اللجنة الاقتصادية والاجتماعية لغربي آسيا

Optimization Model Development for Poverty Reduction

Work done by ESCWA and consultant (Majd OLLEIK)

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Description of the mathematical formulation

- Objective function: Minimize total efforts across all active indicators:
  - $min \sum_J E_j$

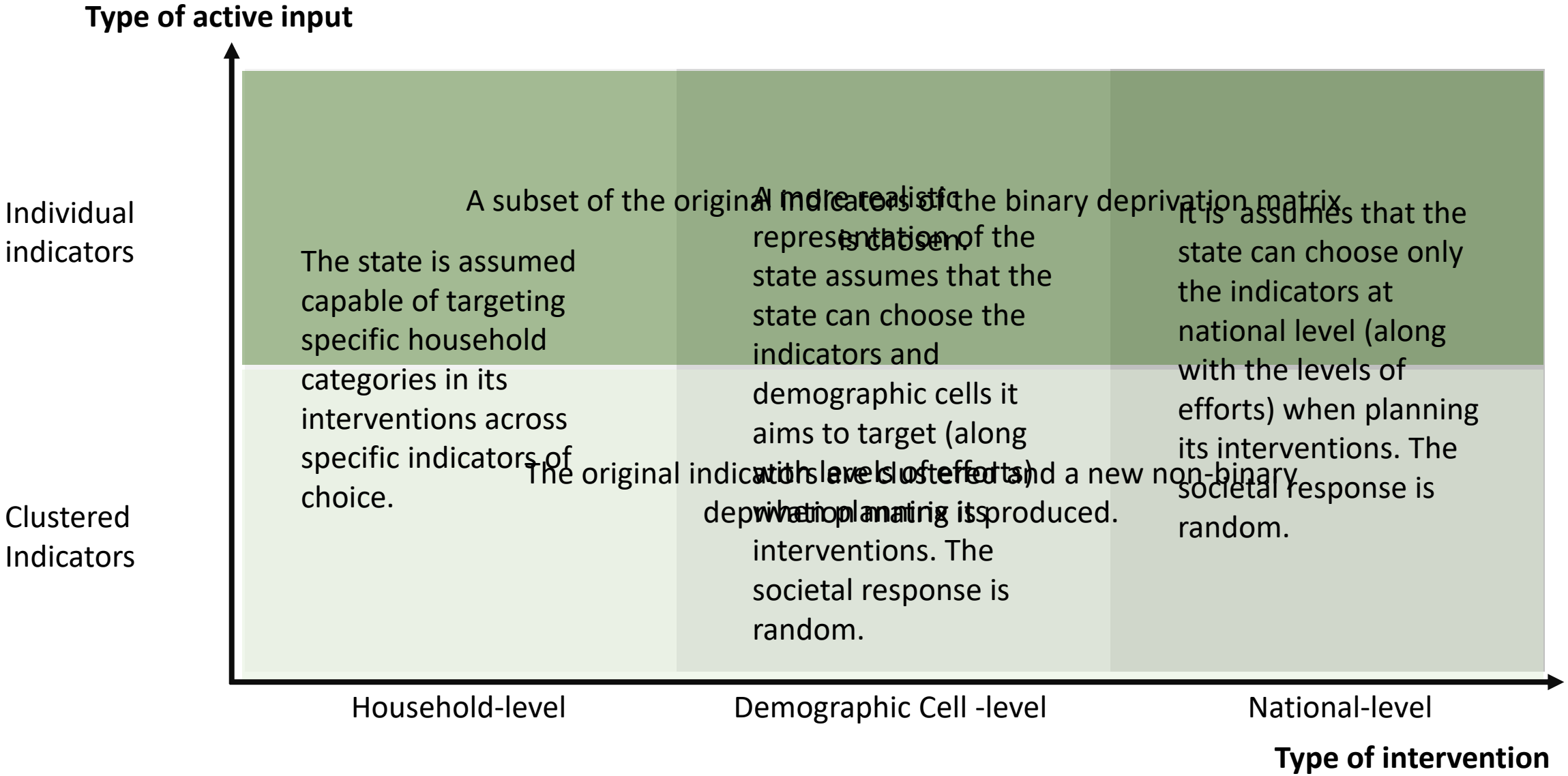
- Constraints:
  1. Each element of the new deprivation matrix is at most the corresponding element in the old deprivation matrix. This implies that the deprivations are only reduced and cannot be increased.
  2. If after optimization a household category is poor, then it will contribute to the resulting MPI (according to the AF method rules and axioms). If after optimization a household category is not poor, then its contribution to the resulting MPI is 0.
  3. The total effort per indicator must be within the minimum and maximum values. (Input 1, efforts by indicator)
  4. The resulting MPI must be at most equal to the preset target MPI. (Input 2, MPI setting target). The resultant MPI is the sum of the contributions to the MPI of all households.

  The above optimization model is linear as the objective function and constraints are linear (after linearizing the logical constraints) with respect to the decision variables

Assumptions

1. The indicators that will be used in optimization are assumed to be independent.
2. For each indicator, the policy maker is able to specify a measure of effort required to remove a single household from deprivation.
3. The overall goal is to reach a preset target MPI (lower than the existing MPI) while minimizing the total effort.
4. The optimization model generates:
    a. Total effort required per indicator
    b. Total effort per demographic cell and per indicator
    c. A delta deprivation matrix (between the new matrix and the original matrix) that can be analyzed to infer where effort should be focused

Optimization models – along two levels



Example of indicators vs. clustered indicators

Original deprivation matrix

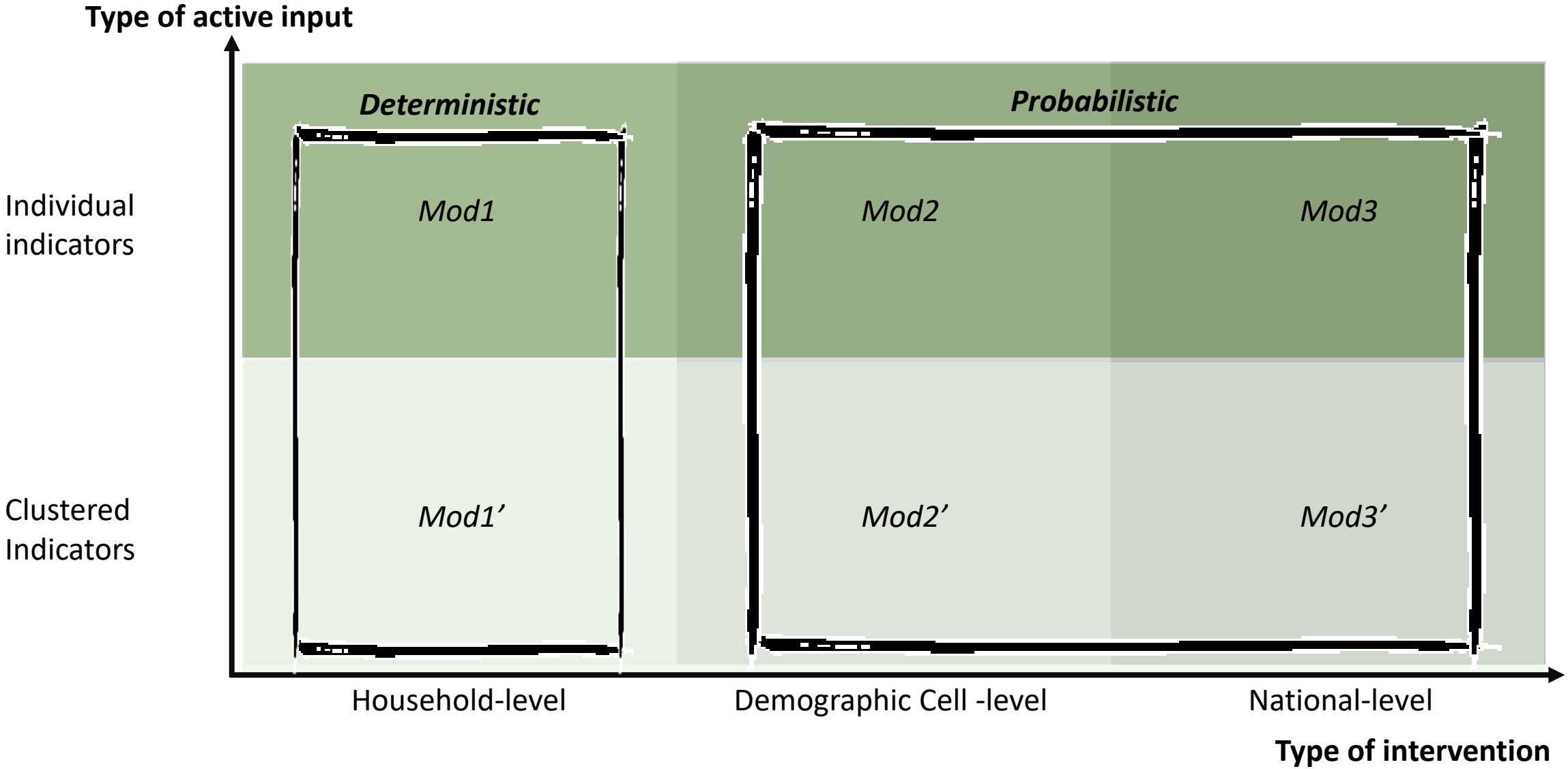
Household	Indicator 1	Indicator 2	Indicator 3	Indicator 4
1	1	0	0	1
2	1	0	0	0
3	1	1	1	1
Weights	*0.25*	*0.25*	*0.25*	*0.25*

Household	***Clustered indicator 1***	***Clustered indicator 2***
1	1	1
2	1	0
3	2	2
Weights	*0.25*	*0.25*

Clustered indicators are assumed:

- Externally fully independent
- Composed of internally fully dependent indicators

Six optimization models



Input parameters

Input variables	Description
$\boldsymbol{I}$	Set of households
$\boldsymbol{J}$	set of (clustered) indicators
$\forall j \in J, l_j$	Lower bound on the effort spent per indicator
$\forall j \in J, u_j$	Upper bound on the effort spent per indicator
$\forall j \in J, EpF_j$	Effort required to induce a flip per indicator
MPI_r	Reduction required in MPI

Output

Input variables	Description
$\forall j \in J, E_j$	Effort in the corresponding Indicator(cluster of indicators)
MPI_p	New MPI
Distribution of efforts by Indicator and by demographic unit	

Application on Lebanon – Survey 2019, target setting MPI reduction for the year 2025

Data inputs [1/2]

- Binary deprivation matrix, 2019 survey:
  - 38,929 Households and 20 Indicators
  - Each Household is characterized by a household size and by demographic information (governorate).
- Indicators belong to six dimensions.
- Each dimension is equally weighted (in terms of contribution to the MPI) and each indicator within a dimension is equally weighted.
- The poverty cut-off is 0.17.

2019 – MPI results

MPI	**0.112**
H	0.411
A	0.273

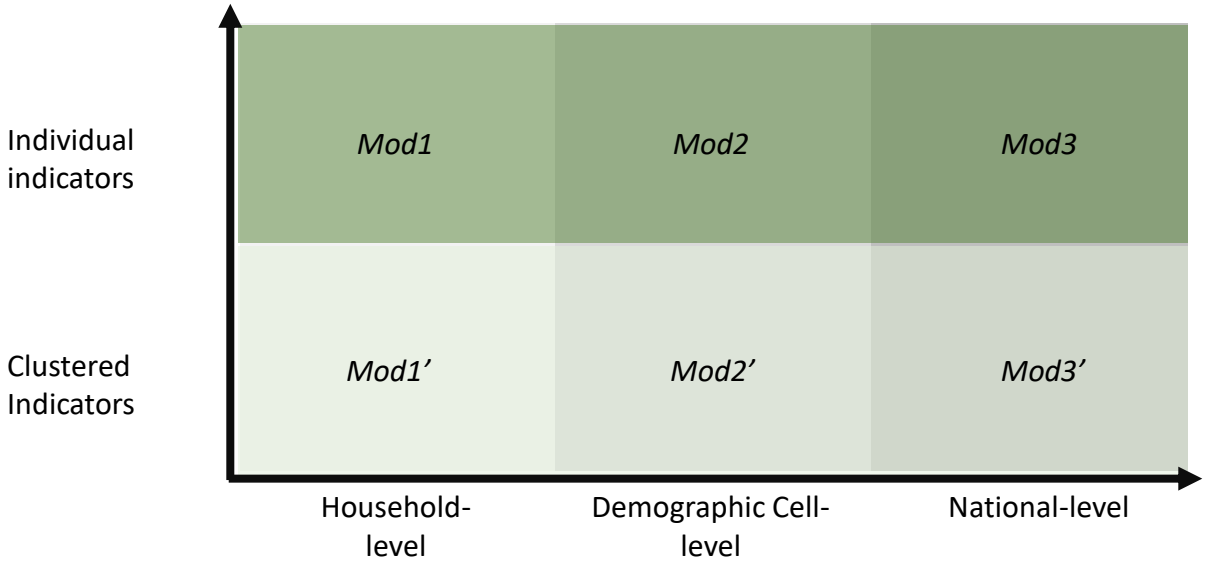
Indicator	% contribution to MPI	Indicator	% contribution to MPI
LF04 - Health Insurance	16.01%	LF02 - Educational Attainment	4.05%
LF20 - Income (2019) - 368,000LL	13.90%	LF06 - Access to Medical Services	3.62%
LF14 - Internet Access and ICT	10.86%	LF08 - Drinking Water	3.27%
LF01 - Access to Education	9.24%	LF17 - Heating devices	2.33%
LF11 - Overcrowding rate	6.27%	LF12 - Housing type	1.62%
LF09 - Sanitation	6.24%	LF15 - Means of transport	1.41%
LF03 - School Attendance	5.30%	LF19 - Employment Informality (ALL)	1.38%
LF05 - Access to Medicines	4.57%	LF10 - Waste Collection	1.24%
LF07 - Electricity	4.46%	LF13 - Having a toilet	0.15%
LF18 - Employment deprivation	4.06%	LF16 - Household electrical devices	0.02%

Additional assumed input parameters

- Desired reduction in MPI: 20%

- For Mod1, Mod2, Mod 3:
  - Active individual indicators
  - Measure of effort per flip per active indicator

- For Mod1’, Mod2’ and Mod3’:
  - Active clustered indicators (*dimensions*)
  - Measure of effort per flip per active clustered indicator (*dimension*)



Active individual indicators (Mod1, Mod2, Mod3)

- Contribute to 50.02% of MPI
- Removing deprivation in them reduces MPI by 79%

Indicator	% contribution to MPI	Indicator	% contribution to MPI
Ind2: Health Insurance	16.01%	Educational Attainment	4.05%
Ind20: Income (2019)	13.90%	Access to Medical Services	3.62%
Ind18: Internet Access and ICT	10.86%	Drinking Water	3.27%
Ind13: Access to Education	9.24%	Heating devices	2.33%
Overcrowding rate	6.27%	Housing type	1.62%
Sanitation	6.24%	Means of transport	1.41%
School Attendance	5.30%	Employment Informality (ALL)	1.38%
Access to Medicines	4.57%	Waste Collection	1.24%
Electricity	4.46%	Having a toilet	0.15%
Employment deprivation	4.06%	Household electrical devices	0.02%

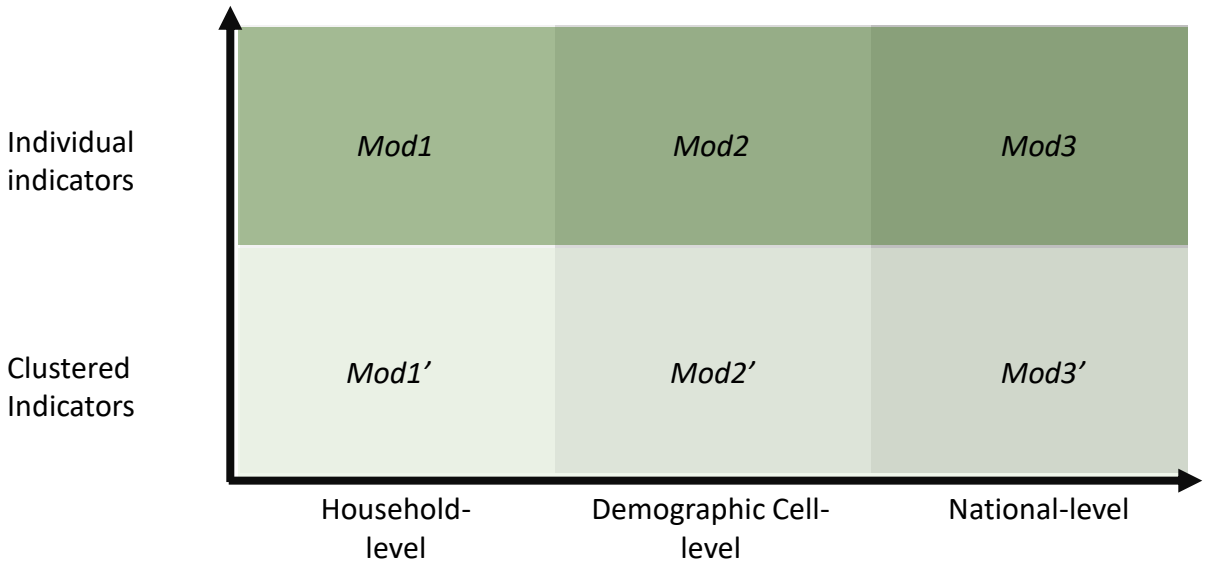
Effort per flip (*EpF*)

For Mod1, Mod2 and Mod3

Individual indicator	***EpF***
Ind2: Health Insurance	6
Ind13: Access to Education	5
Ind18: Internet Access and ICT	3
Ind20: Income (2019)	6

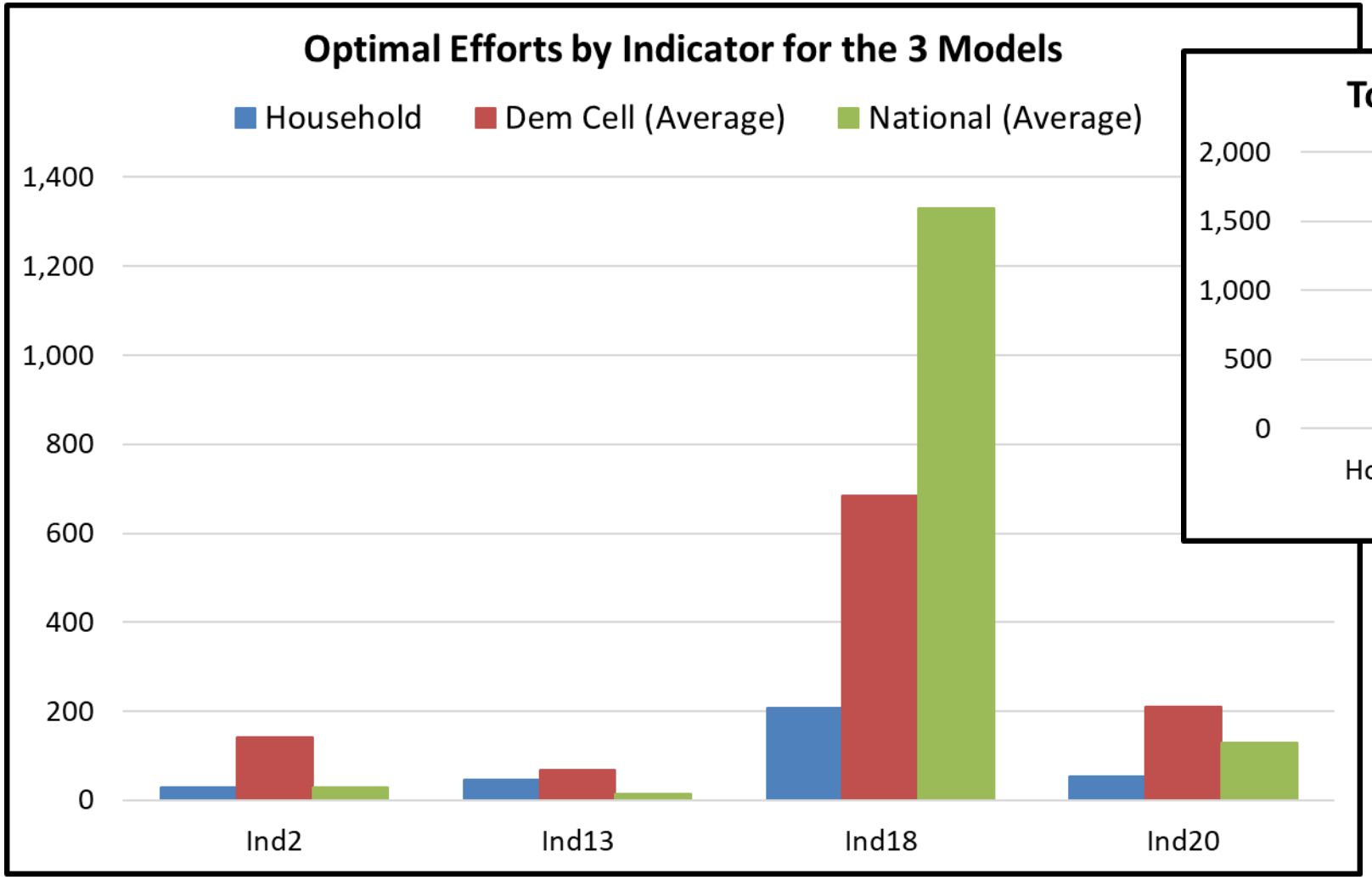
For Mod1', Mod2' and Mod3'

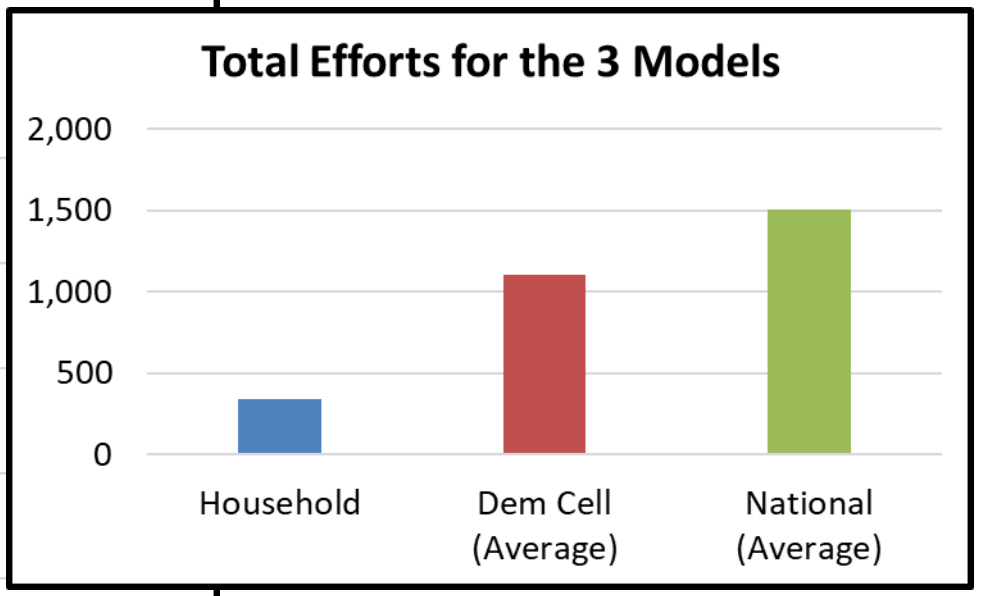
Dimensions	***EpF***
Dim1: Health	6
Dim2: Education	5
Dim5: ICT and Appliances	3
Dim6: Employment and Income	6



Results for Individual Indicators (year 2025)

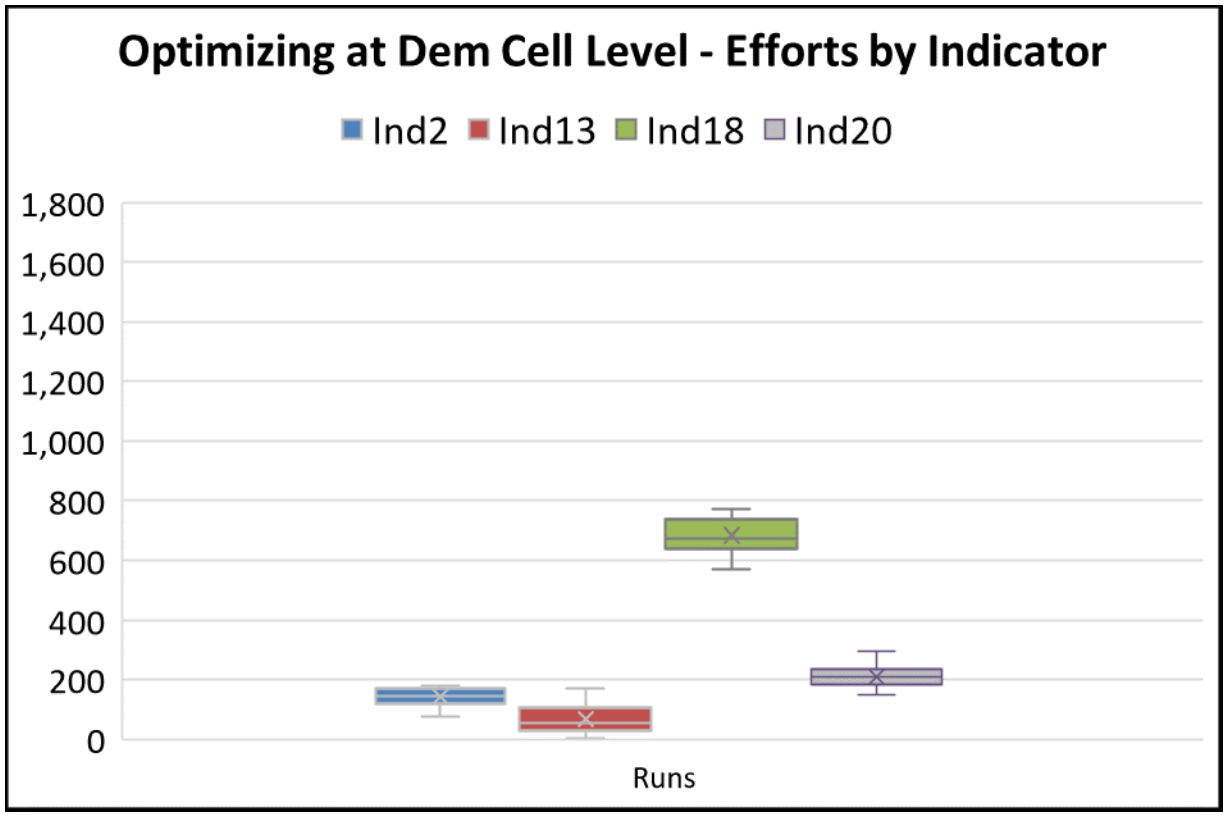
Comparison of Results – Three Models

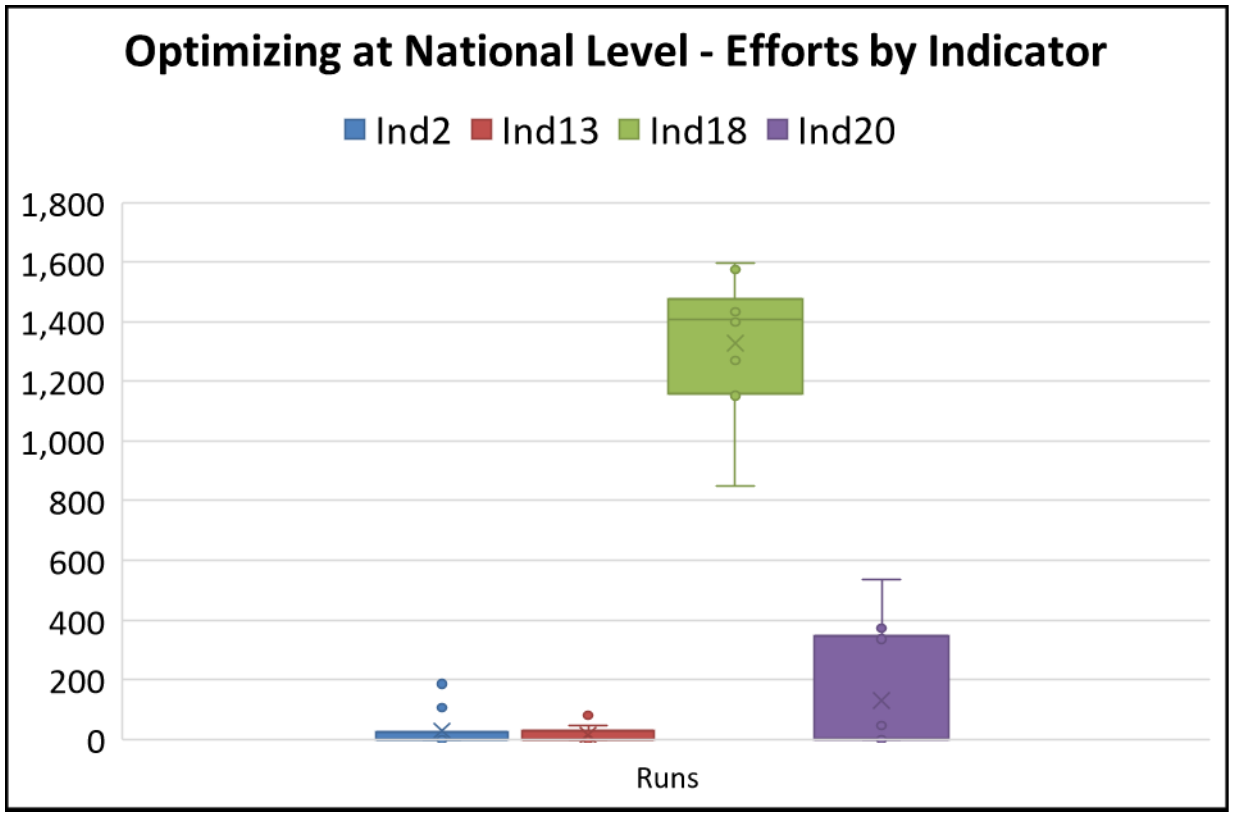




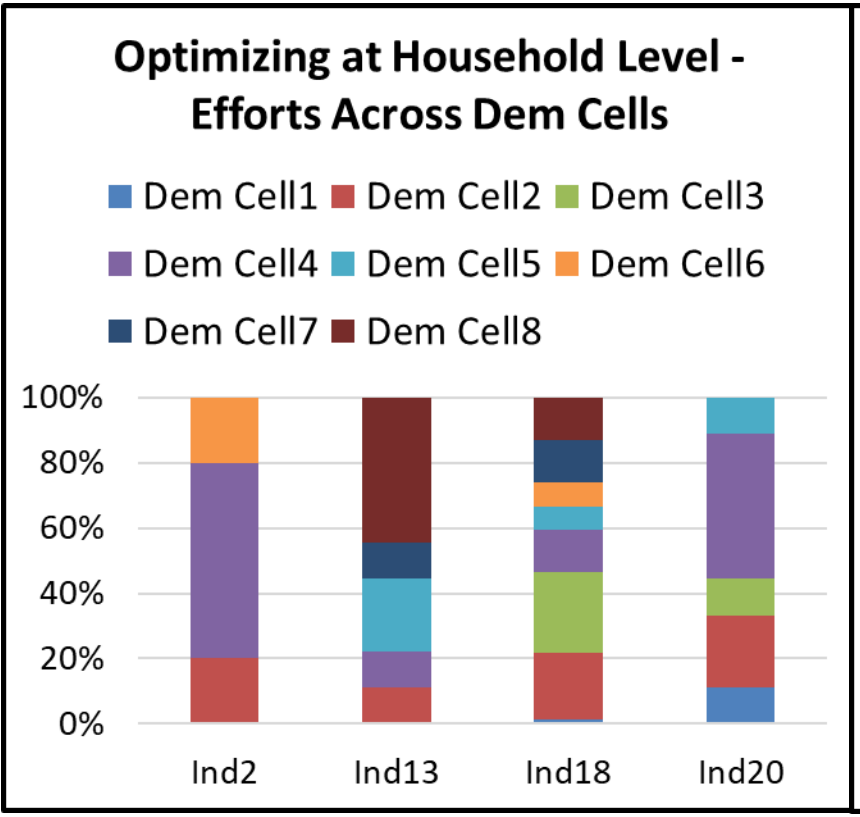
Individual indicator	*EpF*
Ind2: Health Insurance	6
Ind13: Access to Education	5
Ind18: Internet Access and ICT	3
Ind20: Income (2019)	6

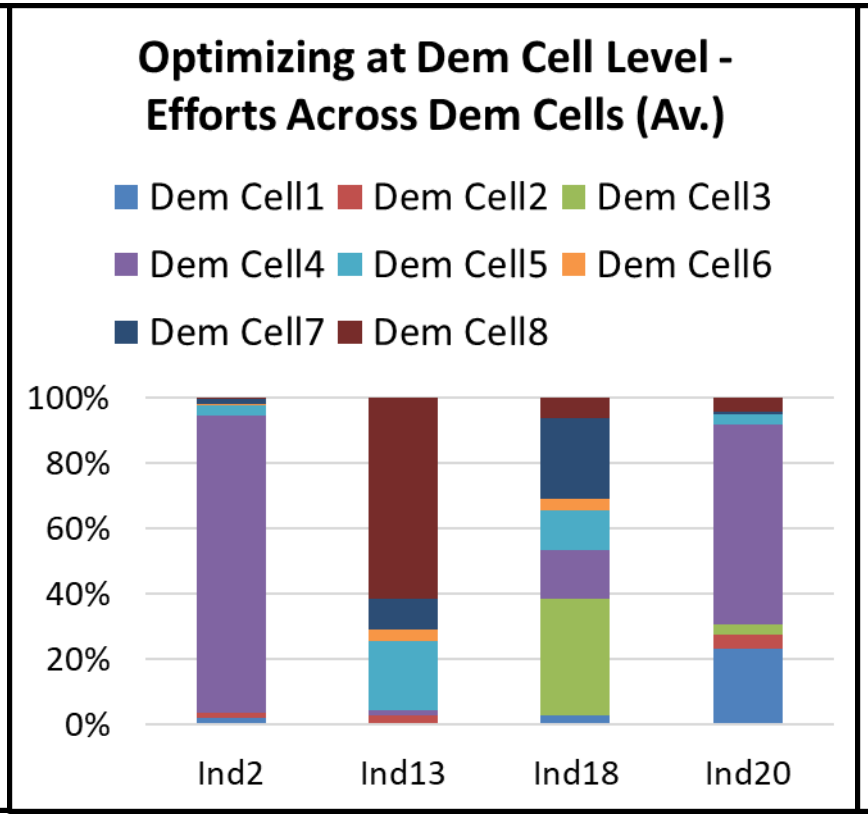
Comparison of Results – Spread of Efforts by Indicator over the Different Runs

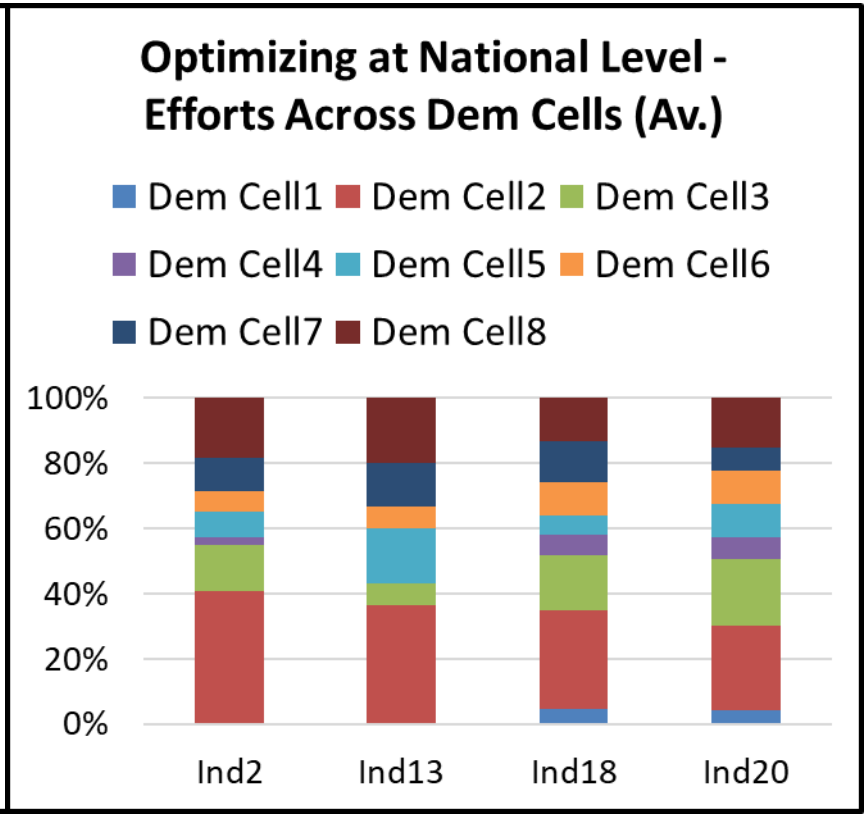




Comparison of Results – Distribution of Effort by Demographic Cell







Conclusions

1. We presented 6 theoretical optimization models for MPI reduction.
    1. Mod1:
        - Targets individual households
        - Is very efficient
        - Yet is unrealistic => main value is to calculate a lower bound on effort and to check how efficient are other solutions.
    2. Mod2:
        - Targets indicators and demographic cells
        - Is practical and realistic
        - Provides solid solutions despite random societal response
    3. Mod3:
        - Targets indicators at national level
        - Is practical and realistic
        - Is less efficient than Mod2 but might be resorted to if focusing on demographic cell is not possible
    4. Mod1', Mod2' and Mod3' are variants of the previous models that consider a novel non-binary deprivation matrix that should be carefully studied.

Thank you