DESIRE
Development of a System of Indicators for a Resource Efficient Europe

European Commission

How many environmental performance indicators do we need?

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Environmental performance indicators

Problem setting

- Many different indicators
  - Relatively simple environmental: Water, Land, Materials, ...
  - More complex environmental: Acidification, Toxicity, ...
  - Social: Hours of “vulnerable” labour, ...

- Hundreds of indicators: difficult to communicate to decision makers

Central question

- How many indicators do we need to inform decision-makers?

Goal

- To systematically identify a small representative and non-redundant set of environmental perfomance indicators

EEIO time series and macro indicators as a basis

- **Improved EXIOBASE**
  - 48 countries, 163 sectors, 200 products
  - 1995-2013 + nowcasting
  - 40 emissions, water, land, 200 resources
  - 15 categories of labor, added value
  - Economic and physical flows, globally (allows analysis of physical resource loss at sector level)

- **Relates production to consumption**
  - Example: 5 Euro coffee at Starbucks
    - 3 Euro for Starbucks = Restaurant
    - 1 Euro for roaster = Food industry
    - 0.5 Euro for transport = Transport
    - 0.25 Euro for farmer = Agriculture
    - 0.25 Euro for fertiliser, etc.
    - Impacts per sector/country per Euro known
    - Multiply -> you see how impacts of production relate to consumption

		Industries				$Y_{*,A}$	$Y_{*,B}$	$Y_{*,C}$	$Y_{*,D}$	q
Products		$Z_{A,A}$	$Z_{A,B}$	$Z_{A,C}$	$Z_{A,D}$	$Y_{A,A}$	$Y_{A,B}$	$Y_{A,C}$	$Y_{A,D}$	q_A
		$Z_{B,A}$	$Z_{B,B}$	$Z_{B,C}$	$Z_{B,D}$	$Y_{B,A}$	$Y_{B,B}$	$Y_{B,C}$	$Y_{B,D}$	q_D
		$Z_{C,A}$	$Z_{C,B}$	$Z_{C,C}$	$Z_{C,D}$	$Y_{C,A}$	$Y_{C,B}$	$Y_{C,C}$	$Y_{C,D}$	q_C
		$Z_{D,A}$	$Z_{D,B}$	$Z_{D,C}$	$Z_{D,D}$	$Y_{D,A}$	$Y_{D,B}$	$Y_{D,C}$	$Y_{D,D}$	q_D
W		W_A	W_B	W_C	W_D					
g		g_A	g_B	g_C	g_D					
C & L		$Capital_A$	C_B	C_C	C_D					
		$Labor_A$	L_B	L_C	L_D					
Environ Ext		$NAMEA_A$	$NAMEA_B$	$NAMEA_C$	$NAMEA_D$					
		$Agric_A$	$Agric_B$	$Agric_C$	$Agric_D$					
		$Energy_A$	$Energy_B$	$Energy_C$	$Energy_D$					
		$Metal_A$	$Metal_B$	$Metal_C$	$Metal_D$					
		$Mineral_A$	$Mineral_B$	$Mineral_C$	$Mineral_D$					
		$Land_A$	$Land_B$	$Land_C$	$Land_D$					

Case study 1: Multi-regional Input-Output model

- Exiobase: MRIO model for the world economy
  - 200 product groups from 163 sectors in 49 countries/regions
  - ILCD impact indicators + social/economic indicators + resource uses

Indicator	Unit
Employment	1000s of persons
Employment hour	Million hours
Global Warming, GWP100	kg CO2-eq
Particulate matter/Respiratory inorganics midpoint	kg PM2.5-eq
Photochemical ozone formation midpoint, human health	kg-C2H4 equivalents
Acidification midpoint	Accumulated Exceedance (AE)
Eutrophication marine midpoint	kg-N equivalent
Ecotoxicity freshwater midpoint	CTUe = PAF.m3.year
Total Energy Use	TJ
Water Consumption Green - Agriculture	Mm^3
Water Consumption Blue - Total	Mm^3
Water Withdrawal Blue - Total	Mm^3
Land use	km^2
Material footprint	kt

Set up

- Analysis on final consumption per Million euro of 7,858 non-zero sector-region combinations for 14 indicators = 7,858 x 14 matrix

- Correlations between indicators → Indicators are ultimately driven by the same process:

  Burning coal example

  Emissions: CO_2, NO_x, SO_x, extraction coal

  Impacts: Global Warming, Particulate matter/Respiratory inorganics, Acidification and Resource Use

- The higher the correlation, the more potential for reducing the number of variables

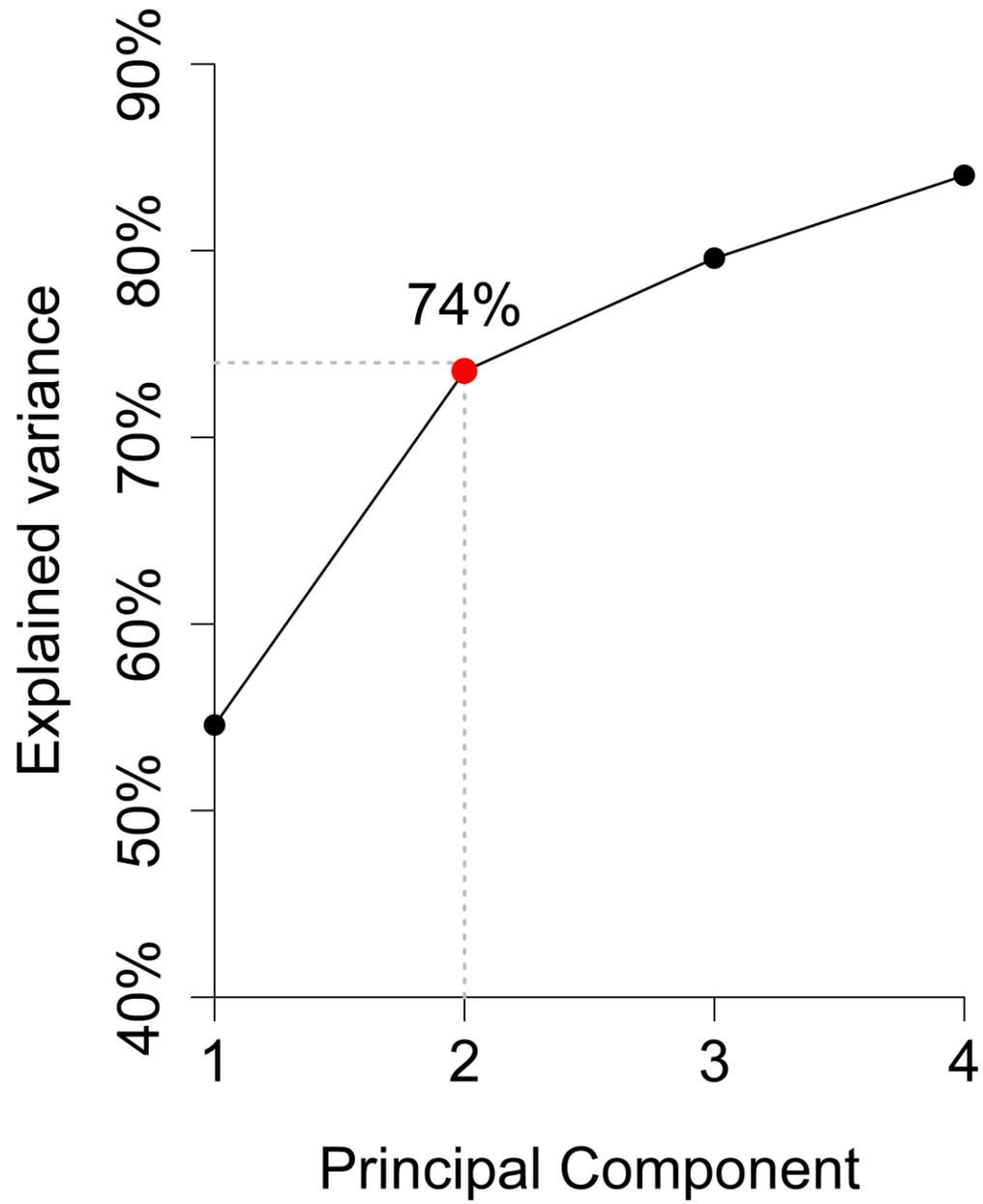
PCA, Principal Component Analysis

- PCA: Principal Component Analysis
  - The number of components necessary to explain x% of the total variance
  - Based on the correlation matrix of the variables
  - Tranform the original data into uncorrelated components
  - The first component covers the maximum amount of variance, consecutive components cover less

- First couple components cover the majority of the variance → potential for reduction

- How many components should be retained?
  - Retain component if explained variance > the average explained variance of 1,000 Monte Carlo samples for random data

Non-trivial components



2 Non-trivial components

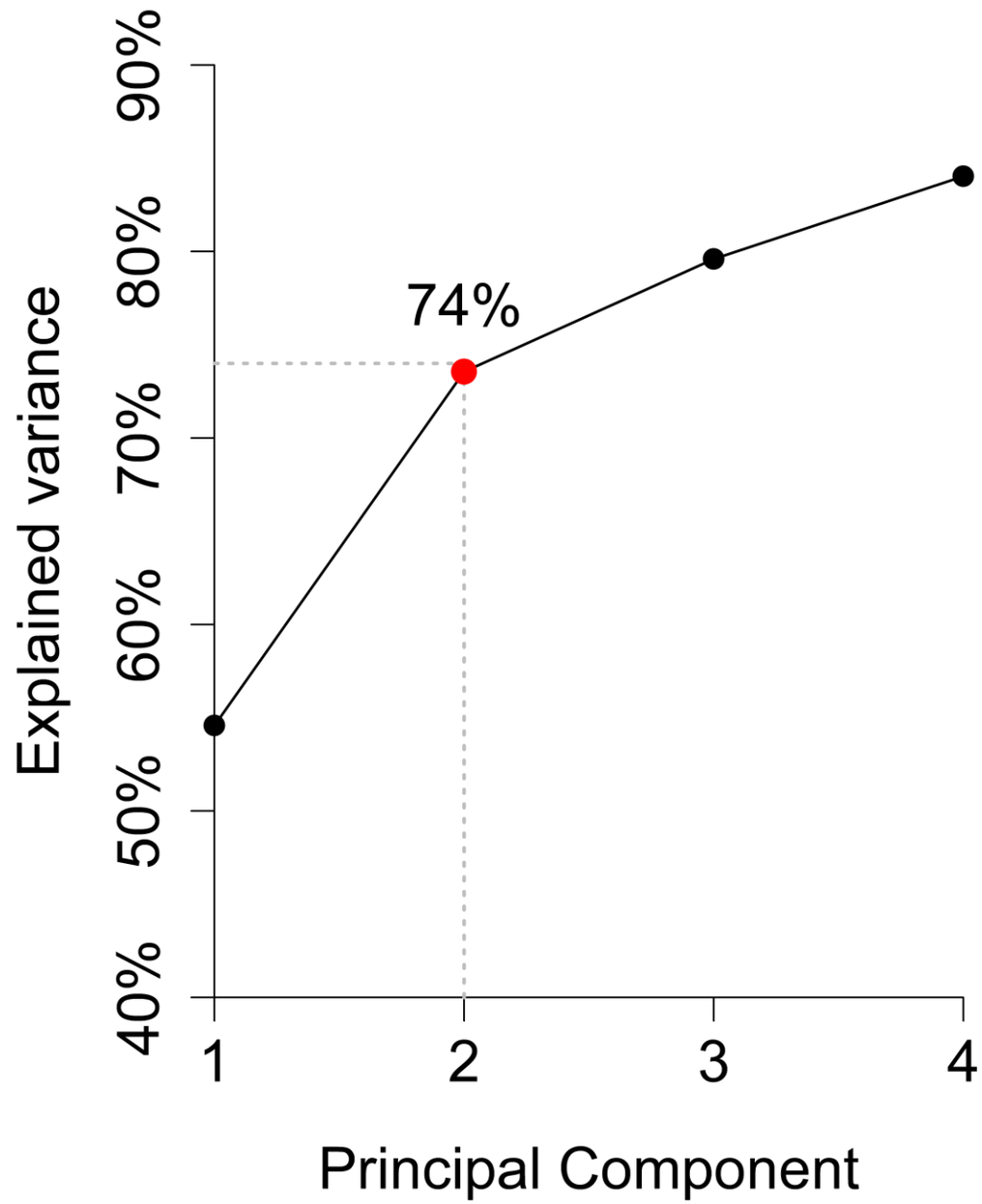
74% explained variance

Best set of indicators

- 2 components are non-trivial
  - Which indicator set covers these components the best?

- Selection of best set indicators: Based on a multiple regression with the principal component scores. Retain the smallest set with an explained variance > the explained variance by the non-trivial components (74%)

Best set of indicators



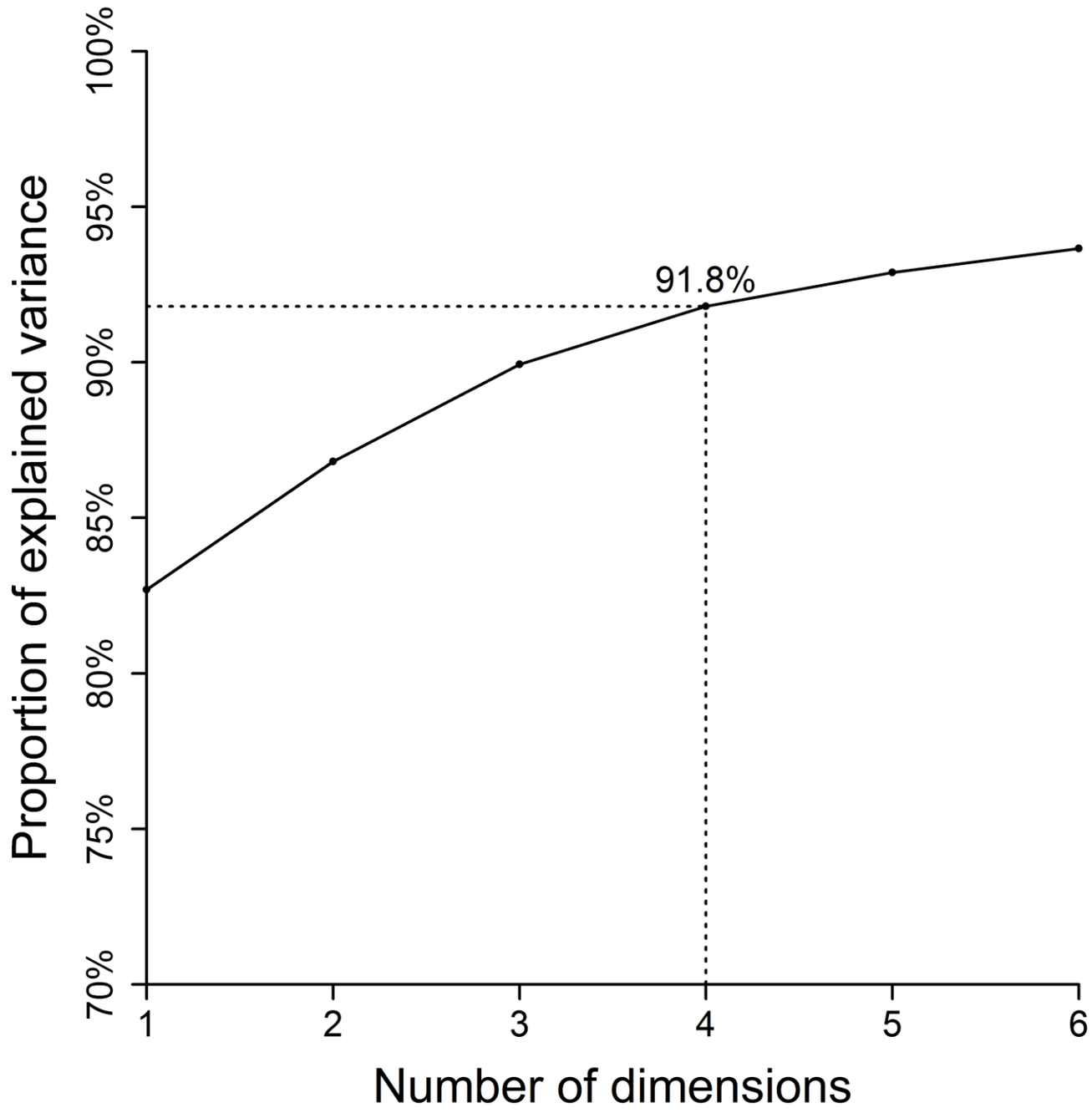
4 Indicators are needed to cover > 74%

Best set of indicators
Total energy use
Acidification midpoint
Water consumption Blue - Total
Employment hour

Case study 2: Life Cycle Assessment

- 976 commodities (Ecoinvent database)
  - 140 different environmental indicators (Midpoint, Endpoint and Resource based)
  - Methodologies: CML, EDIP, Impact2002, ReCiPe, TRACI, Ecological Scarcity, EcoIndicator 99, EPS, Ecological footprint, Energy, Water, Land and Material footprints
- Do we need 14 methodologies and up to 140 indicators?

Contribution of the principal components

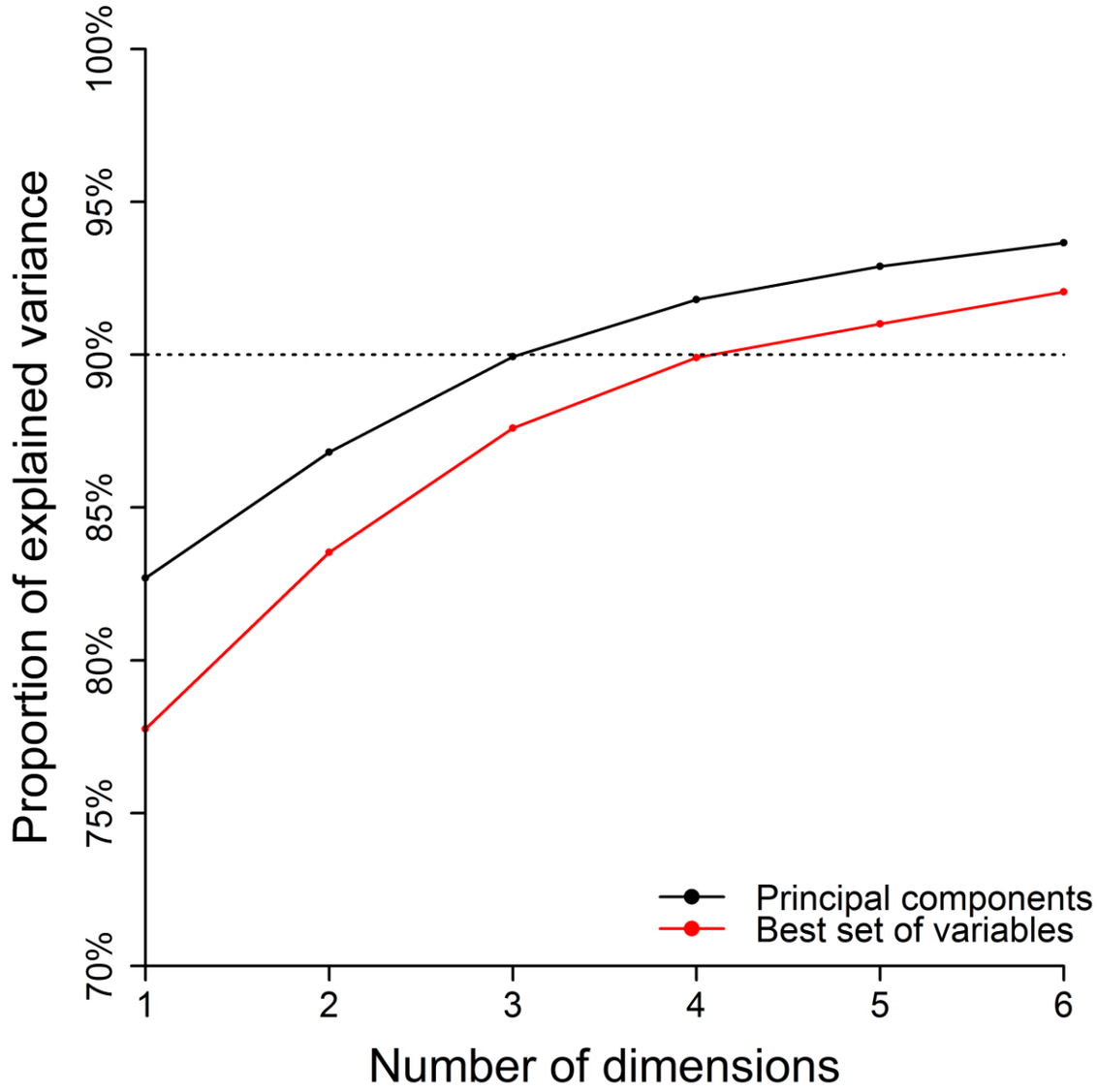


First four components are retained

First component: 82.7%

Together the first four components explain 91.8% of the total variance

Which indicators do we retain?



To explain >90%:

4 principal components

OR

<u>Best 5 Indicators</u>:

- Climate change
- Ozone depletion
- Terrestrial ecotoxicity
- Marine ecotoxicity
- Land footprint

Which indicators do we retain?

- 5 indicators cover first 4 components well. However:
  Toxicity potentials are not easily calculated

- What if we 4 use simple indicators:
  - Energy
  - Land
  - Water
  - Materials

  $\Rightarrow$84.8% of total variance

Conclusion and outlook

- Systematically reduce to 4-5 indicators while retaining +/- 80% of the variance is feasible
- RACER criteria could be used to define additional selection rules for indicators (Relevant, Accepted, Credible, Easy, Robust)
- Add new indicators (biodiversity) and regionalized indicators of impact (e.g water use)
- Alignment between the selection of indicators for MRIO and LCA?

Thank you for your attention!

- Points for the group discussion
  - policy relevance of indicators;
  - roadmap towards indicator implementation;
  - further (data) needs and indicator development

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