Ranking Karnataka Districts by the Multidimensional Poverty Index (MPI) and by Applying Simple Elements of Partial Order Theory

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Outline

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- The Multidimensional Poverty Index (MPI)
- The State of Karnataka
- Data, software
- Alkire and Foster Approach
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Goal of study

- We focus on the Multidimensional Poverty Index (MPI) ranking
- The standard ranking process of the MPI produces a single total (linear) rank of units by simply ordering them from the best to the worst (or the inverse) as function of their MPI score
- However, units are not necessarily comparable regarding all 10 indicators simultaneously on which the MPI is based
- The aggregation process leading to the MPI hides the individual role of indicators
- By using partial order theory (i.e. the Hasse Diagram technique), we analyze comparabilities and incomparabilities
- Specifically, we dealt with local partial order, average height and antichain analysis

MPI

- The MPI is based on Sen's capability approach (1981, 1987, 1999)
- Includes three dimensions: education, health, and standard of living with a total of 10 indicators (nutrition, child mortality, years of schooling, children enrolled, cooking fuel, toilet, drinking water, electricity, floor, and assets)
- The statistical methodology of the MPI is the Alkire and Foster's counting approach (2007, rev. 2008), and its application consists of identifying who is 'multidimensionally poor' and of computing some poverty statistics including the headcount ratio, the intensity of multidimensional poverty

Karnataka

- Karnataka is one of the 29 states and 7 union territories of India, located at the south of the country
- Its capital is Bangalore which is the economic center of Karnataka (e.g. domestic and international investments in technology and research)
- But, agriculture remains an important sector with nearly half (49.94%) of the economically active population
- Imbalances within Karnataka are quite pronounced

DATA, SOFTWARE

- 2012/13 India DLHS (District Level Household Survey) wave four
- The indicators for the construction of the MPI comes mainly from the household questionnaire
- DLHS-4 surveyed a total of 1850 primary sampling units covering 47,200 households with 90.8 percent response rate
- 30 districts (e.g. Kodagu (KOD))
- Software package: PyHasse which has been developed by R. Bruggemann since 2007 (see www.pyHasse.org)

Alkire and Foster (AF) Approach

- The AF method handles with binary, categorical variables
- It is characterized by the dual cutoff (*intermediate threshold*) process
- Firstly, the first cutoff (called as *deprivation line*) serves to decide who is deprived or not regarding each functioning; for instance, if a unit is deprived or not in terms of educational attainment
- Secondly, the total number of deprivations is counted for each unit
- Thirdly, poor people are identified thanks to the second cutoff (called as *poverty line*) which is settled by researcher (or, in general 33,3%)
- The multidimensional poverty index (MPI), a composite indicator:
  - $MPI = H \times A = \frac{\sum_{i=1}^{p} c_i}{n} = \frac{\sum_{i=1}^{p} \sum_{j=1}^{10} w_j z_j}{n}$

The MPI and its components, weights

Dime-nsion	Name of variable	Content of variable	Indicator	Scale of variable (all are binary variable)	First cutoff	Weight
Education	SC	Years of schooling	No household member has completed five years of schooling	SC=1 if no member has completed five years of schooling; 0=otherwise	Household is deprived if SC==1	16.7
	CE	Child enrolled	At least one school-age child not enrolled in school	CE=1 if at least one school-age child not enrolled in school; 0= otherwise	Household is deprived if CE==1	16.7
Health	CM	Child mortality	One or more children has died in the household in last five years	CM=1, if at least one or more children has died in last 5 yrs; 0= otherwise)	Household is deprived if CM==1	16.7
	NU	Nutrition	At least one household member is malnourished	NU=1 if at least one household member is malnourished; 0 otherwise)	Household is deprived if NU==1	16.7
Living Standard	EL	Electricity	Household not having access to electricity	EL=1 if household has no electricity; 0= otherwise)	Household is deprived if EL==1	5.6
	SA	Toilet	Household not having access to adequate sanitation	SA=1 if household has no access to adequate sanitation; 0= otherwise	Household is deprived if SA==1	5.6
	DW	Water	Household not having access to safe drinking water	DW=1 if household has no access to safe drinking water; 0= otherwise	Household is deprived if DW==1	5.6
	FL	Floor	Household having home with dirt, sand or dung floor	FL=1 if dwelling has a dirty floor; 0 =otherwise	Household is deprived if FL==1	5.6
	CF	Cooking fuel	Household uses “dirty” cooking fuel (dung, firewood or charcoal)	CF=1 if household uses dung, firewood, or charcoal as cooking fuel; 0= otherwise	Household is deprived if CF==1	5.6
	AS	Assets	Household having no access to asset related to information, mobility or livelihood	AS=1 if household has no access asset relating to information, mobility or livelihood; 0 otherwise	Household is deprived if AS==1	5.6

1/3=0,333 (equal weighting across dimensions)

Then,

0,333/2=0,166=16,7%
(equal weighting within dimension)

Partial Order Methodology

- In a data matrix including several objects (e.g. countries, districts) in rows and indicators in columns, the objects of any subset (e.g. the finite set of objects $X = \{x, y, z, \dots\}$) can be ordered by a partial order relation (i.e. $\leq$), as function of their indicators values
  - a partially ordered set $P = (X, \leq)$ (called a finite *poset*)
- Antichain: a subset of elements, where the elements are mutually incomparable
- The number of pairs $(q_j, q_{j'})$ causing an incomparability of x with y is called the number of conflicts

Results: Weighted censored headcount ratios per indicator and the aggregated MPI score (in %)

- For the district BEL:
  - (i) the SC indicator score (1.475) means that in this district, 1.475% of (weighted) population is multidimensionally poor and deprived regarding the indicator SC,
  - (ii) the MPI score (8.814) means that 8.814% of the weighted population of the district BEL is multidimensionally poor

District	SC	CE	CM	NU	EL	SA	DW	FL	CF	AS	MPI
BEL	1.475	1.293	0.246	3.095	0.198	0.989	0.195	0.202	1.687	0.101	**8.814**
BID	1.668	1.493	0.255	4.386	0.172	1.498	0.221	0.608	1.531	0.241	**12.07**
BIJ	1.762	1.829	0.393	4.702	0.415	1.629	0.124	0.709	1.635	0.174	**13.37**
BNG	0.528	0.316	0.207	0.842	0.039	0.177	0.04	0.085	0.145	0.02	**2,40**
CHM	0.577	0.38	0.125	1.041	0.034	0.29	0.072	0.198	0.329	0.05	**3.096**

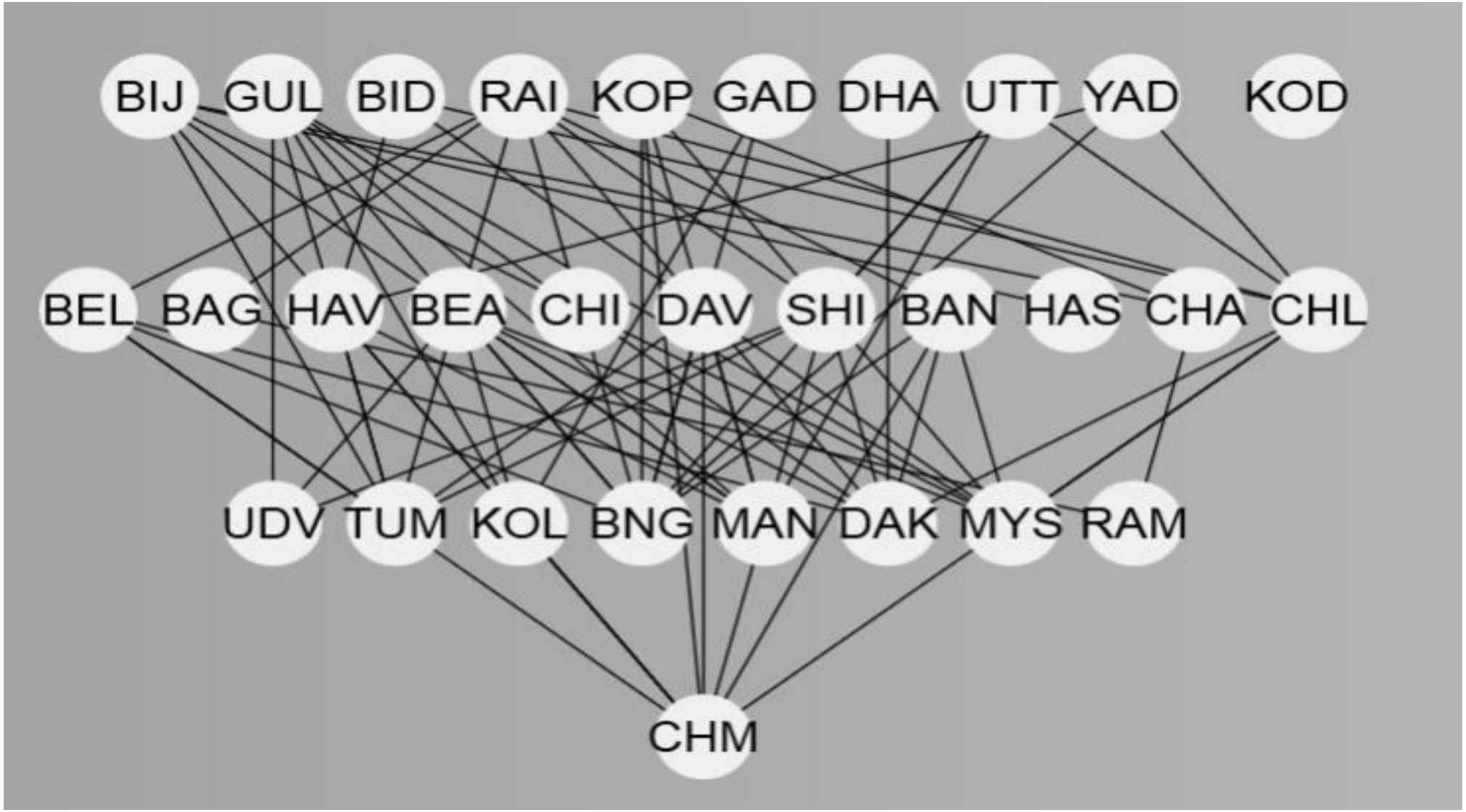
Results: Ranking of districts regarding the indicators

SC (years of schooling)
CE (child enrolled)
CM (child mortality)
NU (nutrition)
EL (electricity)
SA (toilet)
DW (drinking water)
FL (floor)
CF (cooking fuel)
AS (assets)

and the aggregated index MPI (based on weighted censored headcount ratios)

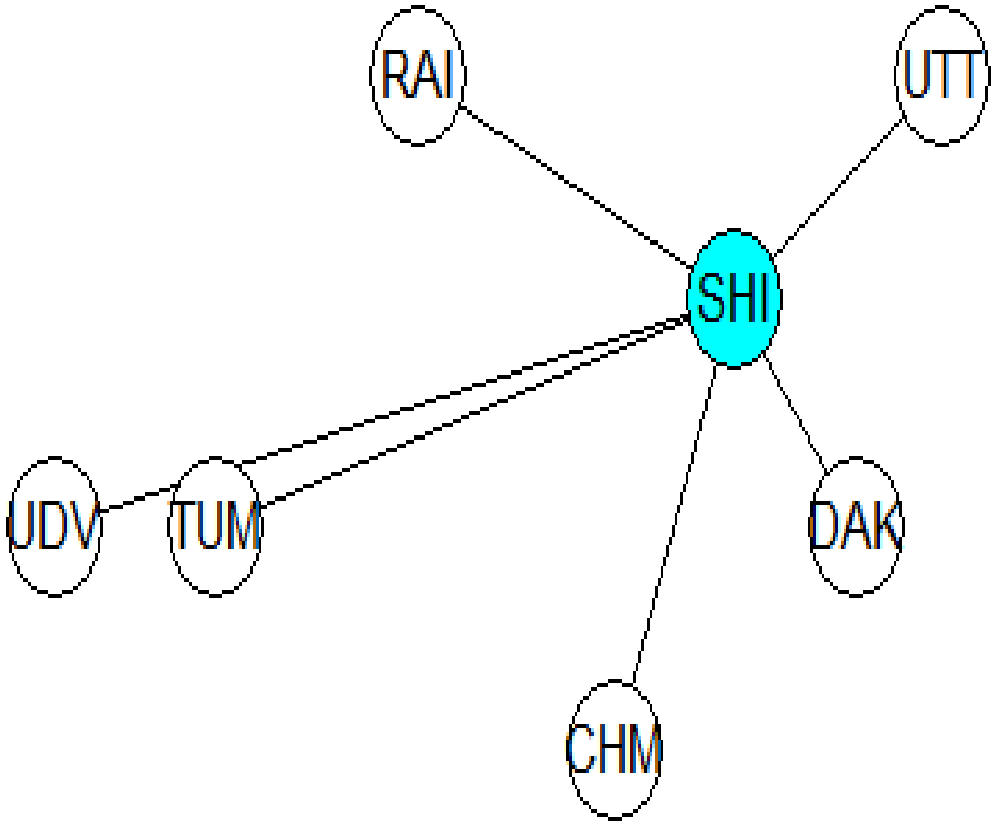
District	R_SC	R_CE	R_CM	R_NU	R_EL	R_SA	R_DW	R_FL	R_CF	R_AS	R_MPI
BAG	6	7	7	8	7	7	29	3	7	11	7
BAN	21	15	6	21	17	19	16	13	20	24	19
BEA	4	5	10	5	18	5	4	10	5	20	5
BEL	12	11	17	12	5	12	11	25	14	18	12
BID	9	8	15	7	12	8	10	7	8	1	8
BIJ	8	6	5	6	1	6	19	4	6	3	6
BNG	28	28	18	30	28	29	25	29	30	30	30
CHA	10	16	8	16	16	15	28	9	16	7	16
CHI	20	14	9	11	6	11	24	5	13	15	13
CHL	17	19	19	18	22	18	15	11	19	19	18
CHM	26	25	25	28	30	26	22	26	28	27	28
DAK	30	26	29	29	23	30	17	30	29	29	29
DAV	15	12	16	13	14	16	13	22	15	12	15
DHA	14	13	28	14	15	14	7	18	12	8	14
GAD	7	10	3	9	27	9	8	16	9	10	9
GUL	3	2	2	2	8	3	2	14	3	16	3
HAS	23	22	23	20	2	20	23	17	21	26	21
HAV	11	9	21	15	13	13	18	15	11	6	11
KOD	29	30	30	27	3	27	12	21	26	14	27
KOL	16	18	11	17	29	17	9	20	17	21	17
KOP	5	3	1	4	11	4	21	6	4	2	4
MAN	19	27	22	23	19	24	27	23	25	23	24
MYS	22	24	20	25	26	25	26	24	27	25	25
RAI	2	4	4	1	4	2	3	1	2	9	2
RAM	18	20	12	24	25	22	30	19	23	13	22
SHI	24	21	24	19	20	21	5	12	18	17	20
TUM	25	23	27	22	21	23	20	28	22	22	23
UDV	27	29	26	26	24	28	6	27	24	28	26
UTT	13	17	14	10	9	10	1	8	10	4	10
YAD	1	1	13	3	10	1	14	2	1	5	1

Results: The Hasse Diagram



Results: Local partial analysis

- For instance, RAI and UTT (RAI ‖ UTT): The kind of poverty is specific for RAI and for UTT.
  - (i) RAI > UTT with respect to years of schooling, child enrolled, child mortality, nutrition, electricity, toilet, floor, cooking fuel
  - (ii) RAI < UTT with respect to drinking water, assets
- Contextually, RAI has a high degree of poverty with respect to 8 of 10 indicators; whereas, for UTT 2 of 10 indicators are describing those aspects of poverty where UTT has problems in comparison to RAI



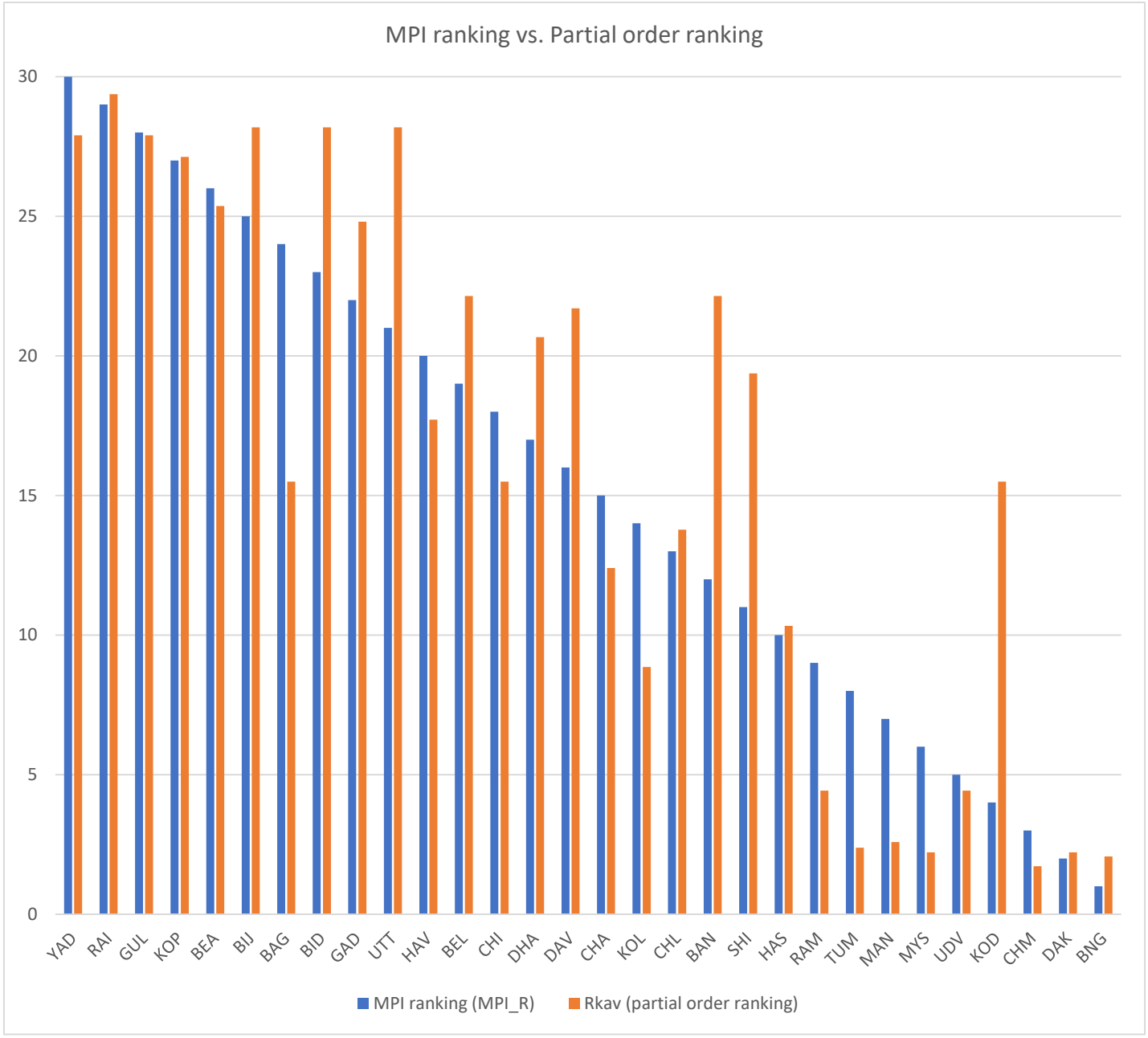
Results: Partial order ranking by average heights of districts

- The top 6 elements are RAI, BIJ, BID, UTT, YAD, and the least element is CHM
- Therefore, based on Rkav, the richest district is CHM and the poorest district is RAI
- The districts BIJ, BID and UTT are equivalent with respect to their average height. The reason is that all these three districts 'see' the same number of elements in their downsets
- The results of LPOM0 (Rkav) ranking is different than those of the linear MPI ranking (MPI_R). For instance, regarding the Rkav, the poorest district is RAI and the richest district is CHM, but regarding the MPI ranking the district YAD is the poorest and the district BNG is the richest

District	MPI ranking (MPI_R)	Rkav (partial order ranking)	Incomparable districts	Comparable districts	$\lvert O(x) \rvert$ (downset)
YAD	30	27.9	21	8	9
RAI	29	29.368	12	17	18
GUL	28	27.9	21	8	9
KOP	27	27.125	23	6	7
BEA	26	25.364	20	9	9
BIJ	25	28.182	20	9	10

Results: MPI ranking vs. Partial order ranking

- Particularly, for the districts from BIJ to KOD the difference between Rkav and MPI_R becomes more important
- Because of incomparabilities, for the most of our sample, the MPI ranking does not provide an adequate rank
- Based on these findings, the Rkav ranking process can be considered as an important tool for testing the robustness of the MPI ranking; notably, to find out the districts in ambiguous ranking situation



Anti chain analysis

- The delta values, describing the numerical differences in the [0,1]-normalized indicator values of two objects of interest, are defined as follows:

(x, y) with $x \parallel q_i, q_j\ y$: $delta1 = q_i(x) - q_i(y), delta2 = q_j(x) - q_j(y)$

where $x \parallel y$ is valid, when the sign of delta1 is different than the sign of delta2

- 6 of 13 pairs, namely (GUL, YAD), (BIJ, GUL), (BIJ,YAD), (GUL, KOP), (RAI, KOP) (UTT,YAD), have more than 20 conflicts with the indicator pairs having at the same time *pronounced* numerical differences (i.e. when the absolute delta values are larger than the arbitrary limiting value 0.4)
- Seven pairs of districts out of the 13 pairs such as the pair (RAI, YAD), they do not have any numerically relevant conflicting indicator pairs

Results: Anti chain analysis (Cont'd)

- So, how to deal with incomparabilities? For this purpose, we answer the following questions:
- Let x, y be two districts with $x \parallel y$. Which pair of districts (x, y) has a more 'intense' incomparability?
- Which pair of indicators are most involved in the incomparabilities?

Districts (x,y)	Conflicting indicators	Delta1, Delta2
GUL-YAD	(drinking water, floor)	(0,691, -0,427)
BIJ-GUL	(child enrolled, electricity)	(-0,418, 0,596)
BIJ-GUL	(electricity, drinking water)	(0,596, -0,757)
BIJ-YAD	(years of schooling, electricity)	(-0,624, 0,614)
BIJ-YAD	(child enrolled, electricity)	(-0,578, 0,614)
GUL-KOP	(drinking water, assets)	(0,822, -0,548)
RAI-KOP	(drinking water, assets)	(0,622,-0,457)
UTT-YAD	(years of schooling, drinking water)	(-0,728, 0,792)
UTT-YAD	(child enrolled, drinking water)	(-0,728, 0,792)
UTT-YAD	(nutrition, drinking water)	(-0,897, 0,792)
UTT-YAD	(toilet, drinking water)	(-0,443, 0,792)
UTT-YAD	(drinking water, cooking fuel)	(-0,526, 0,792)

Conclusion

- We obtain a Hasse diagram which is neither composed of a complete antichain nor a complete chain:
  - ❑ the number of incomparabilities exceeds greatly the number of comparabilities (328 vs. 107)
- The Hasse Diagram shows that poverty is a multidimensional phenomenon:
  - ❑ each district has its specific capability deficits. They need their own and specific poverty reduction management plans
- There is no district having the best score in all indicators simultaneously
- MPI ranking:
  - ❑ one best district: BNG
  - ❑ the poorest district is YAD
- The Hasse Diagram:
  - ❑ several districts (e.g. BIJ, GUL, BID, RAI, KOP, GAD, DHA, UTT, YAD, KOD) occupy a similar level of maximal poverty, but without showing same poverty structure (no equivalent elements)
- Rkav ranking:
  - ❑ the poorest district: RAI
  - ❑ the richest district: CHM
- The multidimensional poverty structure (i.e. types of deprivation among multidimensionally poor people) in the state of Karnataka varies across its districts highlighting the complex nature of poverty configurations:
  - ❑ we suggest that the Hasse Diagram technique can be used as a robustness tool that complements the standard ranking process of the MPI

MANY THANKS FOR YOUR KIND ATTENTION!