implementation
  – differences in extent to which impacts can be monetized

• Remember audience and perspective
HYPE! Hypothetical BCA

- Conservative analysis
  - Only considered single immediately observed impact (aggression)
  - Assumed complete fade-out after 1 year
- Cost-of-illness approach for shadow pricing
  - Prices derived by Foster et al. (2005), adapted by Belfield et al. (2015)
  - Belfield et al. (2015) expressed prices in 2013 dollars and used 3.5% discount rate to adjust by 1 year
  - Converted Belfield et al. (2015) estimated price ($34,385 per 1 SD decrease in aggression) to 2016 dollars and back-discounted:
    \[
    \frac{34385}{(e^{0.035 \times (1-2)})} \times \frac{711.104}{697.836} = 36,286.83
    \]
  - \( B_i = P_i \times E_i = 36286.83 \times 0.13 = 4,717.29 \)
- \( NPV = 4717.29 \times 100 - 865.02 \times 100 = 385,227 \)
- \( BCR = 4717.29/865.02 = 5.45 \)
Other Considerations
Acknowledging Uncertainty

• Economic analyses involve
  – parameter uncertainty (e.g., sample & measurement error, rates)
  – structural uncertainty (e.g., different theories of change)

• Usual methods for capturing uncertainty are hard to apply due to
  – small sample sizes underlying cost estimates
  – multiple sources of uncertainty
  – ratio estimation
  – non-normality

• But still need sensitivity testing to gauge impact of uncertainty
  – Informal methods (e.g., vary parameters to determine sensitivity)
  – Formal methods (e.g., Fieller’s theorem, bootstrapping, Monte Carlo)
General Recommendations

- Be transparent
- Be consistent
- Err on the side of being conservative
- Follow the principle of proportionality
- See p. 269 of Levin et al. (2018) for a complete checklist of good practices
References


References


Questions? Comments?

Correspondence to:
Natalie Koziol
nkoziol@unl.edu