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AF Method

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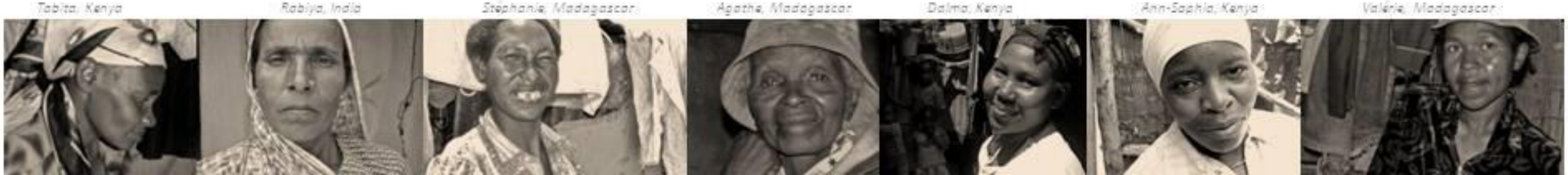

[T]he job of a 'measure' or an 'index' is to distill what is particularly relevant for our purpose, and then to focus specifically on that. … The central issues in devising an index relate to systematic assessment of importance. Measurement has to be integrated with evaluation. This is not an easy task.

−Amartya Sen (1989)

Sources

- Alkire, S., Foster, J.E., 2011. "Counting and Multidimensional Poverty Measurement," *Journal of Public Economics*

- See also Alkire, S., Foster, J.E., 2011. "Understandings and Misunderstandings of Multidimensional Poverty Measurement," *Journal of Economic Inequality*

Outline

- Motivation
- Multidimensional Data
- Identification
- Aggregation
- Examples

Challenge

- A government would like to create an official multidimensional poverty indicator
- **Desiderata**
  - It must understandable and easy to describe
  - It must conform to "common sense" notions of poverty
  - It must be able to target the poor, track changes, and guide policy.
  - It must be technically solid
  - It must be operationally viable
  - It must be easily replicable

    - **What would you advise?**

Practical Steps

- **Select**
  - Purpose of the index (monitor, target, etc)
  - Unit of Analysis (indy, hh, cty)
  - Dimensions
  - Specific variables or indicators for each dimension
  - Whether variables or dimensions should be aggregated with others or left independent
  - Cutoff for each independent variable/dimension
  - Value of deprivation for each variable/dimension
  - **Identification method**
  - **Aggregation method**

This morning's focus:

- **Identification** – Dual cutoffs
- **Aggregation** – Adjusted FGT

- Purpose, Variables, Dimensional Cutoffs, Weights and all other steps – Assume given

- Sen (1976)

Review: Unidimensional Poverty

Variable – income

Identification – poverty line

Aggregation – Foster-Greer-Thorbecke '84

Example: **Incomes = (7,3,4,8)** **Poverty line z = 5**

Deprivation vector $g^0 = (0,1,1,0)$

Headcount ratio $= P_0 = \mu(g^0) = 2/4$

Normalized gap vector $g^1 = (0, 2/5, 1/5, 0)$

Poverty gap $= P_1 = \mu(g^1) = 3/20$

Squared gap vector $g^2 = (0, 4/25, 1/25, 0)$

FGT Measure $= P_2 = \mu(g^2) = 5/100$

Multidimensional Data

Matrix of well-being scores for n persons in d domains

Domains

$$y = \begin{bmatrix} 13.1 & 14 & 4 & 1 \\ 15.2 & 7 & 5 & 0 \\ 12.5 & 10 & 1 & 0 \\ 20 & 11 & 3 & 1 \end{bmatrix}$$

Persons

Multidimensional Data

Matrix of well-being scores for *n* persons in *d* domains

Domains

$$y = \begin{bmatrix} 13.1 & 14 & 4 & 1 \\ 15.2 & 7 & 5 & 0 \\ 12.5 & 10 & 1 & 0 \\ 20 & 11 & 3 & 1 \end{bmatrix}$$ Persons

$$z \quad (13 \quad 12 \quad 3 \quad 1)$$ Cutoffs

z vector = Deprivation Cutoffs

- **Schooling:** "How many years of schooling have you completed?"
  - **6 or more (bold is non-poor)**
  - 1-5 years (non-bold is poor)
- **Drinking Water:** "What is the main water source for drinking for this household?"
  - **9. Piped Water**
  - **8. Well/Pump (electric, hand)**
  - 7. Well Water
  - 6. Spring Water / Rain Water / River/Creek Water / Pond/Fishpond
  - 5. Other
- **Sanitation:** "Where do the majority of householders go to the toilet?"
  - **11. Own toilet with septic tank**
  - **10. Own toilet without septic tank**
  - 9. Shared toilet
  - 8. Public toilet
  - 7. Creek/river/ditch (without toilet)
  - 6. Yard/field (without toilet)
  - 5. Sewer
  - 4. Pond/fishpond
  - 3. Animal stable
  - 2. Sea/lake
  - 1. Other

Deprivation Matrix

Replace entries: 1 if deprived, 0 if not deprived

Domains

$$y = \begin{bmatrix} 13.1 & 14 & 4 & 1 \\ 15.2 & \underline{7} & 5 & \underline{0} \\ \underline{12.5} & \underline{10} & \underline{1} & \underline{0} \\ 20 & \underline{11} & 3 & 1 \end{bmatrix}$$ Persons

$$z \quad (\mathbf{13} \quad \mathbf{12} \quad \mathbf{3} \quad \mathbf{1})$$ Cutoffs

Deprivation Matrix

Replace entries: 1 if deprived, 0 if not deprived

Domains

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \quad \text{Persons}$$

$z \quad (13 \quad 12 \quad 3 \quad 1)$ Cutoffs

Identification

Domains

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix}$$

Persons

Matrix of deprivations

Identification – Counting Deprivations

Domains $\qquad c$

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \cdots\cdots\cdots \begin{matrix} 0 \\ 2 \\ 4 \\ 1 \end{matrix}$$

Persons

Identification – Counting Deprivations

Q/ Who is poor?

Domains $\qquad\qquad c$

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \cdots\cdots \begin{matrix} 0 \\ 2 \\ 4 \\ 1 \end{matrix} \qquad \text{Persons}$$

Identification – Union Approach

Q/ Who is poor?

A1/ Poor if deprived in any dimension $c_i \geq 1$

$$
\begin{array}{cc}
\text{Domains} & c \\
g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} & \begin{array}{c} 0 \\ 2 \\ 4 \\ 1 \end{array}
\end{array}
\quad \text{Persons}
$$

Identification – Union Approach

Q/ Who is poor?

A1/ Poor if deprived in any dimension $c_i \geq 1$

$$
\begin{array}{cc}
 & \text{Domains} \qquad\qquad c \\
\text{Persons} & g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \quad \begin{array}{c} 0 \\ \underline{2} \\ \underline{4} \\ \underline{1} \end{array}
\end{array}
$$

Observations

Union approach often predicts high numbers.

Charavarty et al '98, Tsui '02, Bourguignon & Chakravarty 2003 etc use the union approach

Identification – Intersection Approach

Q/ Who is poor?

A2/ Poor if deprived in all dimensions $c_i = d$

$$
\begin{array}{c c}
\text{Domains} & c \\
g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} & \begin{matrix} 0 \\ 2 \\ 4 \\ 1 \end{matrix}
\end{array}
\quad \text{Persons}
$$

Identification – Intersection Approach

Q/ Who is poor?

A2/ Poor if deprived in all dimensions $c_i = d$

Domains c

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \quad \begin{matrix} 0 \\ 2 \\ \underline{4} \\ 1 \end{matrix}$$

Persons

Observations

Demanding requirement (especially if d large)

Often identifies a very narrow slice of population

Atkinson 2003 first to apply these terms.

Identification – Dual Cutoff Approach

Q/ Who is poor?

A/ Fix cutoff k, identify as poor if $c_i \geq k$

Domains

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \qquad c = \begin{matrix} 0 \\ 2 \\ 4 \\ 1 \end{matrix}$$

Persons

Identification – Dual Cutoff Approach

Q/ Who is poor?

A/ Fix cutoff k, identify as poor if $c_i \geq k$ **(Ex: k = 2)**

Domains

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \quad c = \begin{matrix} 0 \\ \underline{2} \\ \underline{4} \\ 1 \end{matrix}$$

Persons

Identification – Dual Cutoff Approach

Q/ Who is poor?

A/ Fix cutoff k, identify as poor if $\mathbf{c_i \geq k}$ **(Ex: k = 2)**

$$
\begin{array}{cc}
 & \text{Domains} \qquad\qquad c \\
g^0 = & \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \quad \begin{array}{c} 0 \\ \underline{2} \\ \underline{4} \\ 1 \end{array} \quad \text{Persons}
\end{array}
$$

Note

Includes both union ($k = 1$) and intersection ($k = d$)

Identification – The problem empirically

***k* =**	**H**
Union 1	91.2%
2	75.5%
3	54.4%
4	33.3%
5	16.5%
6	6.3%
7	1.5%
8	0.2%
9	0.0%
Inters. 10	0.0%

Poverty in India for 10 dimensions:

91% of population would be targeted using union,

0% using intersection

Need something in the middle.

(Alkire and Seth 2009)

Create Censored Deprivation Matrix

Censor data of nonpoor

Domains

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \qquad c = \begin{matrix} 0 \\ \underline{2} \\ \underline{4} \\ 1 \end{matrix}$$

Persons

Censored Deprivation Matrix

Censor data of nonpoor

Domains $\qquad c(k)$

$$g^0(k) = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix} \qquad \begin{matrix} 0 \\ \underline{2} \\ \underline{4} \\ 0 \end{matrix} \qquad \text{Persons}$$

Aggregation – Headcount Ratio

Domains $\qquad c(k)$

$$g^0(k) = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix} \qquad \begin{matrix} 0 \\ \underline{2} \\ \underline{4} \\ 0 \end{matrix}$$

Persons

Aggregation – Headcount Ratio

Domains $\qquad$ $c(k)$

$$g^0(k) = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix} \quad \begin{matrix} 0 \\ \underline{2} \\ \underline{4} \\ 0 \end{matrix}$$

Persons

Two poor persons out of four: **H = 1/2**

Aggregation – Intensity (A)

Need to augment information deprivation shares among poor

	Domains				$c(k)$	$c(k)/d$	
$g^0(k) =$	0	0	0	0	0		Persons
	0	1	0	1	<u>2</u>	2 / 4	
	1	1	1	1	<u>4</u>	4 / 4	
	0	0	0	0	0		

Aggregation – Intensity (A)

Need to augment information   deprivation shares among poor

	Domains				$c(k)$	$c(k)/d$	
$g^0(k) =$	0	0	0	0	0		
	0	1	0	1	<u>2</u>	2 / 4	Persons
	1	1	1	1	<u>4</u>	4 / 4	
	0	0	0	0	0		

A = average deprivation share among poor = 3/4

Aggregation – Adjusted Headcount Ratio

Adjusted Headcount Ratio = M_0 = HA

Domains $\qquad c(k) \qquad c(k)/d$

$$g^0(k) = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix} \quad \begin{matrix} 0 \\ \underline{2} \\ \underline{4} \\ 0 \end{matrix} \quad \begin{matrix} \\ 2/4 \\ 4/4 \\ \end{matrix}$$

Persons

A = average deprivation share among poor = 3/4

Aggregation – Adjusted Headcount Ratio

Adjusted Headcount Ratio = M_0 = HA = $\mu(g^0(k))$

Domains $\quad c(k) \quad c(k)/d$

$$g^0(k) = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix} \quad \begin{matrix} 0 & \\ \underline{2} & 2/4 \\ \underline{4} & 4/4 \\ 0 & \end{matrix}$$

Persons

A = average deprivation share among poor = 3/4

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Aggregation – Adjusted Headcount Ratio

Adjusted Headcount Ratio = M_0 = HA = $\mu(g^0(k))$ = 6/16 = .375

	Domains				$c(k)$	$c(k)/d$	
$g^0(k) =$	0	0	0	0	0		
	0	1	0	1	2	2 / 4	Persons
	1	1	1	1	4	4 / 4	
	0	0	0	0	0		

A = average deprivation share among poor = 3/4

Aggregation – Adjusted Headcount Ratio

Adjusted Headcount Ratio = M_0 = HA = $\boldsymbol{\mu(g^0(k))}$ **= 7/16 = 0.44**

Domains $\quad c(k) \quad c(k)/d$

$$g^0(k) = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix} \cdots\cdots \begin{matrix} 0 \\ \underline{3} \ldots 3/4 \\ \underline{4} \ldots 4/4 \\ 0 \end{matrix}$$

Persons

A = average deprivation share among poor = 3/4

Note: if person 2 has an additional deprivation, M_0 rises

Satisfies dimensional monotonicity

Aggregation: Adjusted FGT Family

Adjusted FGT is $M_\alpha = \mu(g^\alpha(\tau))$ for $\alpha \geq 0$

Domains

$$g^\alpha(k) = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0.42^\alpha & 0 & 1^\alpha \\ 0.04^\alpha & 0.17^\alpha & 0.67^\alpha & 1^\alpha \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Persons

Theorem 1 For any given weighting vector and cutoffs, the methodology $M_{k\alpha} = (\rho_k, M_\alpha)$ satisfies: decomposability, replication invariance, symmetry, poverty and deprivation focus, weak and dimensional monotonicity, nontriviality, normalisation, and weak rearrangement for $\alpha \geq 0$; monotonicity for $\alpha > 0$; and weak transfer for $\alpha \geq 1$.

Extension – General Weights

Modifying for weights: identification and aggregation (technically weights need not be the same, but conceptually probably should be)

- Use the g_0 or g_1 matrix
- Choose relative weights for each dimension w_d
- Apply the weights (sum = d) to the matrix
- c_k now reflects the *weighted sum* of the dimensions.
- Set cutoff k across the weighted sum.
- Censor data as before to create $g_0(k)$ or $g_1(k)$
- Measures are *still* the mean of the matrix.

Example: Weights

Domains

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix}$$

Persons

Matrix of deprivations

Weighting vector $\omega = \quad (.5 \quad 2 \quad 1 \quad .5)$

Example: Weights

Domains

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 2 & 0 & .5 \\ .5 & 2 & 1 & .5 \\ 0 & 2 & 0 & 0 \end{bmatrix}$$

Persons

Matrix of deprivations

Weighting vector ω = **(.5 2 1 .5)**

Weighted Deprivation Matrix

Note that we use the same notation as for the deprivation matrix on purpose.

Where

- $g_{ij}^{0} = w_j$ if $x_{ij} < z_j$ (deprived)
- $g_{ij}^{0} = 0$ if $x_{ij} \geq z_j$ (non-deprived)

- Or equivalently:

$$g_{ij}^{0} = w_j \left(\frac{z_j - x_{ij}}{z_j} \right)^{0}$$

$$g^{0} = \begin{bmatrix} g_{11}^{0} & \cdots & g_{1d}^{0} \\ g_{21}^{0} & \cdots & g_{2d}^{0} \\ \cdots & & \\ & & \cdots \\ g_{n1}^{0} & \cdots & g_{nd}^{0} \end{bmatrix}$$

$$z = (z_1, z_2, \ldots\ldots, z_d)$$

$$w = (w_1, w_2, \ldots\ldots, w_d)$$

AF Method: Decompositions

By Population Subgroup

- M_0 Poverty
- H Headcount
- A Intensity

Post-identification: By Dimension

- Censored Headcount (column vector)
- Percentage Contribution (weighted)

All draw on <u>censored</u> matrix

Informal Glossary of Terms

Deprivation: if $y_{id} < z$ person i is **deprived** in y_d

Poverty: if $c_i \leq k$ person i is poor.

Deprivation cutoffs: the z cutoffs for each dimension

Poverty cutoff: the overall cutoff k

Dimension: for AF – a column in the matrix having its own deprivation cutoff (sometimes called an 'indicator')

Joint distribution: showing the simultaneous or coupled deprivations a person/hh has

Deprivation Count Vector

Where the 'deprivation count' or score for each person is the sum of her weighted deprivations

- $c_i = g_{i1} + ... + g_{id}$

$$c = \begin{bmatrix} c_1 \\ c_2 \\ \\ \\ c_n \end{bmatrix}$$

Identify the poor

Given a poverty cut-off k, we compare the deprivation count with the k cutoff and then censor the deprivations of those who were not identified as poor.

$$\rho_k(x_i;z)=1 \quad \text{if} \quad c_i \geq k \quad poor$$
$$\rho_k(x_i;z)=0 \quad \text{if} \quad c_i < k \quad non-poor$$

$$c = \begin{bmatrix} c_1 \\ c_2 \\ \\ \\ c_n \end{bmatrix}$$

Key point: Deprivation and Censored Matrix

$g^0(k)$ needed for associated partial indices

Deprivation Matrix

$$g^0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 2 \\ 4 \\ 1 \end{bmatrix}$$

$\Longrightarrow$

Censored Deprivation Matrix, k=2

$$g^0(k) = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix} \quad \begin{bmatrix} 0 \\ 2 \\ 4 \\ 0 \end{bmatrix}$$

Headcount Ratio of MD Poverty

It is the proportion of people who have been identified as poor. Thus:

$$H = \frac{\sum_{i=1}^{n} \rho_k(x_i; z)}{n} = \frac{q}{n}$$

Where q is the number of poor people.

Headcount Ratio is sometimes called the ***incidence*** of poverty, or the poverty rate.

Intensity (or breadth) of MD Poverty

- It is the average proportion of deprivations in which the poor are deprived.

$$A = \frac{\sum_{i=1}^{n} c_i(k)}{dq}$$

Note that it is simple to compute:

1) You compute the proportion of total deprivations each poor person has ($c_i(k)/d$). Note we need to use the censored deprivation count vector, ie: we ignore the deprivations of the non-poor.
2) You take the average of those proportions (that's why we divide by q, the number of the poor)

Multidimensional Poverty: M_0

(Adjusted Headcount Ratio)

- It is the product of incidence and intensity.

$$M_0 = H * A$$

- Or equivalently, it is the mean of the censored (weighted) deprivation matrix:

$$M_0 = \mu(g^0(k)) = \frac{\sum_{i=1}^{n}\sum_{j=1}^{d} g_{ij}^0(k)}{nd}$$

How do we interpret M_0?

- M_0 Interpretation

  M_0 is the mean of the weighted censored deprivation matrix.

  Thus, **it gives the proportion of weighted deprivations that the poor experience in a society of all the total potential deprivations that the society could experience**.

How do we decompose M_0 by Indicators?

There are two useful but distinct indicators to look at:

1) Censored headcount ratios
2) Contributions by indicators and dimensions.

Censored Headcount Ratios

- **Censored headcount ratios are the % of people who are poor <u>and</u> deprived in a certain indicator.**
- Careful! Censored headcounts **<u>are not</u>** the % of the <u>poor</u> deprived in a certain indicator.
- Raw headcount ratios are the % of people who are deprived in a certain indicator.

Censored Headcount Ratios

- They are the mean of each column of the (weighted) censored deprivation matrix divided by the indicator's weight.

$$H_j^C = \frac{\sum_{i=1}^{n} g_{ij}^0(k)}{w_j n}$$

- M_0 is the weighted sum of the censored headcount ratios.

$$M_0 = \sum_{j=1}^{d} \left(\frac{w_j}{d} \right) H_j^C$$

Raw Headcount Ratios

- These are the deprivation rates by dimension, ie. the proportion of people who are deprived in that dimension.
- It is simply the mean of each column of the [uncensored] deprivation matrix:

$$H_j = (g^0_{1j} + g^0_{2j} + \ldots + g^0_{nj}) / n$$

Contribution by Indicator and Dimension

- It is the proportion of total poverty which arises from a particular deprivation.
- Recall from the previous slide:

$$M_0 = \sum_{j=1}^{d} \left(\frac{w_j}{d} \right) H_j^C$$

- Thus, the contribution of indicator j to overall poverty is given by:

$$C_j = \frac{(w_j / d) H_j^C}{M_0}$$

Contribution by Indicator and Dimension

- Note: The sum of the contributions of all d indicators needs to add up to 1 (or 100%).
- The percentage contribution includes the **weight** on each indicator, and is useful when the weights are not equal.
- If there are more than one indicators in a dimension, the dimensional contribution is simply the sum of the indicators' contribution.

How do we decompose M_0 by population subgroups?

Visually…

GROUP A

Peo	Ye. Ed	Child Attend.	Nutr	Mor	Elec	Wat	Sani	Floor	Cook. Fuel	Assets	Depr. Count
1	1.67	1.67	0	0	0	0.56	0	0.56	0	0	4.44
2	0	0	1.67	1.67	0	0	0	0	0	0	3.33
3	0	0	0	0	0.56	0.56	0.56	0.56	0.56	0.56	3.33
4	1.67	0	0	1.67	0.56	0.00	0.56	0	0.56	0	5
5	0	0	0	0	0	0	0	0	0	0	0

GROUP B

Decomposition by Population Subgroups

If the entire population X (of size n) is divided into two subgroups X_1 (of size n_1) and X_2 (of size n_2), then overall M_0 is the weighted sum of M_0 in each subgroup:

$$M_0(X;z) = \left(\frac{n_1}{n}\right) M_0(X_1;z) + \left(\frac{n_2}{n}\right) M_0(X_2;z)$$

Thus, the contribution of subgroup *i* to overall poverty is

$$C_{Gi} = \frac{(n_i/n)\,M_0(X_i;z)}{M_0(X;z)}$$

Decomposition by Population Subgroups

- Note that the sum of the contributions of all groups needs to add up to 1 (or 100%).
- You take the mean of the matrices of each population subgroup individually.
- The population-weighted mean of subgroups is equal to the national M_0.