Using a Multilevel Structural Equation Modeling Approach to Explain Cross-Cultural Measurement Noninvariance

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2. What do we mean by invariance?
3. What to do when there is no invariance?
4. Using multilevel techniques to explain measurement noninvariance
5. Empirical illustration
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1. Introduction

More and more ***studies test*** the ***invariance*** (equivalence) ***properties*** of scales across

- countries,
- cultural groups,
- time points,
- modes of data collection etc.

There are **two** typical scenarios:

- We analyze and find high levels of invariance and we are **happy**.
- Invariance across groups is absent and we are **disappointed** and question , whether it makes sense to continue comparisons.

1. Introduction

In this study we propose using

- **mulilevel structural equation modeling** (ML SEM)
- to **explain** noninvariance,
- **not to solve** it (diagnosis of the problem).

We will **exemplify** its use with an example from the European Social Survey (ESS).

2. What do we mean by invariance

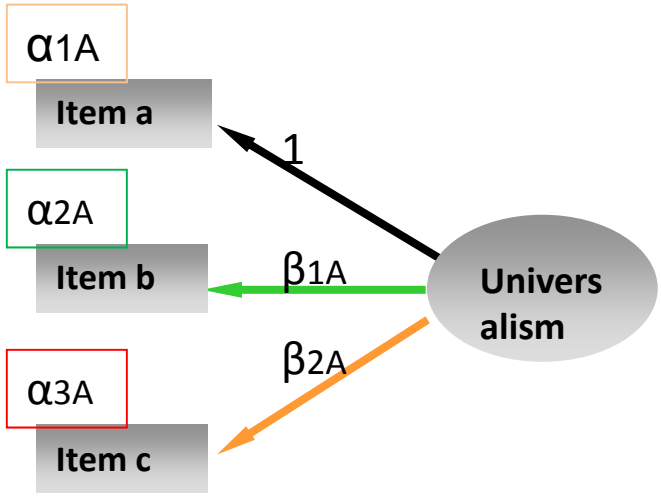
There are typically three important levels of testing measurement invariance:

- Configural Invariance,
- Metric Invariance,
- Scalar Invariance.

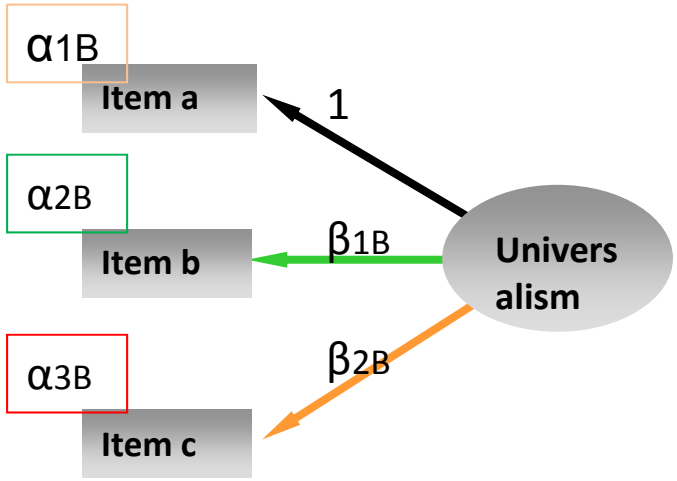
2. What do we mean by invariance

Measurement Invariance:

Group A (Culture, country, time point)



Group B (Culture, country, time point)



All levels of invariance are necessary for meaningful mean comparisons.

2. What do we mean by invariance

But:

Higher levels of invariance (i.e., scalar)

- are **seldom guaranteed**,
- **especially when many groups are compared.**

3. What to do when there is no invariance?

1) Resort to partial invariance

(Byrne/Shavelson/Muthén 1989; Steenkamp/Baumgartner 1998).

2) Compare only a subset of countries (or other groups)

where invariance of the involved concepts does not hold

(e.g., Byrne/van de Vijver 2010).

3) Even refrain from cross-country comparisons

when invarince is not found even across a subset of countries.

4) Decrease the number of items and **delete those items** whose parameters are very different across groups. However, when this approach is applied, one has to address the **question whether** the **meaning of the concept has changed** after the item reduction (Bynre/van de Vijver 2010).

2. What to do when there is no invariance?

But:

None of these solutions explains

where the problem comes from!

4. Using mulilevel techniques to explain measurement noninvariance

5) Explain noninvariance by introducing **contextual variables** and using **multilevel analysis** (Schlüter/Meulemann 2009).

Noninvariance can be viewed as a **useful source of information on cross-cultural differences**
(e.g., Poortinga 1989; Schlüter/Meulemann 2009).

Although it was already referred to by some authors (e.g., Hox/de Leeuw/Brinkhuis 2010) and although the **technique is not new** (e.g., Muthén 1985)

to the best of our knowledge this possibility has **not yet been explicated** and **applied for** the goal of **explaining noninvariance systematically.**

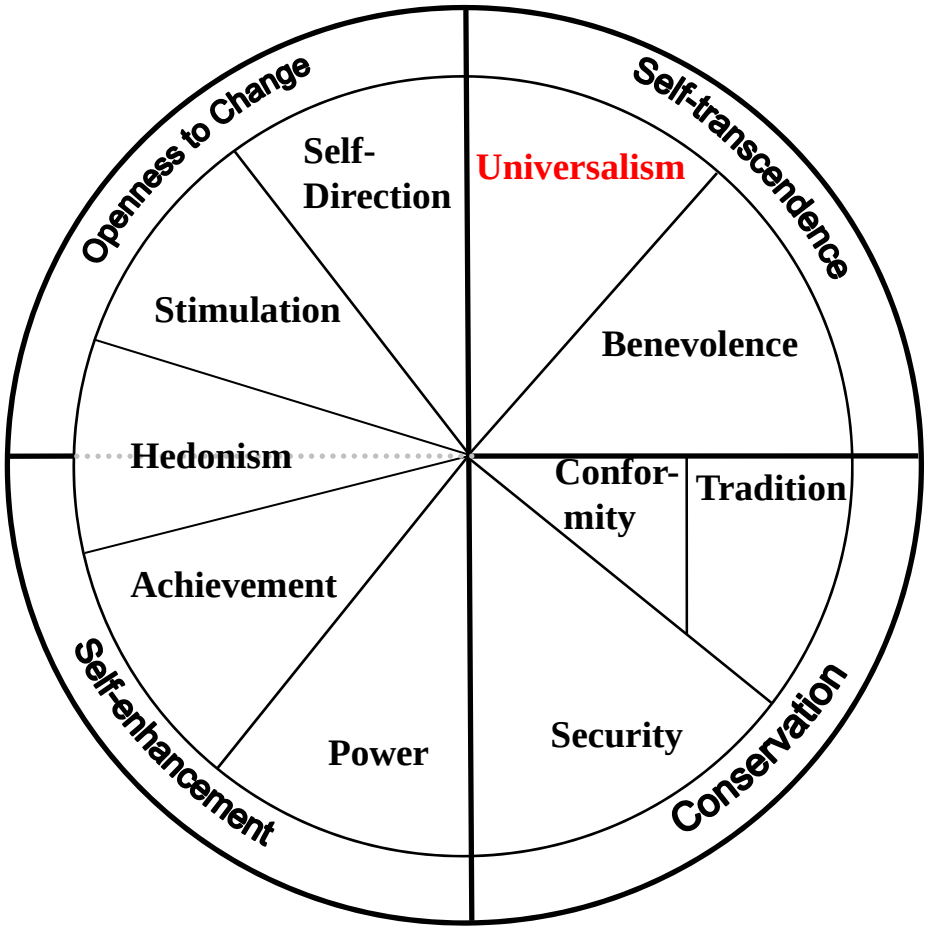
5. Empirical illustration

Theory of 10 Universal Values (Schwartz 1992)

- Focus of our Analysis:
  Universalism

- Universalism
  is measured by 3 Items:
  - Equality
  - Understanding Different People
  - Environment Protection

Data Source: ESS 2004-5



5. Empirical illustration

Test of invariance of universalism across 25 ESS countries by using multiple group confirmatory factor analysis (**MGCFA**)

Results:

- **Configural** and **metric invariance** were confirmed by the data:
  - Factor loadings are equal across countries.
- **Scalar invariance** was **rejected:**
  - Indicator intercepts are different. People use the scale differently.

More specifically:

- The **intercept of the indicator Environment** is particularly different across countries.

5. Empirical illustration

Theoretical Expectations (Inglehart 1990, 1997):

H1: The value of Universalism is more important in Postmodern advanced industrial countries than in less developed Modern countries.

- Intergenerational value change from **Materialist** to **Postmaterialist** value priorities in advanced Modern societies (Inglehart 1990):
  - Postmaterialist needs (belonging, self-expression) become more important than more fundamental Materialist needs (physical/economical security).
- Shift from Materialist to Postmaterialist value priorities is a key indicator for a broader syndrome of **Postmodernization** (Inglehart 1997):
  - Postmodernization includes a shift from an emphasis on self-denying achievement orientations toward individual choice of lifestyles, greater **tolerance for ethic, cultural and sexual diversity**, and an increasing emphasis on **protection of environment** and **quality of life** in general.

5. Empirical illustration

Theoretical Expectations (Inglehart 1990, 1997):

H2: Environment protection is perceived more important in less developed countries than in Postmodern advanced industrial countries.

- Inglehart (1997: 242) also states that in less developed countries where air/water pollution are far worse than in advanced industrial societies, environment protection is less a quality of life issue but much more a matter of physical health.

5. Empirical illustration

Theoretical Expectations (Inglehart 1990, 1997):

Thus:

People may ‘react’ differently to the environment item, because of differences in the level of human development (**HDI**) between the countries.

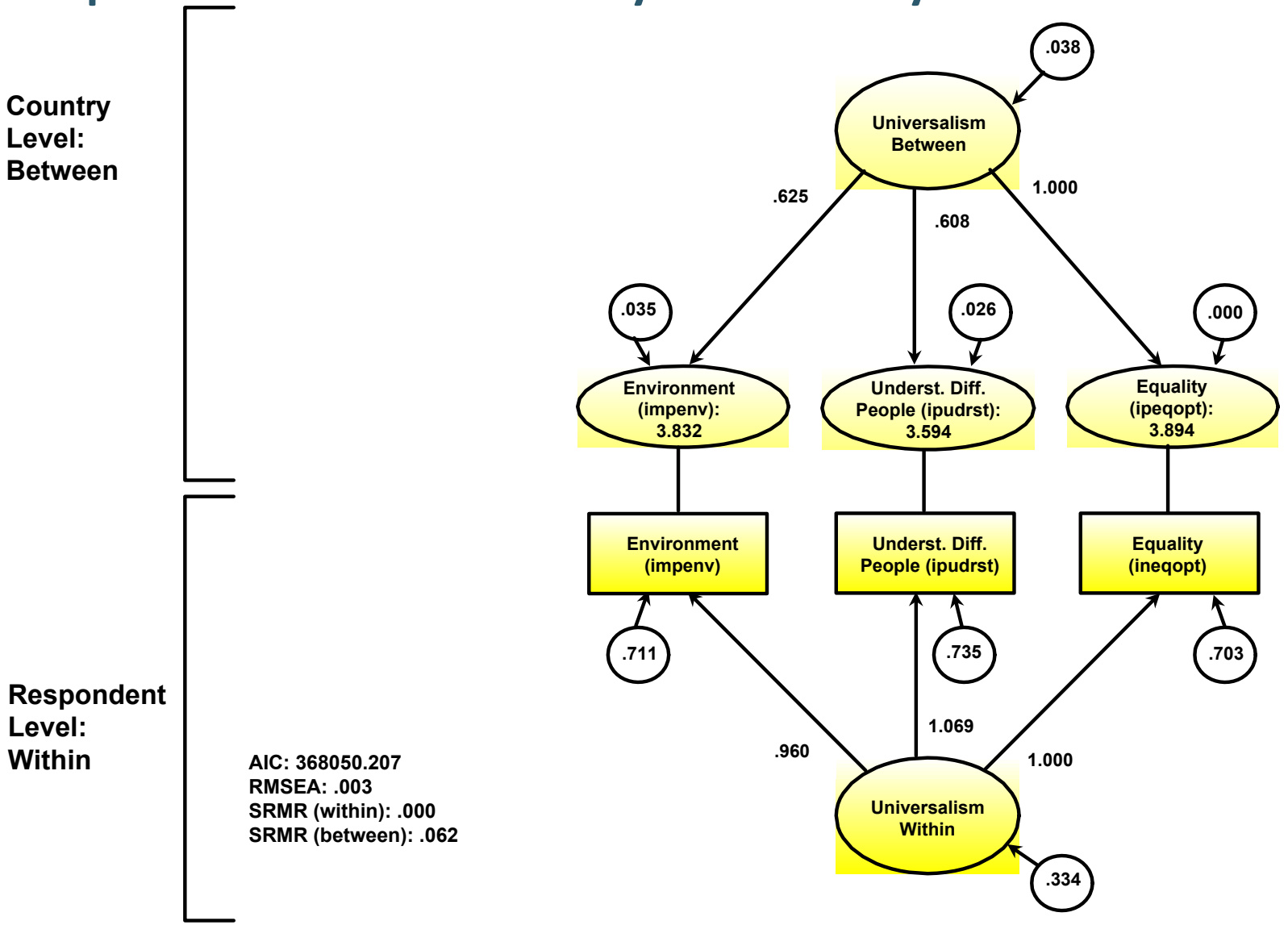
Human Development Index (HDI 2004):

Geometric Mean of

- Standard of Living: Logarithm of the GDP pc in PPP $US
- Educational Attainment: Index for Adult Literaty Rate and Gross Enrolment Rate in Primary/Secondary/Tertiary Schools
- Health: Life Expectation at Birth

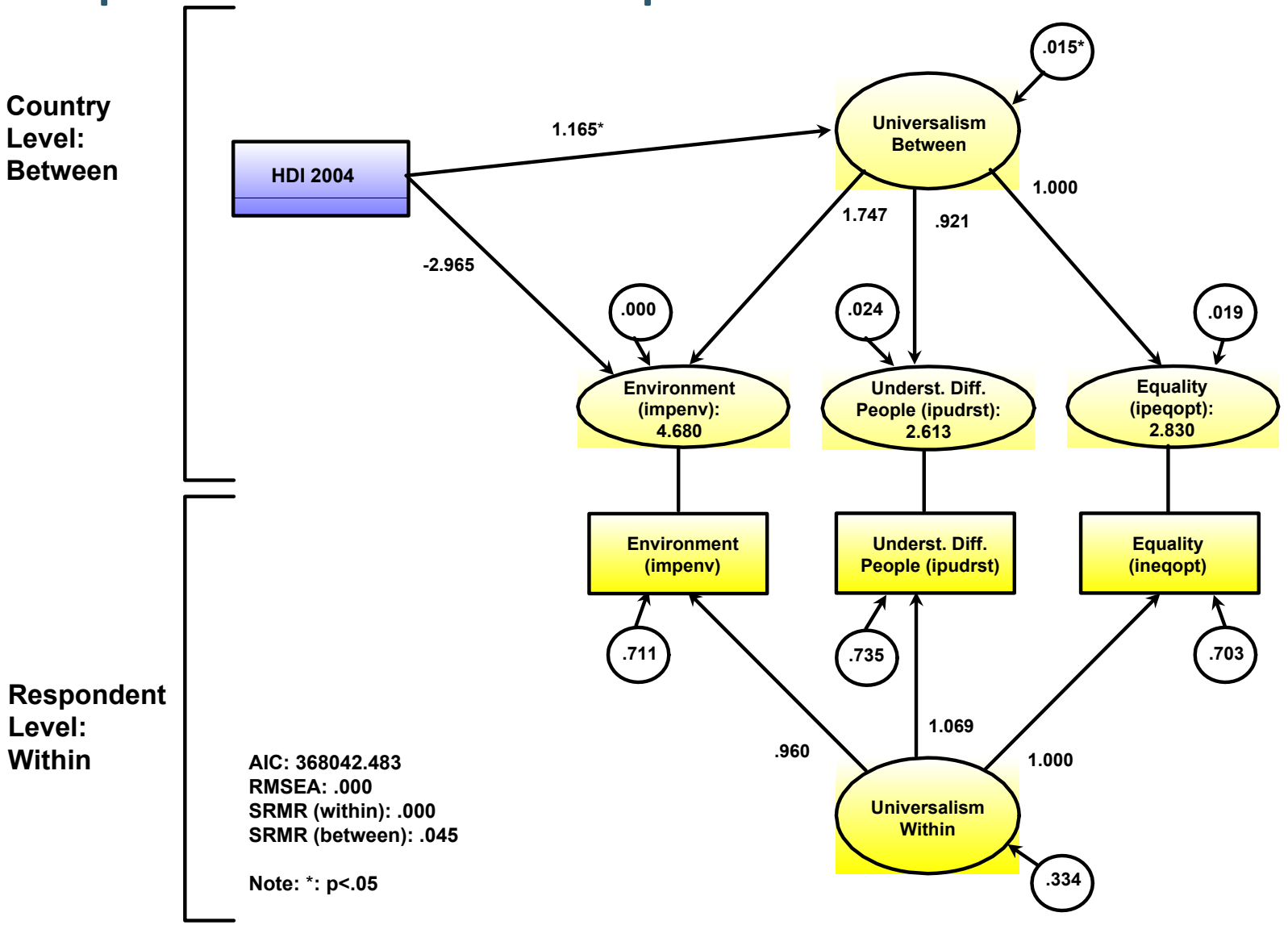
5. Empirical illustration

1st step: Two-Level Confirmatory Factor Analysis



5. Empirical illustration

2nd step: Two-Level Structural Equation Model



6. Conclusion

Our empirical results

confirm our hypotheses concerning the impact of a country‘s level of economic/technical development (HDI)

- on the value of Universalism (H1)
- on the citizens attitude toward environment protection (H2, intercept noninvariance)

The level of human development explains

why scalar invariance was absent for the item Environment.

6. Conclusion

- ML SEM is a rather straightforward technique to **explain variation** in an item‘s intercept.

- Although ML SEM does **not** provide **a resolution** to the problem of noninvariance, it is a useful tool for the **diagnosis of the causes**.

- Diagnosis and systematic identification of the sources of item bias are an **essential step before measurement scales can be improved for cross-cultural analysis.**

Thank you very much

for

your attention!!!

Descriptive Findings

Variances, Covariances, and ICC for the Indicators of Universalism

		Pooled Sample Correlations and Covariances				Within and Between Countries Correlations and Covariances		
		1	2	3		1	2	3
					within			
1	Equality (ipeqopt)	1.079	**.344**	**.324**		1.037	**.332**	**.312**
2	Understanding Diff. People (ipudrst)	.385	1.162	**.334**		.357	1.117	**.321**
3	Environment (impenv)	.347	.372	1.066		.321	.343	1.019
					between			
1	Equality (ipeqopt)					.038	**.591**	**.547**
2	Understanding Diff. People (ipudrst)					.023	.040	**.477**
3	Environment (impenv)					.024	.021	.049
	Means	**3.890**	**3.589**	**3.845**		**3.894**	**3.593**	**3.832**
	ICC					.036	.035	.046

Note: Bold entries in the upper diagonal are the correlations, entries in the diagonal are variances, and entries in the lower diagonal are covariances; the total sample includes 43,779 respondents from 26 countries

Two-Level CFA and Two-Level SEM for Universalism

Respondent Level (n = 43,779) Country Level (n = 26)	Model 1: Two-Level CFA			Model 2 Multilevel SEM		
AIC	**368050.207**			**368042.483**		
SRMR Within						
SRMR Between	**.062**			**.045**		
	b	z		b	z	
Confirmatory Factor Analysis						
Intercept Level 2						
Equality (ipeqopt)	3.894	100.478**		2.830	4.968**	
Underst. Diff. People (ipudrst)	3.594	90.518**		2.613	4.795**	
Environment (impenv)	3.832	87.229**		4.680	6.384**	
Factor Loadings	b	z	beta	b	z	beta
Equality (ipeqopt)	1.000	-.-	1.000	1.000	-.-	.707
Underst. Diff. People (ipudrst)	.608	3.666**	.592	.921	3.197**	.637
Environment (impenv)	.625	3.277**	.549	1.747	4.599**	1.090
Equality (ipeqopt)	1.000	-.-	.568	1.000	-.-	.568
Underst. Diff. People (ipudrst)	1.069	57.275**	.585	1.069	57.275**	.585
Environment (impenv)	.960	58.203**	.550	.960	58.202**	.550
Regression						
Environment (impenv) on HDI 2004				**-2.965**	**-3.757****	**-.712**
Universalism (betw.) on HDI 2004				**1.165**	**1.871***	**.449**

Note: * $p \leq 0.05$; ** $p \leq 0.01$; Estimator: Full Maximum Likelihood (ML);
Estimates for level 2 parameters are indented to the right in the first column. Variances/Residual Variances tested one-tailed. Since we formulated hypotheses for the impact of the HDI on environment and universalism (between), the significance level of both b-coefficients are based on a one-tailed test. The beta-coefficients are fully standardized.

Two-Level CFA and Two-Level SEM for Universalism

Respondent Level (n = 43,779) Country Level (n = 26)	Model 1: Two-Level CFA		Model 2 Multilevel SEM	
AIC	**368050.207**		**368042.483**	
SRMR Within				
SRMR Between	**.062**		**.045**	
Residual Variances	Variance	z	Variance	
Equality (ipeqopt)	-.-	-.-	.019	3.478**
Underst. Diff. People (ipudrst)	.026	3.504**	.024	3.477**
Environment (impenv)	.035	3.511**	-.-	-.-
Equality (ipeqopt)	.703	93.393**	.703	93.391**
Underst. Diff. People (ipudrst)	.735	88.396**	.735	88.395**
Environment (impenv)	.711	98.524**	.711	98.525**
Variance	Variance	z	Variance	z
Latent Factor (Universalism betw.)	.038	3.542**		
Latent Factor (Universalism within)	.334	42.894**		
Variance Comp./Residual Var. Level 2				
Intercept Level 2: Universalism (betw.)			.015	1.943*
Level 1: Universalism (within)			.334	42.894**

Note: * $p \leq 0.05$; ** $p \leq 0.01$; Estimator: Full Maximum Likelihood (ML);
Estimates for level 2 parameters are indented to the right in the first column. Variances/Residual Variances tested one-tailed. Since we formulated hypotheses for the impact of the HDI on environment and universalism (between), the significance level of both b-coefficients are based on a one-tailed test.

Two-Level CFA

Respondent Level (within): Country Level (between):

$$y_{ijk} = \alpha_{jk} + \lambda_{Wk} \cdot \eta_{Wij} + \varepsilon_{Wijk} \qquad \alpha_{jk} = \upsilon_{k} + \lambda_{Bk} \cdot \eta_{Bj} + \varepsilon_{Bjk}$$

where

- y_{ijk} refers to the observed value of respondent *i* of country *j* on indicator variable *k*,
- α_{jk} refers to the intercept of country *j* on indicator variable *k*,
- υ_{k} refers to the intercept (usually called grand mean in multilevel analysis) of indicator variable *k*,
- η_{Wij} refers to the score of respondent *i* of country *j* on the within-level latent η_{W} ,
- η_{Bj} refers to the score of country *j* on the between-level latent variable η_{B} ,
- λ_{Wk} refers to the within-level factor loading λ_{W} of indicator variable *k*,
- λ_{Bk} refers to the between-level factor loading λ_{B} of indicator variable *k*,
- ε_{Wijk} refers to the within-level error term ε_{W} for respondent *i* of country *j* on indicator variable *k*, and
- ε_{Bjk} refers to the between-level error term ε_{B} (usually called random term in multilevel analysis) for country *j* on indicator variable *k*.

Two-Level CFA

$$y_{ijk} = \upsilon_k + \lambda_{Bk} \cdot \eta_{Bj} + \varepsilon_{Bjk} \quad + \quad \lambda_{Wk} \cdot \eta_{Wij} + \varepsilon_{Wijk}$$

where

- y_{ijk} refers to the observed value of respondent *i* of country *j* on indicator variable *k*,
- η_{Bj} refers to the score of country *j* on the between level latent variable η_B ,
- η_{Wij} refers to the score of respondent *i* of country *j* on the within level latent η_W ,
- υ_k refers to the intercept (usually called grand mean in multilevel analysis) of indicator variable *k*,
- λ_{Bk} refers to the between level factor loading λ_B of indicator variable *k*,
- λ_{Wk} refers to the within level factor loading λ_W of indicator variable *k*,
- ε_{Bjk} refers to the between level error term ε_B (usually called random term or u_{jk}-term in multilevel analysis) for country *j* on indicator variable *k*, and
- ε_{Wijk} refers to the within level error term ε_W for respondent *i* of country *j* on indicator variable *k*.

One-Level CFA vs. Two-Level CFA for Universalism

Respondent Level (n = 43,779) Country Level (n = 26)	Model 1a: One-Level CFA			Model 1b: Two-Level CFA		
AIC	**372209.497**			**368050.207**		
SRMR Within						
SRMR Between				**.062**		
	b	z		b	z	
Intercept Level 1						
Intercept Level 2						
Equality (ipeqopt)				3.894	100.478**	
Underst. Diff. People (ipudrst)				3.594	90.518**	
Environment (impenv)				3.832	87.229**	
Equality (ipeqopt)	3.890	783.571**				
Underst. Diff. People (ipeqopt)	3.589	696.455**				
Environment (impenv)	3.845	779.247**				
Factor Loadings	b	z	beta	b	z	beta
Equality (ipeqopt)				1.000	-.-	1.000
Underst. Diff. People (ipudrst)				.608	3.666**	.592
Environment (impenv)				.625	3.277**	.549
Equality (ipeqopt)	1.000	-.-	.578	1.000	-.-	.568
Underst. Diff. People (ipudrst)	1.069	60.117**	.596	1.069	57.275**	.585
Environment (impenv)	.964	60.997**	.561	.960	58.203**	.550

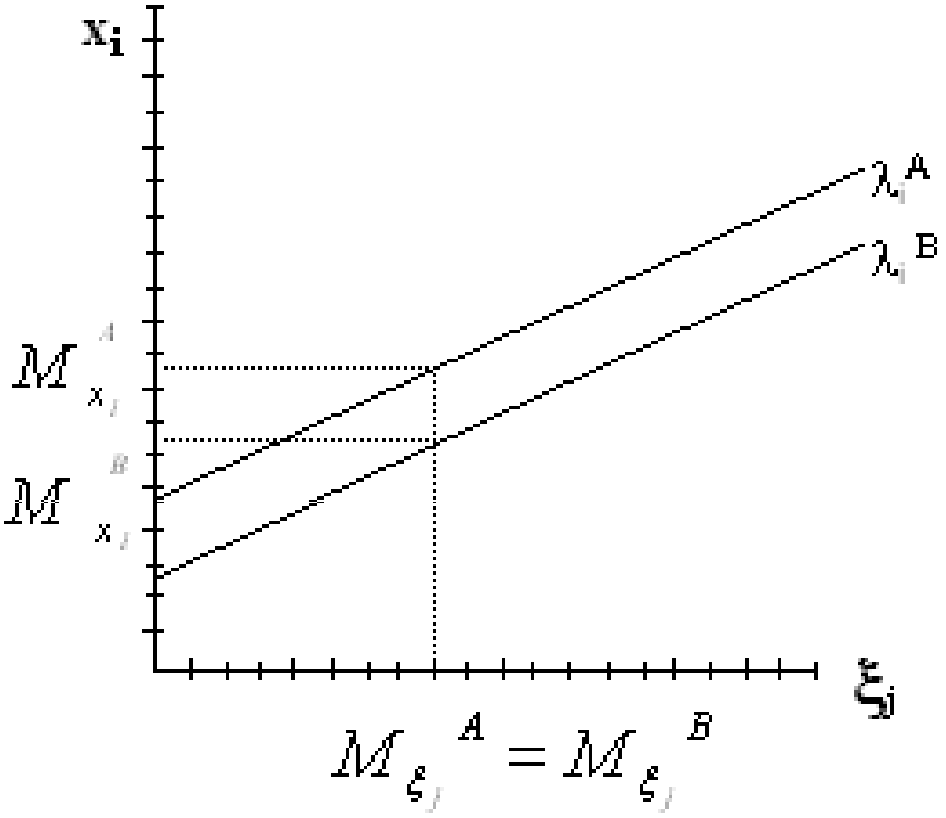
* $p \leq 0.05$; ** $p \leq 0.01$; Estimator: Full Maximum Likelihood (ML); the beta-coefficients are fully standardized; the residual variance of equality at level 2 turned out to be insignificant and has been fixed for that reason

One-Level CFA vs. Two-Level CFA for Universalism

Respondent Level (n = 43,779) Country Level (n = 26)	Model 1a: One-Level CFA		Model 1b: Two-Level CFA	
AIC	**372209.497**		**368050.207**	
SRMR Within				
SRMR Between			**.062**	
Residual Variances	Variance	z	Variance	z
Equality (ipeqopt)			-.-	-.-
Underst. Diff. People (ipudrst)			.026	3.504**
Environment (ipeqopt)			.035	3.511**
Equality (ipeqopt)	.718	93.533**	.703	93.393**
Underst. Diff. People (ipudrst)	.750	88.392**	.735	88.396**
Environment (ipeqopt)	.730	98.486**	.711	98.524**
Variance			Variance	z
Latent Factor (Universalism betw.)			.038	3.542**
Latent Factor (Universalism within)	.360	44.711**	.334	42.894**

* $p \leq 0.05$; ** $p \leq 0.01$; Estimator: Full Maximum Likelihood (ML); the residual variance of equality at level 2 turned out to be insignificant and has been fixed for that reason

Intercepts and Slopes:
Equal Slopes and Unequal Intercepts



Using mulilevel technique to explain measurement invariance

- The basic idea behind a two-level confirmatory factor analysis is to **decompose the variability** of the indicator variables **into** a respondent-level **“within” variability** and a country-level (group level) **“between” variability**.

- It **allows**, in a subsequent step, to **account for differences** in the **parameters between groups** by **including contextual variables**.

- In this way, the **multilevel CFA** (cf. Muthén 1994; Hox 2002) is extended to a **multilevel SEM** (cf. Muthén 1994; Selig et al. 2008), which allows the explanation of measurement noninvariance by contextual variables.