Outline

1. Formulas
2. Data sources and estimation methods
3. Errors, interactions, and unintended consequences
There are many tradeoffs
  – Political
  – Programmatic
  – Statistical

Choices can have unintended consequences
Basic Features of Fund Allocation Programs

- Recipient units
- Frequency of allocations
- (Total allocation)
Components of Formulas

- Measures of
  - Need
  - Fiscal capacity
  - Effort
Need

- Potential measures
  - Number eligible
  - Percentage eligible
- Proportional allocation
Special Features of Formulas

- Thresholds
- Limits
- Hold-harmless provisions and caps
- Step functions
- Bonuses and penalties
Why Have Special Features?

- Promote efficient use of funds
- Stabilize funding
- Negotiate political compromise
Thresholds

- No allocation if below threshold
- Based on need
  - Number eligible
  - Percentage eligible
- Rationale
  - Minimum size to run program effectively
  - Focus assistance where need is greatest
Hold-Harmless Provisions

- Limit decrease in funding between periods
- Percentage of previous allocation
- Rationale: stability of funding
  - Political
  - Administrative
- With constant total appropriations, 100% hold-harmless implies fixed allocations
Data Sources for Estimating Formula Components

- Decennial census
  - Short-form
  - Long-form
- Intercensal population estimates
- Household surveys
  - Current Population Survey
  - American Community Survey
- Administrative records
- Other statistical programs
Methods for Estimating Formula Components

- Direct estimation
- Indirect estimation
Assessing Quality of Data Sources and Estimation Methods

- Conceptual fit
- Level of geographic detail
- Timeliness
- Statistical accuracy
  - Bias
  - Variance
- Susceptibility to manipulation
- Cost
Tradeoffs in Quality of Data Sources

- **Decennial census**
  - Sampling error negligible for some small areas, large for others
  - Long interval between updates
  - Limited content

- **Household surveys**
  - More current
  - More detailed content
  - Small samples for even “large” small areas
Tradeoffs in Quality of Data Sources

- Administrative data
  - Sampling error often negligible
  - Idiosyncratic content
  - Local variations
  - Practical challenges in obtaining and assembling
Introducing a New Data Source: The American Community Survey

- More current than decennial census
- Much bigger than other current household surveys—250,000 households/month
- Smaller than decennial census in one year—use moving averages
- Decennial census long-form content
- Full-scale implementation in 2005
- Replace decennial census long-form in 2010
- Political support still tenuous
Errors, Interactions, and Errors

- Errors in inputs (components)
- Interactions with special features
- Errors in outputs (allocations)
Estimation method and formula are not entirely distinct.

Example: Equivalence of
- single year estimates as inputs to formula using moving average
- moving average estimates as inputs to formula using single year
Allocations are “unbiased” over time if both estimation method and formula are linear.
How Formulas and Estimates Interact: Simulations

- Simulate estimates of need and resulting formula allocations under several scenarios.
- Evaluate by bias (mean allocation versus “correct” allocation).
Simulation Procedure

1. Define true annual values.
2. Simulate annual direct estimates by adding random (normal) noise.
3. Apply estimation method.
4. Apply formula over four-year period.
5. Assume areas are independent.
6. Repeat many times (~ 10,000 per scenario).
Factors Defining Scenarios

- Time pattern of true need
  - Constant
  - Upward Trend
  - Downward Trend
- Sampling standard error of estimates
Factors Defining Scenarios

- Estimation method
  - Direct (single year)
  - 3-year moving average
  - 3-year exponentially weighted moving average (weights 1, .7, .49 at lags 0, 1, 2)
- Formula—allocation proportional to estimated need, possibly with
  - Hold harmless (at 80%)
  - Threshold (at 1)
Assume

- Constant true values (.7, .9, 1.1, 1.3)
- Various sampling SEs (.10, .25, .50, 1)
- Single year estimation method
- Threshold = 1
Effect of Sampling Error When Have a Threshold

**Graph:**
- **Y-axis:** Expected allocation
- **X-axis:** True need level
- **Legend:**
  - Red line: Need
  - Magenta triangle: SE=.1
  - Cyan asterisk: SE=.25
  - Yellow asterisk: SE=.50

**Key Observations:**
- As the true need level increases, the expected allocation increases for all error levels.
- The effect of sampling error is evident as the allocation diverges from the need line.
- The impact of error increases with SE, as indicated by the steeper slopes for higher error levels.
Effect of Sampling Error When Have a Threshold

- As sampling error falls, expected allocation approaches formula allocation based on true need (0 or true need).

- As sampling error grows, expected allocation line straightens out (smoothes out around the threshold). Threshold effect is lost.
Effect of Sampling Error When Have a Hold-Harmless Provision

- Assume
  - Constant true values (\( = 1 \))
  - Various sampling SEs (.10, .25, .50)
  - Three estimation methods
  - Hold Harmless = 80%
Effect of Sampling Error When Have a Hold-Harmless Provision

![Graph showing the effect of sampling error with hold-harmless provision. The graph plots the expected allocation over years with different sampling errors (SE=.25 and SE=.50). The y-axis represents the expected allocation, ranging from 0 to 1.4, and the x-axis represents the years from 1 to 4. The graph includes lines for Need, SE=.25, and SE=.50.](image-url)
Effect of Sampling Error When Have a Hold-Harmless Provision

- With small sampling error, expected allocation is close to correct value.
- With large sampling error, expected allocation drifts above correct value and levels out.
- “Ratcheting” effect—up a lot, but down only a little.
Modifiers of Hold-Harmless Bias

- Moving average estimation greatly reduces ratcheting effect.
- A threshold increases the ratcheting effect.
Effect of Moving Average Estimation

![Graph showing the effect of moving average estimation with years on the x-axis and expected allocation on the y-axis, comparing Need, Single Year, MA, and MA exp.]
Effect of Moving Average Estimation When There Is a Trend

- Single-year estimates track correct value (in expectation)
- 3-year moving average falls behind trend
- 3-year exponentially-weighted moving average falls behind, but less so (for similar variance reduction)
- Optimal weighting (optimal bias-variance tradeoff) depends on autocorrelations of underlying time series
Effect of Moving Average Estimation When There Is a Trend

- Need
- MA
- MA exp

Expected allocation vs. Year
Effect of Hold-Harmless Provision When There Is a Trend

- Ratcheting effect depends on direction of trend
  - Decreased with upward trend
  - Increased with downward trend
- Moving average estimation reduces ratcheting effects
Effect of Hold-Harmless Provision When There Is a Trend

Expected allocation

Year

Need
Single year
MA
MA exp
Stability with Hold-Harmless Versus Moving Average

- Assume
  - Constant true value \( ( = 1) \)
  - Sampling SE = 0.5 or \( 0.5/\sqrt{3} \)
  - Single year or MA3 estimation method
  - Hold Harmless = 80% or none
## Stability with Hold-Harmless Versus Moving Average

<table>
<thead>
<tr>
<th>Formula/Estimation Method</th>
<th>Changes in Allocations from Year 3 to Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HH</td>
</tr>
<tr>
<td>Fraction of changes down</td>
<td>0.624</td>
</tr>
<tr>
<td>Mean downward change</td>
<td>-0.236</td>
</tr>
<tr>
<td>Mean upward change</td>
<td>0.415</td>
</tr>
</tbody>
</table>
Stability with Hold-Harmless Versus Moving Average

- Downward changes no smaller with hold harmless
- Upward changes larger with hold harmless
Interactions and Unintended Consequences

- Larger distortion in allocations for smaller areas
Selected Recommendations

2. Conduct periodic evaluations of fund allocation performance at several points in time and over time (including before implementation).
   – Examine relationships between inputs and outputs
   – Identify misallocations and their causes
   – Assess tradeoff between stability of funding and responsiveness to changing need
   – Examine effects of special features
   – Assess tradeoffs pertaining to accuracy of estimates
   – Weigh costs and benefits of improving data sources and estimation methods
Selected Recommendations

3. Evaluate the effects of special features before implementation and on an on-going basis.
   - Consider a weaker hold-harmless provision or moving average estimation
   - Consider replacing a threshold by a smoother alternative
Selected Recommendations

4. Expand the use of simulations to evaluate fund allocation performance.
   – Focus on the effects of special features.
   – Conduct longitudinal analyses, examining the effects of changes in funding levels and need distributions.