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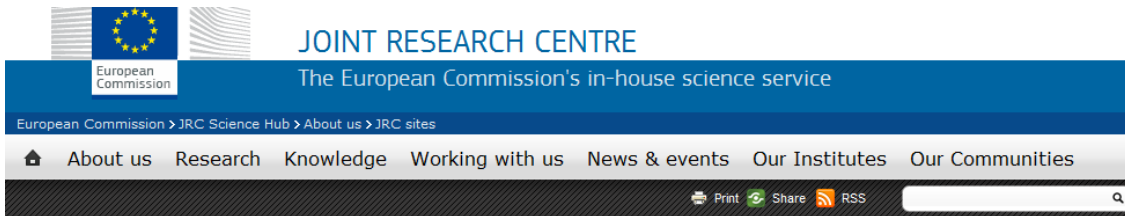


JRC Statistical Considerations on ITU ICT Development Index (IDI)

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JRC - COIN



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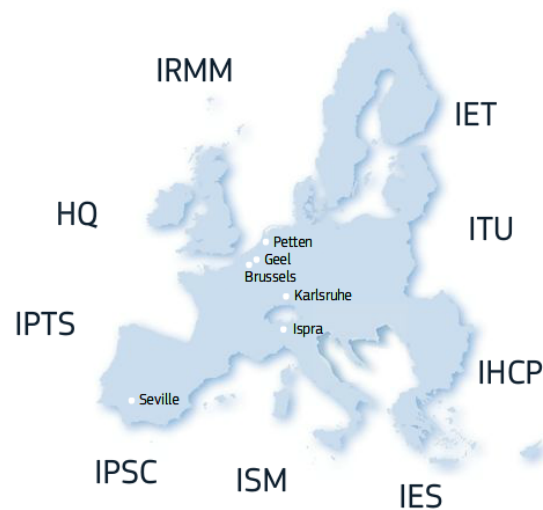
JRC sites

The JRC is located across six different sites within the EU. Brussels is home to the headquarters and also to the Directorate-General, the Scientific Policy and Stakeholder Relations Directorate and the Resources Directorate.

The JRC's site in Ispra, Italy is home to the JRC Visitors' Centre where you can learn about the many areas of our research via our interactive exhibits.

The Ispra site also hosts the Institute for the Protection and Security of the Citizen (IPSC), the Institute for Environment and Sustainability (IES), and the Institute for Health and Consumer Protection (IHCP), as well as the Ispra Site Management (ISM) Directorate.

The JRC's other site in Belgium, in Geel, hosts the Institute for Reference Materials and Measurements (IRMM), while Petten in the Netherlands is home to the Institute for Energy and Transport (IET). The Institute for Transuranium Elements (ITU) can be found in Karlsruhe in Germany, while Seville in Spain hosts the Institute for Prospective Technological Studies (IPTS).



- *Joint Research Centre: the European Commission's in-house science service*
- To provide EU policies with independent, *evidence-based scientific and technical support* throughout the whole policy cycle.
- JRC accumulates *17 years of experience* on the construction and assessment of *performance indices*
- *Competence Centre on Composite Indicators and Scoreboards (COIN)*

Activities on Composite Indicators & Scoreboards



Support to EC

130 CIs developed or used by the EC – 50% of the EC indices are developed with JRC contribution



Collaborations with international partners

Global Innovation Index 2018, Commitment to Reducing Inequality Index 2018, Corruption Perceptions Index 2017



Methodology

In-house developed quality control frame (conceptual coherence, multivariate analysis, sensitivity analysis, multi-criteria decision analysis, statistics and policy)



Training

Over 50 trainings in the last 15 years (**JRC Week on Composite Indicators and Scoreboards, 05-09/11/2018 Ispra, Italy**)

JRC-COIN know-how on construction and statistical assessment of composite indicators is requested by over 100 international partners: OECD, WEF, INSEAD, WIPO, UN-IFAD, UN-ITU, FAO, Harvard U., Yale U., Columbia U., Cornell U., ...

Statistical assessment of ICT Development Index

1. **Conceptual framework** based on **existing literature**

2. **Data quality checks**

3. **Statistical coherence**

4. **Impact of modeling assumptions** on the results

5. **Qualitative confrontation with experts** in order to get feedback on choices made during the index development

JRC Statistical assessment
of the



ICT Development Index
#ITUdata

JRC analysis focuses on providing statistical insights that can guide conceptual refinements and contribute to increasing transparency in the choices made in the IDI development

Framework of ICT Development Index

Code	Indicator	Ind. Weight	Pillar/sub-index	Pillar W.
A.1	%Households with computer	0.2	Access	0.4
A.2	%Households with internet	0.2		
A.3	Internet bandwidth per user	0.2		
A.4	% population covered by mobile networks	0.2		
A.5	Speed of fixed broadband subscription	0.2		
U.1	% Individuals Using internet	0.2	Use	0.4
U.2	Active mobile subscriptions per 100 Inhab	0.2		
U.3	Mobile-Broadband internet traffic per mobile-broadband subscription	0.2		
U.4	Fixed-broadband internet traffic per fixed-broadband subscription	0.2		
U.5	% Individuals who own a mobile phone	0.2		
S.1	Mean years of schooling	0.25	Skills	0.2
S.2	Gross enrollment ratio (secondary)	0.25		
S.3	Gross enrollment ratio (tertiary)	0.25		
S.4	Proportion of individuals with ICT Skills	0.25		

192 economies

14 indicators

3 pillars

Statistical Coherence of the IDI framework

Importance of the components

Proposed weighting scheme			
Component	Importance	Weight	
A.1	0.90	20	Access
A.2	0.90	20	
A.3	0.65	20	
A.4	0.75	20	
A.5	0.68	20	
U.1	0.87	20	Use
U.2	0.81	20	
U.3	0.72	20	
U.4	0.59	20	
U.5	0.75	20	
S.1	0.85	25	Skills
S.2	0.83	25	
S.3	0.83	25	
S.4	0.75	25	
Access	0.97	40	IDI
Use	0.95	40	
Skills	0.88	20	

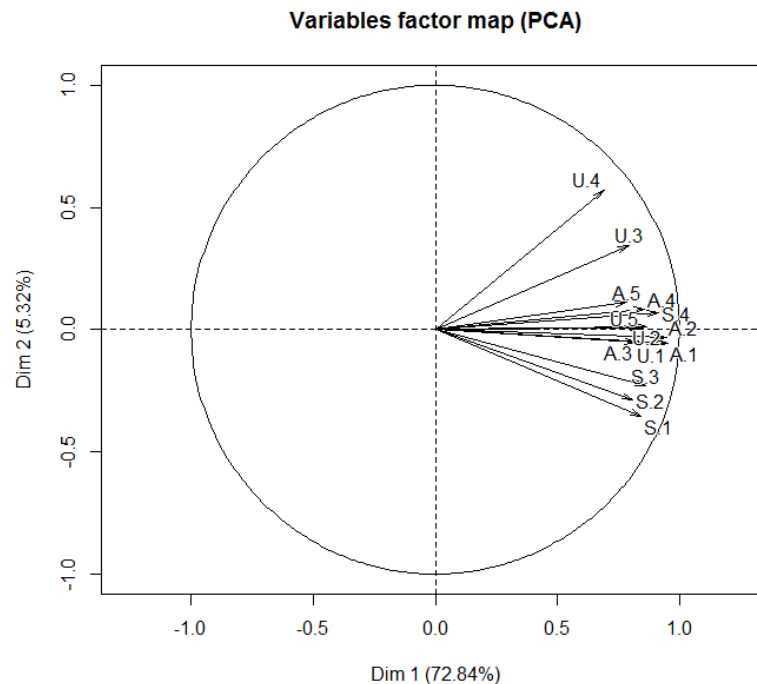
- ❑ The proposed (equal) weighting scheme shows a satisfying balance **within** IDI components
- ❑ **Access** pillar: more influenced by A1 and A2
- ❑ **Use** pillar: less driven by U4
- ❑ **IDI**: more influenced by Access and Use pillars

Notes: Importance measure = Squared Pearson correlation coefficient

Statistical Coherence of the IDI framework

Principal Components Analysis (PCA)

Statistically speaking: one average could tell the IDI story!



PCA among the 14 indicators confirms the presence of a single statistical dimension that captures 72.84% of the total variance

Statistical Coherence of the IDI framework

PCA within pillars



The wealth of information present in the indicators is passed on to the higher level aggregates

ICT Development Index (& pillars)	Variance explained (%)
ICT Development Index (3 sub-indices)	93.6
Access pillar (5 indicators)	78.8
Use pillar (5 indicators)	73.8
Skills pillar (4 indicators)	80.7

- ✓ PCA within each pillar: a single statistical dimension capturing between 73% - 81% of the total variance within pillar
- ✓ PCA across the three pillars confirms their strong statistical coherence, with up to 94% of their variance described using a single average

Insights from the uncertainty analysis: Step 1

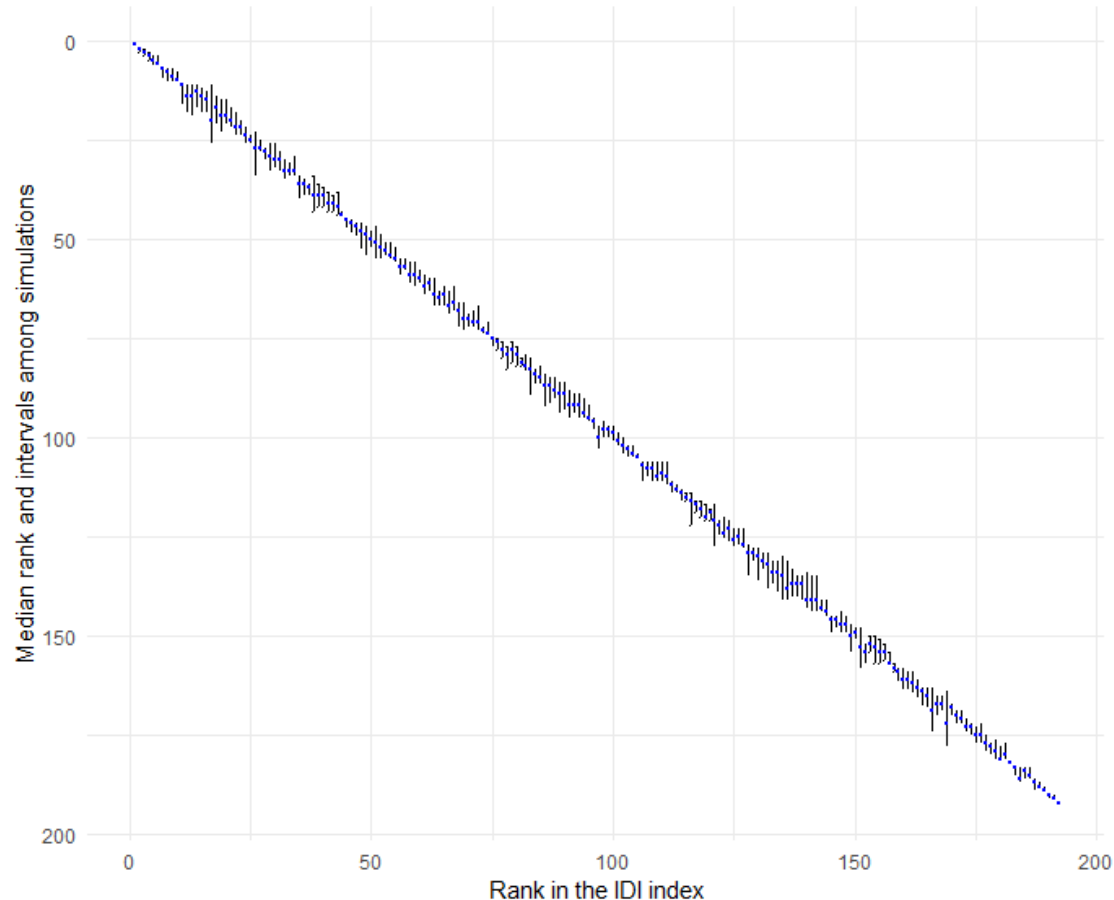
- Uncertainty/robustness analysis explores the **simultaneous and joint impact** of modelling assumptions on the rankings
- Expected result: Country ranks based on IDI should depend mainly on the indicators selected and not on the methodological choices made
- **STEP 1:** Let's consider only the impact of the choice of weights and aggregation formula in the results

	Reference	Alternative
II. Uncertainty in the aggregation function at the sub-index level	Arithmetic average	Geometric average
III. Uncertainty intervals for the three sub-index weights	Reference value for the weight	Distribution for uncertainty analysis
Access	0.4	U[0.30, 0.50]
Use	0.4	U[0.30, 0.50]
Skills	0.2	U[0.15, 0.25]

Insights from the uncertainty analysis: Step 1

The IDI, owing to the high correlation of its components, is relatively robust to changes in aggregation formula and weights

- For only five economies the simulated rank intervals span over more than 10 positions
- For all economies, the IDI ranks differ less than 5 positions compared to the median of the simulations



The challenge of missing values

And which are the variables more affected by the presence of missing values?

Code	Indicator	Average % missing	Pillar/sub-index	Pillar W.
A.1	%Households with computer	<5	Access	0.4
A.2	%Households with internet	<5		
A.3	Internet bandwidth per user	<5		
A.4	% population covered by mobile networks	10-20		
A.5	Speed of fixed broadband subscription	40-50		
U.1	% Individuals Using internet	<5	Use	0.4
U.2	Active mobile subscriptions per 100 Inhab	<5		
U.3	Mobile-Broadband internet traffic per mobile-broadband subscription	>75		
U.4	Fixed-broadband internet traffic per fixed-broadband subscription	>75		
U.5	% Individuals who own a mobile phone	>75		
S.1	Mean years of schooling	<5	Skills	0.2
S.2	Gross enrollment ratio (secondary)	10-20		
S.3	Gross enrollment ratio (tertiary)	10-20		
S.4	Proportion of individuals with ICTSkills	>75		

Insights from the uncertainty analysis: Step 2

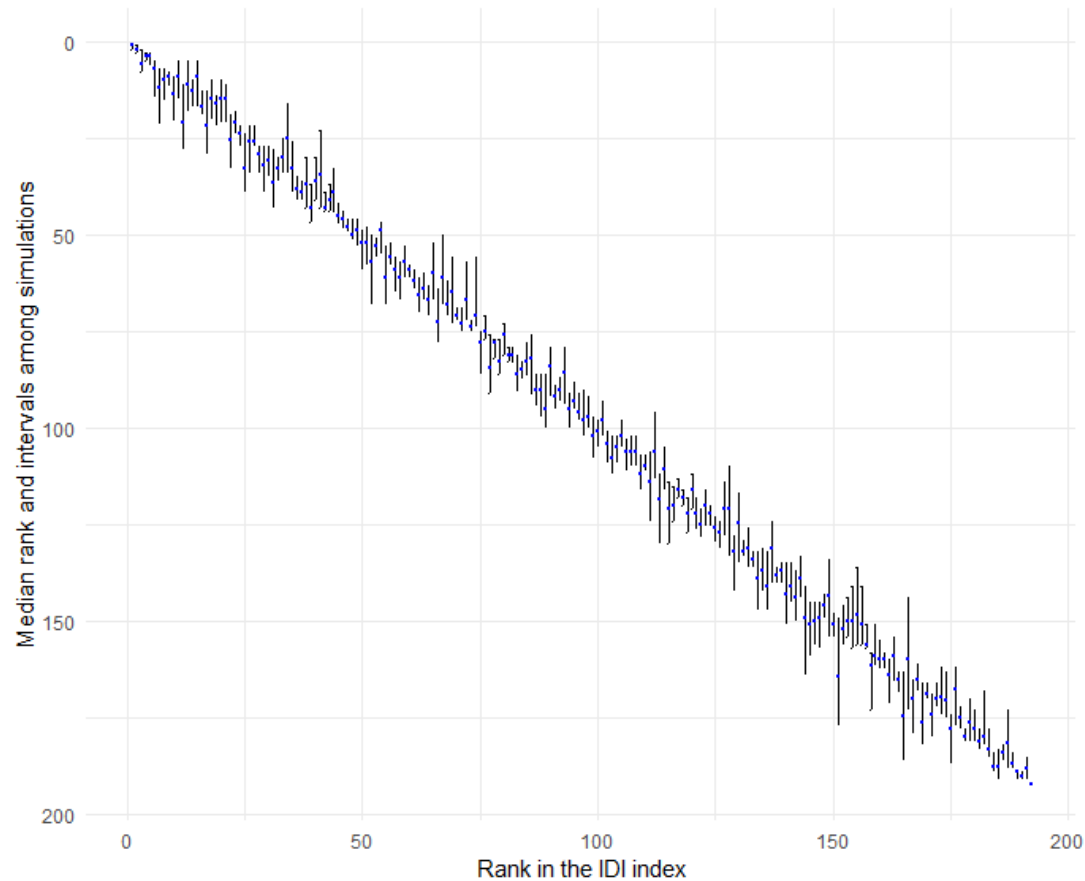
- **STEP 2:** To account for the uncertainty related to the inclusion of variables with high share of missing values, a second uncertainty analysis has been performed, with the additional feature of **excluding from the framework** those variables more affected by the presence of missing values.

	Reference	Alternative	
I. Use of variables with many missing values	Include them	Exclude them	
II. Uncertainty in the aggregation function at the sub-index level	Arithmetic average	Geometric average	
III. Uncertainty intervals for the three sub-index weights	Reference value for the weight	Distribution for uncertainty analysis	
	Access	0.4	U[0.30, 0.50]
	Use	0.4	U[0.30, 0.50]
	Skills	0.2	U[0.15, 0.25]

Insights from the uncertainty analysis: Step 2

The uncertainty analysis reflects the impact of including or not variables with high share of missing values on the robustness of the IDI ranks:

- For 75 economies the simulated rank intervals span over more than 10 positions
- For 14% of the economies, the IDI ranks differ less than 5 positions compared to the median of the simulations



Insights from the Sensitivity Analysis

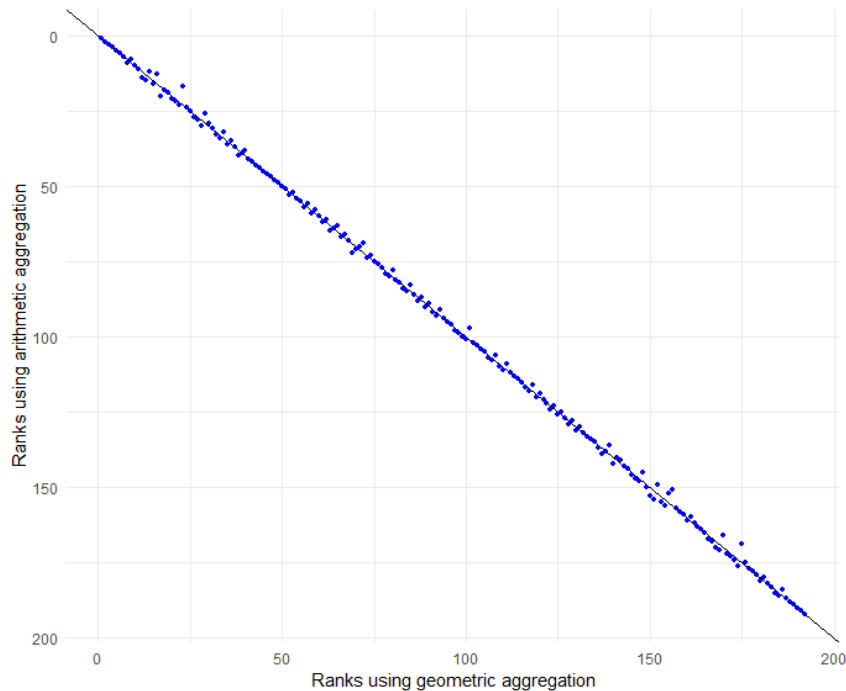
- Sensitivity analysis explores the **direct impact** of modelling assumptions on the rankings
- **Comparison 1:** Consider the impact of the aggregation formula on the ranks
- **Comparison 2:** Consider the impact of the inclusion/exclusion of variables with large percentage of missing values

The comparisons are evaluated respect to the **shifts in economies' ranks**

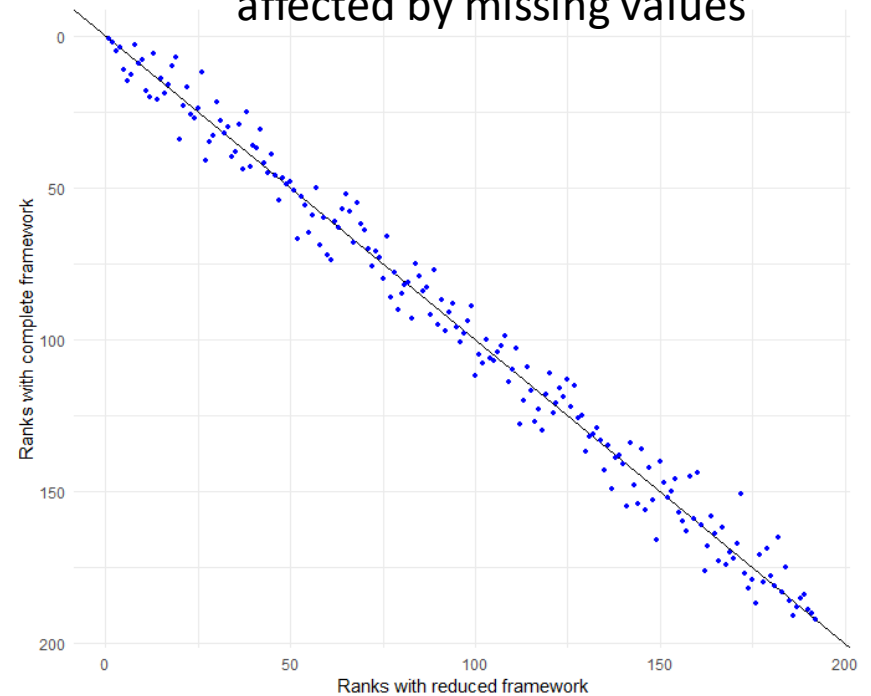
	Reference	Alternative
I. Use of variables with many missing values	Include them	Exclude them
II. Aggregation function at the sub-index level	Arithmetic average	Geometric average

Insights from the sensitivity analysis

IDI vs Geometric average



IDI vs Excluding 4 vbles. most affected by missing values



Excluding vs. keeping the 4 variables has the strongest impact on the country ranks

Insights from the sensitivity analysis

Shift in ranks – comparing IDI with alternative scenarios

	Average Shift	Median Shift	Maximum shift
Geometric Average	0.94	1	6
Excluding All 4	5.41	5	21
Excluding U.3	2.72	2	14
Excluding U.4	1.71	1	9
Excluding U.5	1.91	1	11
Excluding S.4	1.30	1	11

All these variables are influential, but ***Mobile-Broadband internet traffic per mobile-broadband subscription*** is the one with the largest effect.

Conclusion

- The ITU IDI developing team invited, for the second time, the JRC to delve into the statistical properties of the index, so as to ensure the *transparency* and *reliability* of the IDI results.
- The JRC analysis suggests that the current structure of the IDI is statistically *sound, coherent and balanced, robust* to changes in the weights and aggregation rules.
- The methods used for **imputation** of missing data represent the best choice considering the limited data availability.
- The uncertainty/sensitivity analysis highlighted the impact of the indicators with the largest share of missing data on the robustness of the ranks.
- Additional efforts in **data collection** to achieve a better country coverage of the selected indicators should become a **top priority for all ITU members**

References

- OECD/EC JRC. 2008. Handbook on Constructing Composite Indicators: Methodology and User Guide. Paris: OECD.
- Paruolo, P., Saisana, M., Saltelli, A. 2013. Ratings and rankings: Voodoo or Science?, *Journal of the Royal Statistical Society – A* 176(3), 609-634.
- Saisana, M., D’Hombres, B., Saltelli, A. 2011. Rickety numbers: Volatility of university rankings and policy implications, *Research Policy* 40, 165-177.
- Saisana, M., Saltelli, A., Tarantola, S., 2005. Uncertainty and sensitivity analysis techniques as tools for the analysis and validation of composite indicators. *Journal of the Royal Statistical Society A* 168(2), 307-323.
- Saltelli, A., Ratto, M., Andres, T., Campolongo, F., Cariboni, J., Gatelli, D., Saisana, M., Tarantola, S. 2008. *Global Sensitivity Analysis: The Primer*. Chichester, England: John Wiley & Sons.

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Statistical Coherence of the IDI framework

Is there redundancy in the framework?



Correlations among pillars are high, but redundancy of information is not an issue

IDI highlights aspects of the ICT Development that do not emerge directly from the 3 pillars/individual indicators



e.g. : **23%** of the 192 economies the ICT skills rank and the IDI rank differ by at least 20 positions (**35%** wrt ICT Skills rank in the case of Gross enrolment ratio-secondary (S2))

% of economies that shift at least 20 positions wrt the index/pillar

Access	8%
Use	13%
Skills	23%
A.1	23%
A.2	27%
A.3	54%
A.4	38%
A.5	52%
U.1	30%
U.2	42%
U.3	40%
U.4	37%
U.5	34%
S.1	34%
S.2	35%
S.3	24%
S.4	29%