The Abdus Salam International Centre for Theoretical Physics

2372-11

Joint ICTP-IAEA Workshop on Sustainable Energy Development: Pathways and Strategies after Rio+20

1 - 5 October 2012

SUSTAINABILITY COMPOSITE INDICATORS: THE FEEM SUSTAINABLE INDEX

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LECTURE II

SUSTAINABILITY COMPOSITE INDICATORS: THE FEEM SUSTAINABLE INDEX

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Trieste, 2nd October 2012

OUTLINE

- *Motivation and purpose*
- *Methodology*
- *Current and Future sustainability (Scenarios Analysis)*
- *Conclusions*

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MOTIVATION

- Qualitative approaches still predominant => SD concept still vague (many definitions, many conferences, many books, lack of effective measurement)
  - ➢ Policy messages may be subjective or speculative

- Request for measurement through index/indicators

- Many list of indicators but only a few all-comprehensive indexes
  - ➢ Reconciling many indicators to assess overall sustainability performance through one index

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FRAMEWORK

- New approach to consider:

  - ✓ All dimensions simultaneously involved
  - ✓ Common framework for comparison
  - ✓ Future projections and scenario analysis

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MAIN PURPOSE

- Quantitative assessment of sustainability at country/macroregion scale (worldwide coverage) over time

- New (and quite complex) methodology:
  - ✓ Indicators computation => macroeconomic model (recursive-dynamic computable/applied general equilibrium model)
  - ✓ Aggregate Index => normalisation + aggregation

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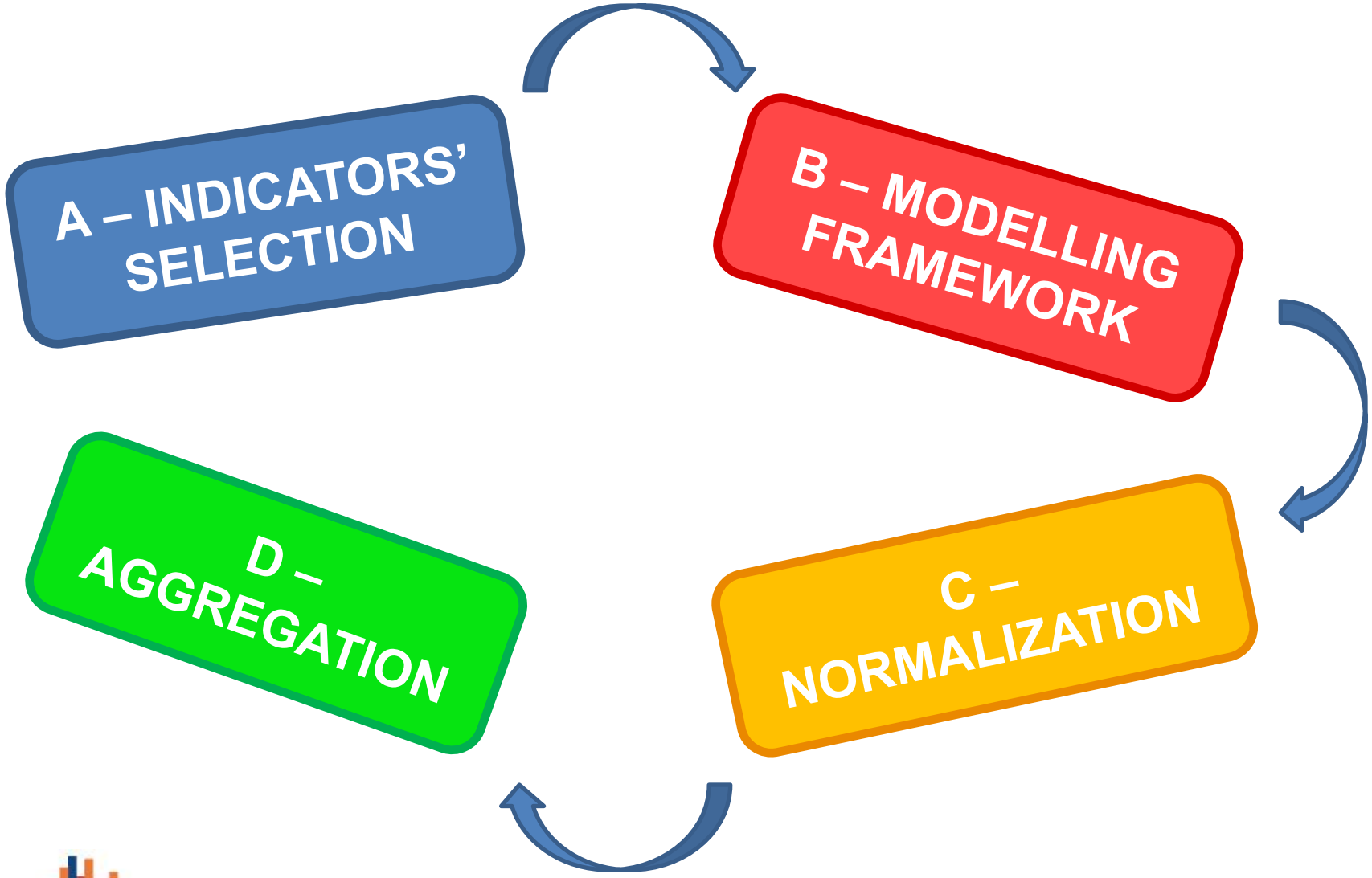
OVERALL STRUCTURE AND MAIN STEPS



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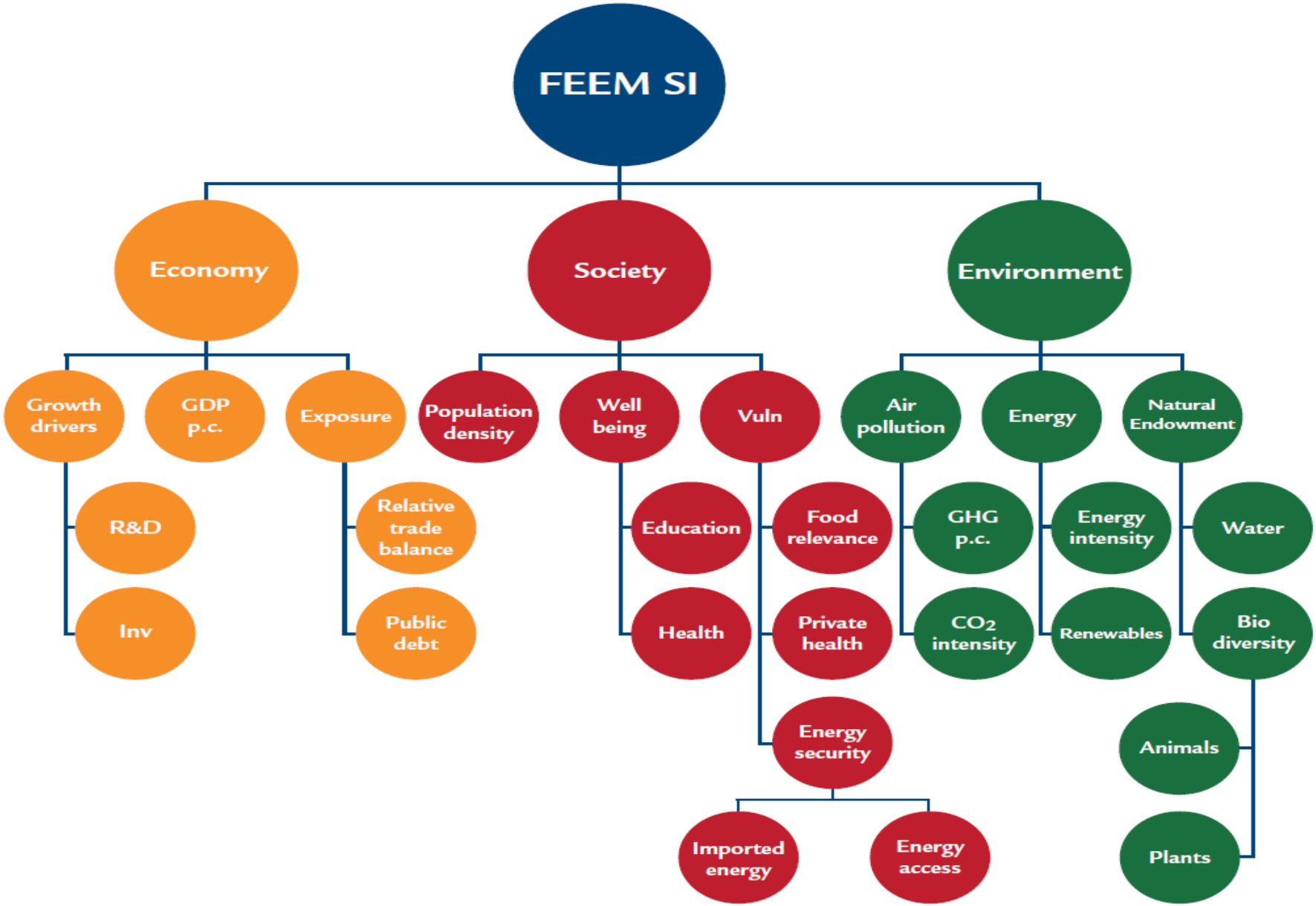
INDICATORS' SELECTION

INDICATOR SET	ORGANIZATION	TYPE
EU Sustainable Development Strategy (EU SDS)	European Commission	Theme-based indicator set
UN Commission on Sustainable Development (UN CDS)	United Nations	Three-pillar indicator set (2001) Theme-based indicator set (2006)
World Development Indicators (WDI)	World Bank	Theme-based indicator set
EEA core set of indicators	Eurostat, European Environmental Agency	Environmental indicators
International Energy Outlook (IEO)	International Energy Agency	Environmental indicators
World Economic Outlook Databases (WEO)	International Monetary Fund	Economic Indicators

INDICATORS' TREE



INDICATORS' DESCRIPTION

SD Dimension	INDICATOR	LONG DESCRIPTION
Economic	R&D	R&D expenditure / GDP (%)
	Investment	Net Investment / Capital Stock (%)
	GDP p.c.	GDP (PPP) / Population
	Relative Trade Balance	Trade Balance / Market Openness (exp + imp)
	Public Debt	Government Debt / GDP (%)
Environmental	GHG per capita	Kyoto GHGs Emissions / Population
	CO_2 Intensity	CO_2 Emissions / Total Primary Energy Cons.
	Energy Intensity	Total Primary Energy Supply / GDP PPP
	Renewables	Renewable Cons. / Total Primary Energy Cons. (%)
	Water	Water Use / Total Available Water (%)
	Plants	Endangered Species / Total Species (%)
	Animals	Endangered Species / Total Species (%)
Social	Population Density	Population / Country Inhabitable Surface
	Education	Education Exp. / GDP (%)
	Health	Health Exp. / GDP (%)
	Food Relevance	Food Cons. / Households' Exp. (%)
	Private Health	Private Health Exp. / Total Health Exp. (%)
	Energy Imported	Energy Imported / Energy Cons. (%)
	Energy Access	Population with Access to Electricity / Total Population (%)

MODELLING FRAMEWORK

- ICES-SI framework

  ✓ Recursive-Dynamic Computable General Equilibrium model (ICES)

  ✓ GTAP 7 database

  => Both extended for FEEM SI purpose

MODELLING FRAMEWORK: DATABASE

- GTAP7 database (Narayanan and Walmsley, 2008)

  - ✓ Content: all economic (and energy) flows in Input-Output (SAM) matrix format
  - ✓ Baseyear: 2004
  - ✓ Geographic coverage: world (113 countries/regions)
  - ✓ Sector coverage: the whole economic system (split in 57 sectors)

MODELLING FRAMEWORK: DATABASE EXTENSIONS

- Split of several sectors

Original GTAP7 sector	New involved sector
"Other Business Services"	*R&D*
"Other Generative Services"	*Private Health/Public Health Education*
"Electricity"	*Renewables*

MODELLING FRAMEWORK: DATABASE EXTENSIONS

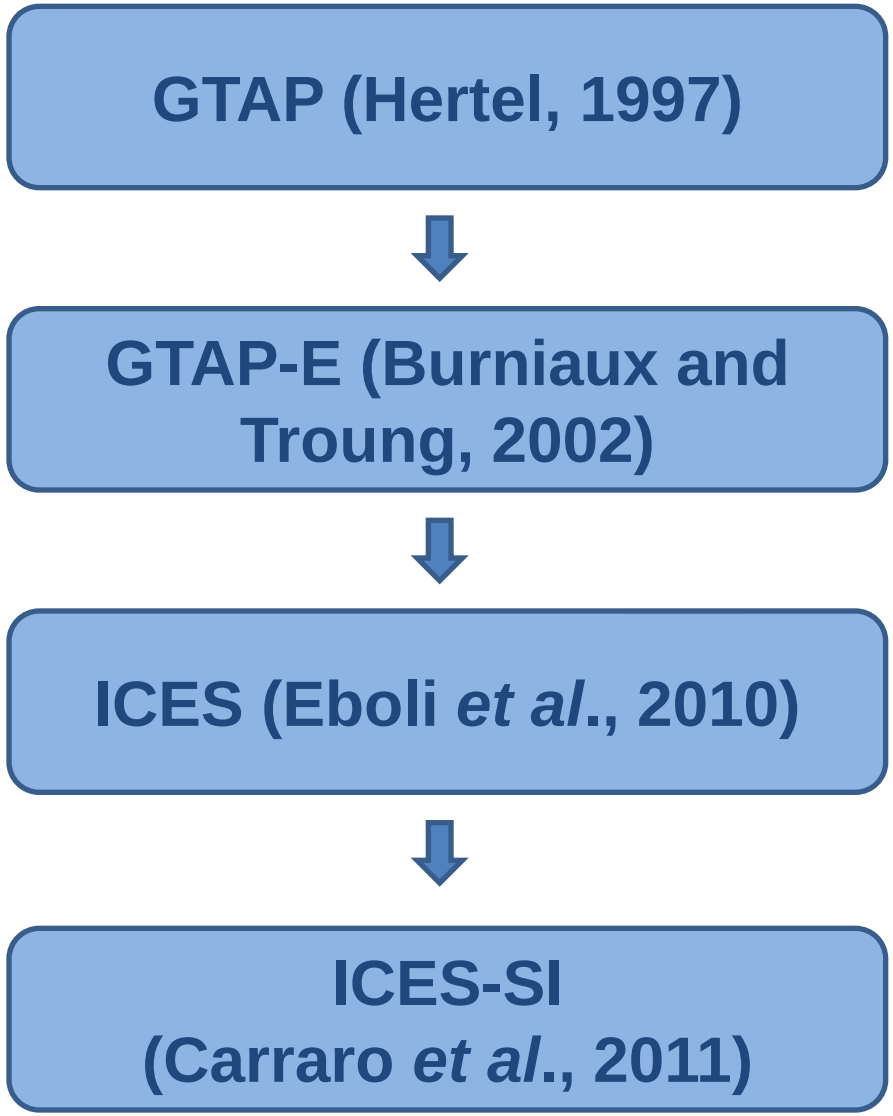
- Enriched with following data for 2004:

  - ✓ GDP (PPP)
  - ✓ Public Debt
  - ✓ CO_2 and other GHGs
  - ✓ Water consumption and available water stock
  - ✓ Animals and Plants species
  - ✓ Inhabitable surface
  - ✓ Energy Access population

MODELLING FRAMEWORK: CGE Models

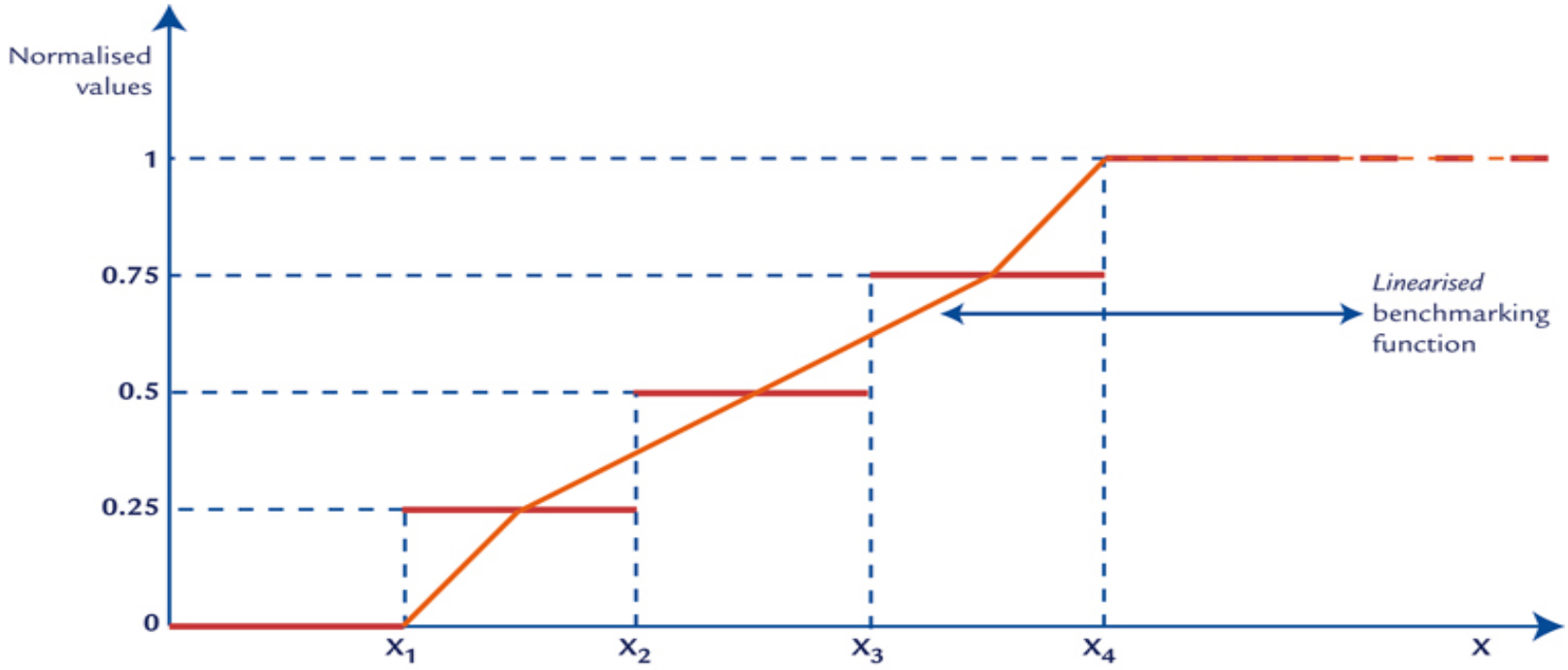
- Main scope: assessing higher-order (general) effects on the whole economic system assuming localized shocks within it
- Initial application: International trade, taxation, agricultural policy => recent development on environmental economics (mainly climate change and other transboundary issues)
- Main results: impacts on GDP, sectoral output and prices, international trade when considering market-driven (autonomous) adaptation of economic agents (vs bottom-up approaches) => scenario analysis

MODELLING FRAMEWORK: MODEL IMPROVEMENT



NORMALIZATION: RESCALING

- Indicators are normally expressed in different measure units. Make them comparable and allow aggregation, requires a normalization procedure such that all of them will be defined in the [0,1] interval.



NORMALIZATION: BENCHMARKING

Normalised Value	Sustainability Level
0	Extremely unsustainable
0.25	Still not sustainable but not as severely as in the previous case
0.50	Discrete level of sustainability, but still far from target
0.75	Satisfactory level of sustainability, yet not on target
1	Fully sustainable

AGGREGATION: preferences' elicitation

- **The preference among sustainability indicators is obtained with an "ad hoc" questionnaire that elicits individual preferences on the specific performance of each sustainability indicator and their coalitions. This allows capturing a broader view on sustainability throughout the world.**

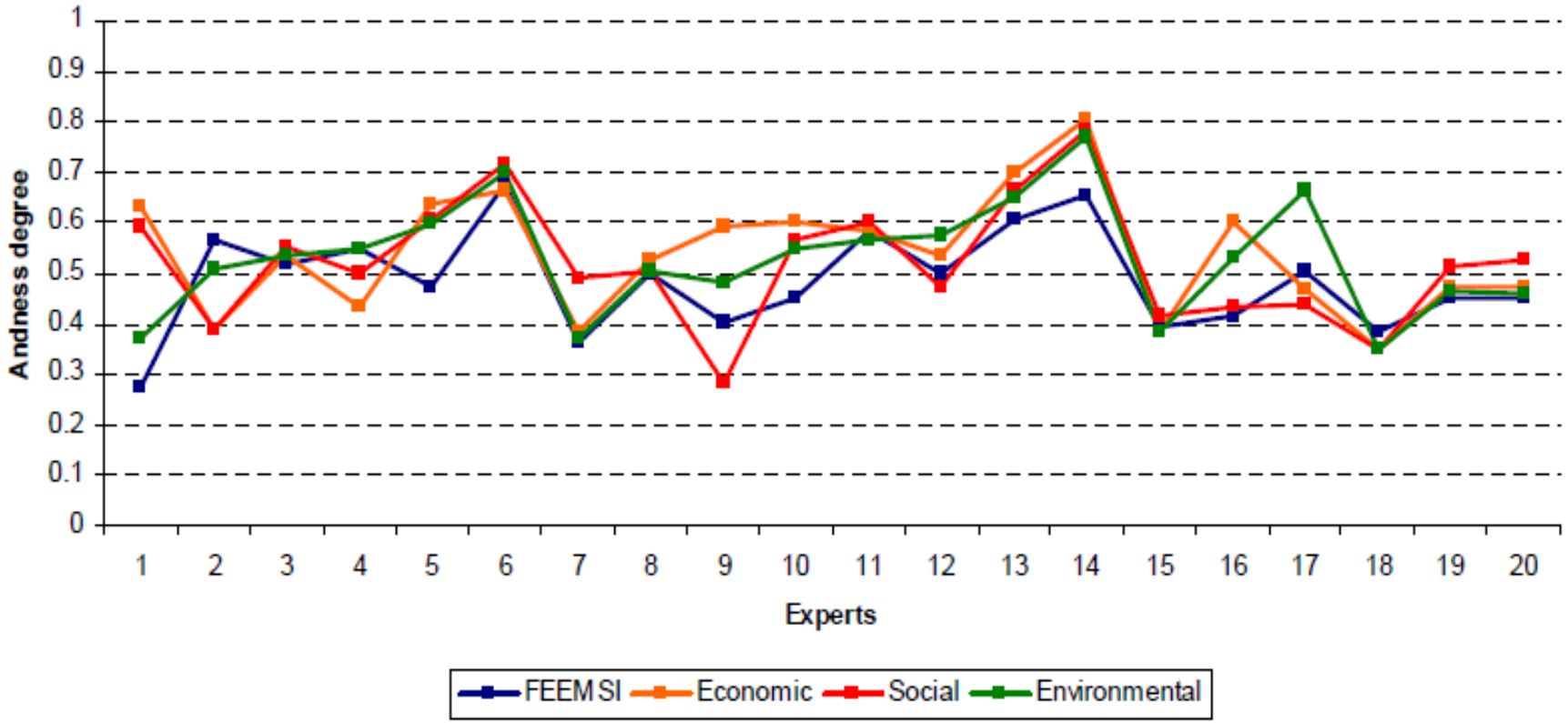
Economic	Social	Environmental	Weights
Worst	Worst	Worst	0
Best	Worst	Worst	20
Worst	Best	Worst	50
Worst	Worst	Best	30
Best	Best	Worst	$X \geq 50$
Best	Worst	Best	$X \geq 30$
Worst	Best	Best	$X \geq 50$
Best	Best	Best	100

Monotonicity

Experts/stakeholders/decision makers?

AGGREGATION: andness/orness

Compensative or not?



AGGREGATION: representativeness and consensus

- A consensus measure among experts' valuations is considered in order to derive a 'representative' weight assigned to each sustainability indicator. For this purpose, the metric distance measure is used to assign weights to valuations of each respondent at each node in the decision tree.

- The FEEM SI 2011 optimises the trade off between simplicity and effectiveness in representing preferences by focusing specifically on the interrelations across indicators (non additive measure, since allows considering redundancy and synergy). Therefore, a suitable algorithm based on the Choquet integral aggregates all criteria into a single outcome, taking into account all the coalition weights.

AGGREGATION: Shapley index

Indicator's contribution to overall index

Indicator	Contribution to overall index
GDP per capita	0.1128
Population Density	0.0790
Education	0.0644
Health	0.0639
GHG per capita	0.0637
R&D	0.0635
Water	0.0635
Renewables	0.0618
CO_2 Intensity	0.0616
Investment	0.0600
Energy Intensity	0.0564
Relative Trade Balance	0.0487
Food relevance	0.0416
National Debt	0.0410
Private Health	0.0362
Animals	0.0258
Plants	0.0253
Energy Imported	0.0154
Energy Access	0.0154

Relative importance of each indicator at a given node

Node	Criterion	Shapley value
FEEMSI	Economic	0.326
	Social	0.316
	Environmental	0.358
Economic	Growth drivers	0.379
	GDP per capita	0.346
	Exposure	0.275
Social	Population Density	0.250
	Well Being	0.406
	Vulnerability	0.344
Environment	Air pollution	0.350
	Energy	0.330
	Natural Endowment	0.320
Growth Drivers	R&D	0.514
	Investment	0.486
Exposure	Relative Trade Balance	0.543
	National Debt	0.457
Well Being	Education	0.502
	Health	0.498
Vulnerability	Food relevance	0.383
	Energy Security	0.283
	Private Health	0.333
Energy Security	Energy Imported	0.500
	Energy Access	0.500
Air pollution	GHG per capita	0.508
	CO_2 Intensity	0.492
Energy	Energy Intensity	0.477
	Renewables	0.523
Natural Endowment	Biodiversity	0.446
	Water	0.554
Biodiversity	Animals	0.504
	Plants	0.496

APPLICATION: REGIONAL DETAIL

No.	Country/Region
1	Australia
2	NewZealand
3	Japan
4	Korea
5	China
6	India
7	Indonesia
8	SEastAsia
9	RoAsia
10	USA
11	Canada
12	Mexico
13	Brazil
14	RoLA
15	Austria
16	Benelux
17	Denmark
18	Finland
19	France
20	Germany

No.	Country/Region
21	Greece
22	Ireland
23	Italy
24	Poland
25	Portugal
26	Spain
27	Sweden
28	UK
29	RoEU
30	Switzerland
31	Norway
32	RoEurope
33	Russia
34	RoFSU
35	Turkey
36	MiddleEast
37	NorthAfrica
38	RoAfrica
39	SouthAfrica
40	RoWorld

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APPLICATION: SECTOR DETAIL

No.	Sector
1	Food
2	Forestry
3	Fishing
4	Coal
5	Oil
6	Gas
7	Petroleum Products
8	Other Electricity
9	Renewables
10	Nuclear
11	Biofuels
12	Energy Intensive Industries
13	Other Industries
14	Water
15	Market Services
16	Public Services
17	R&D
18	Education
19	Private Health
20	Public Health

WORLD SUSTAINABILITY RANKING IN 2011

Rank 2011	Country	FEEM SI 2011
1	Norway	0.82
2	Sweden	0.77
3	Switzerland	0.70
4	Austria	0.69
5	Finland	0.66
6	Denmark	0.65
7	Canada	0.64
8	France	0.63
9	Ireland	0.62
10	NewZealand	0.61
11	USA	0.55
12	Australia	0.55
13	Brazil	0.55
14	UK	0.53
15	RoEurope	0.53
16	Germany	0.52
17	Portugal	0.52
18	RoLA	0.51
19	Spain	0.50
20	Benelux	0.50

Rank 2011	Country	FEEMSI 2011
21	Russia	0.49
22	RoEU	0.49
23	Mexico	0.49
24	Korea	0.48
25	Italy	0.47
26	Japan	0.46
27	Turkey	0.45
28	MiddleEast	0.45
29	Poland	0.43
30	SouthAfrica	0.43
31	Greece	0.40
32	RoAfrica	0.40
33	RoWorld	0.39
34	SEastAsia	0.37
35	RoFSU	0.37
36	NorthAfrica	0.34
37	RoAsia	0.33
38	Indonesia	0.30
39	China	0.29
40	India	0.24

FEEM SUSTAINABILITY INDEX

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FEEM SI vs … GDP!!!

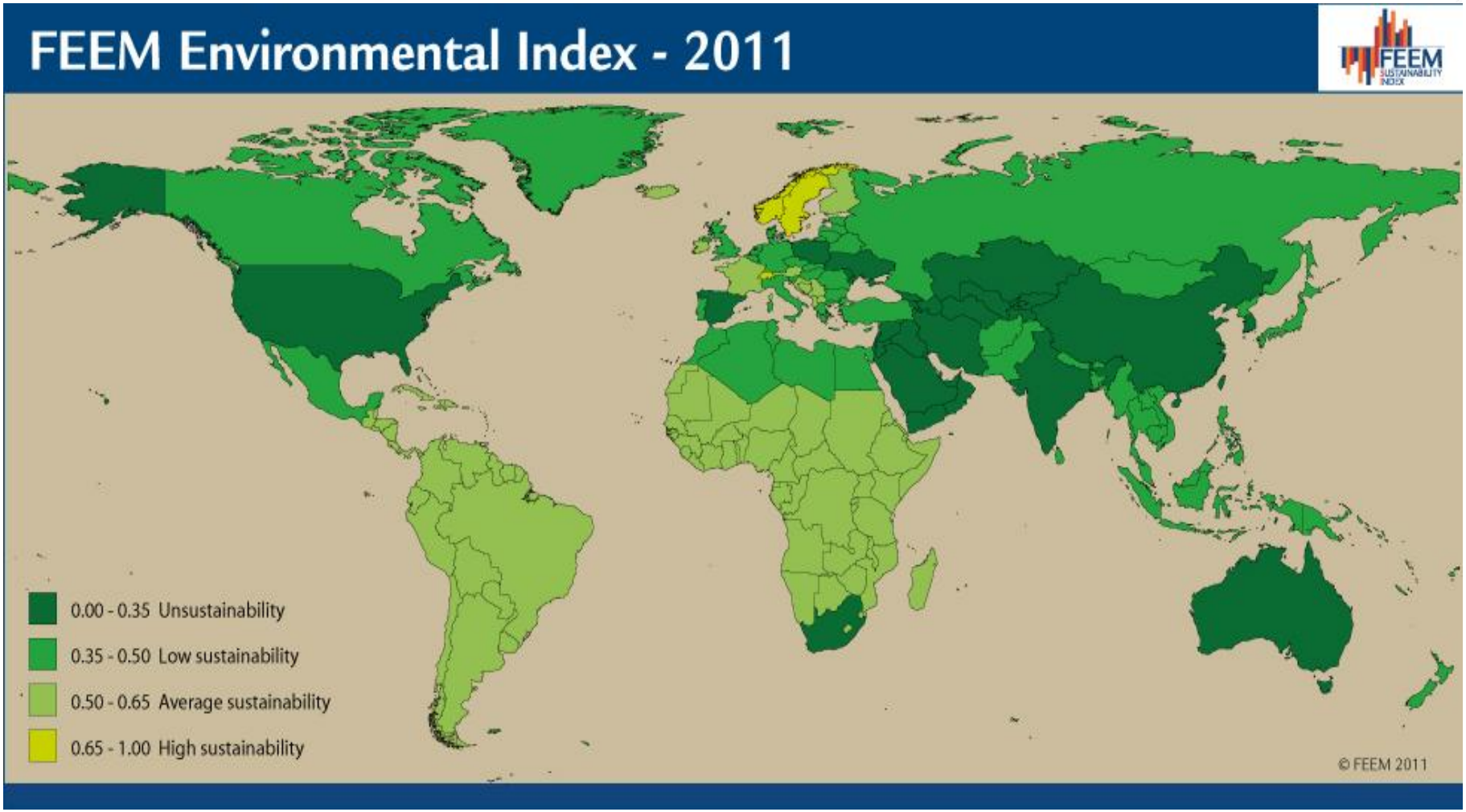
Correlation coefficients between GDP p.c. & FEEM SI, economic, social and environmental pillars

	FEEM SI	ECONOMIC	SOCIAL	ENVIRONMENTAL
GDP p.c. (Pearson)	0.804*** (0.000)	0.881*** (0.000)	0.739*** (0.000)	0.253 (0.115)
GDP p.c. (Spearman)	0.841*** (0.000)	0.884*** (0.000)	0.760*** (0.000)	0.227 (0.159)
GDP p.c. (Kendall)	0.650*** (0.000)	0.731*** (0.000)	0.579*** (0.000)	0.187* (0.091)

Data are significant at different levels: * p<0.1, ** p<0.05, *** p<0.01

P-values are reported in brackets

WORLD SUSTAINABILITY MAPS IN 2011



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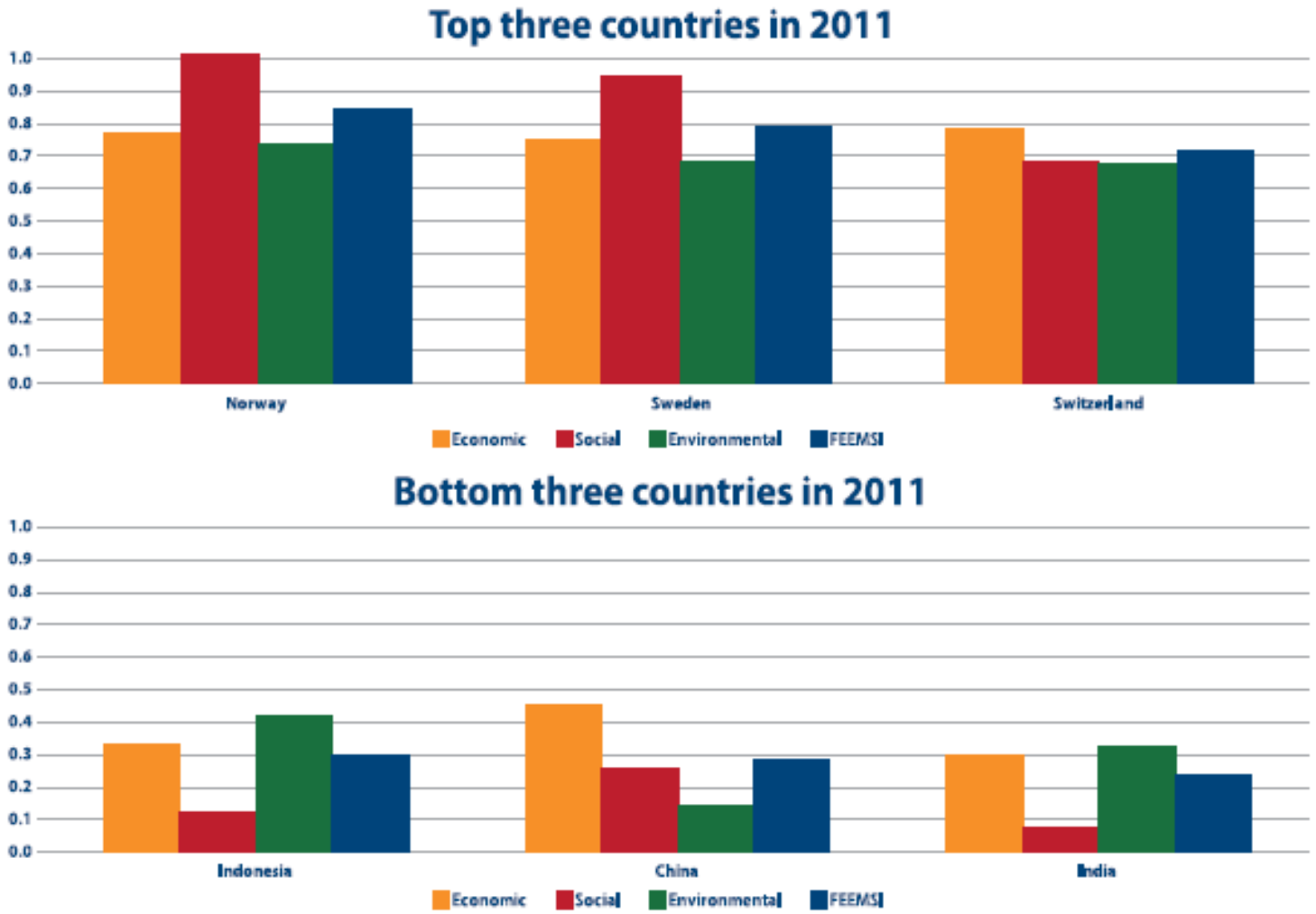
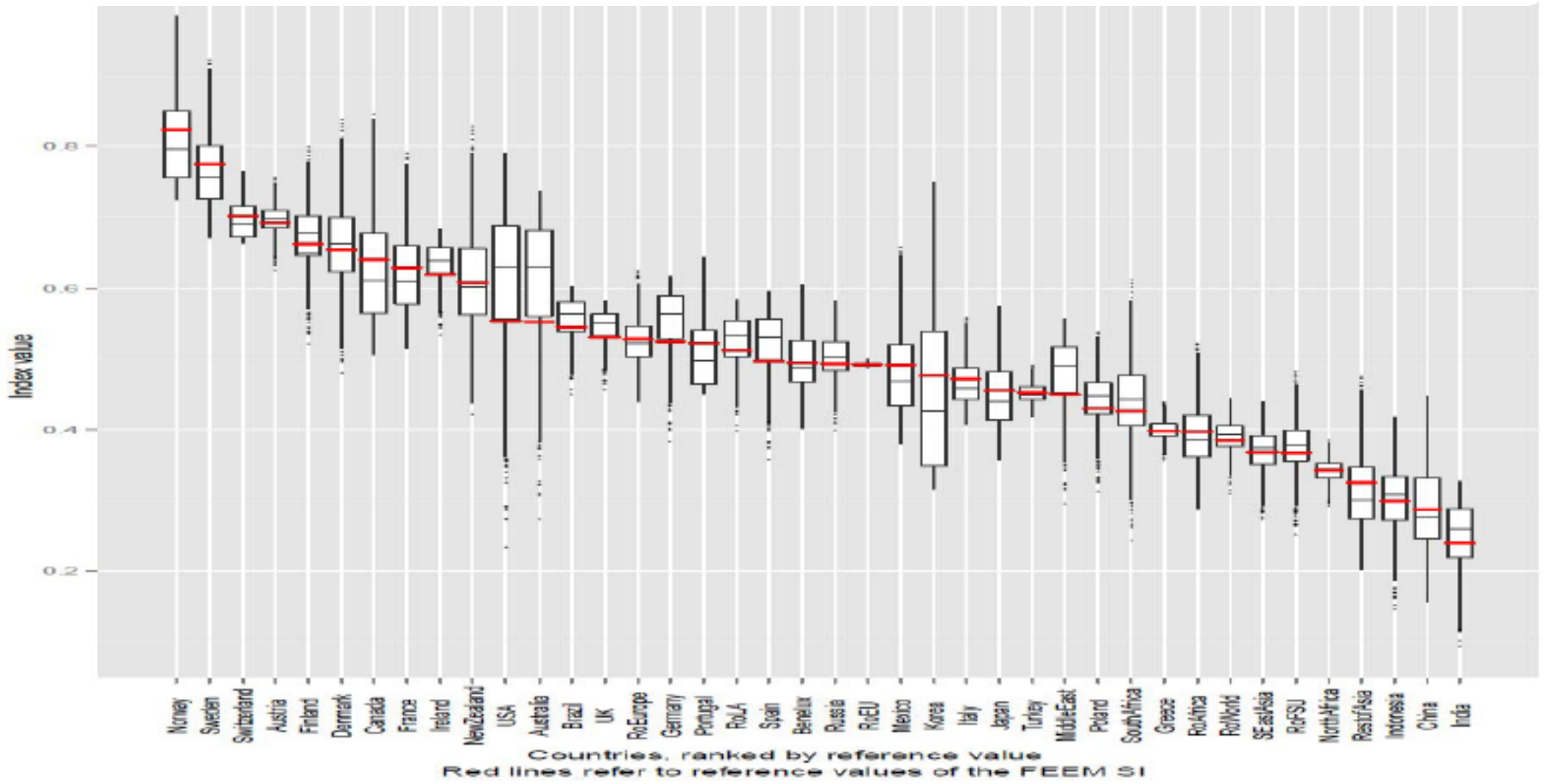
CURRENT SUSTAINABILITY DRIVERS

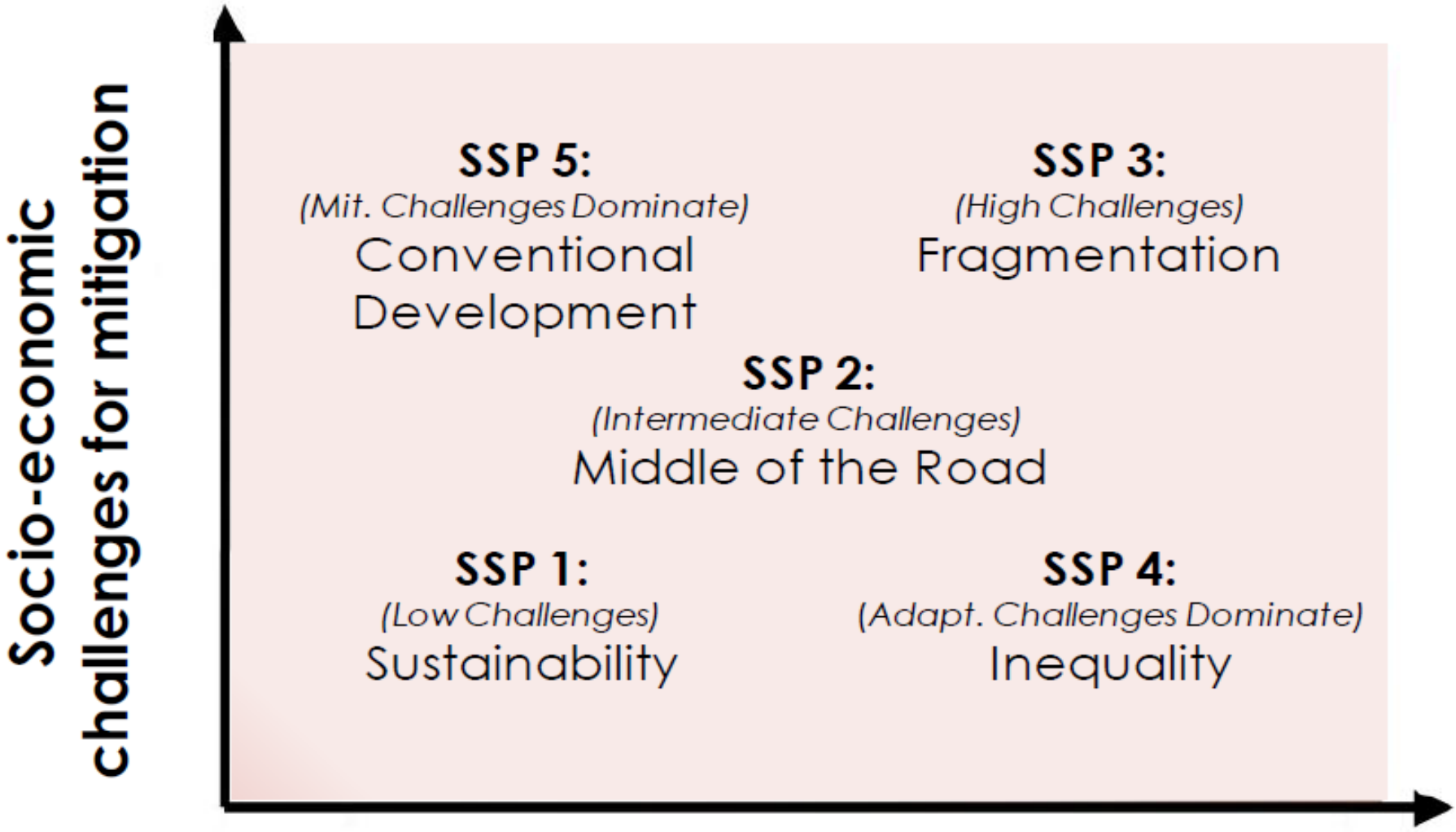


SENSITIVITY/ROBUSTNESS

Distribution of FEEM SI value by country according to 500 artificial decision makers



THE BASELINE SCENARIO

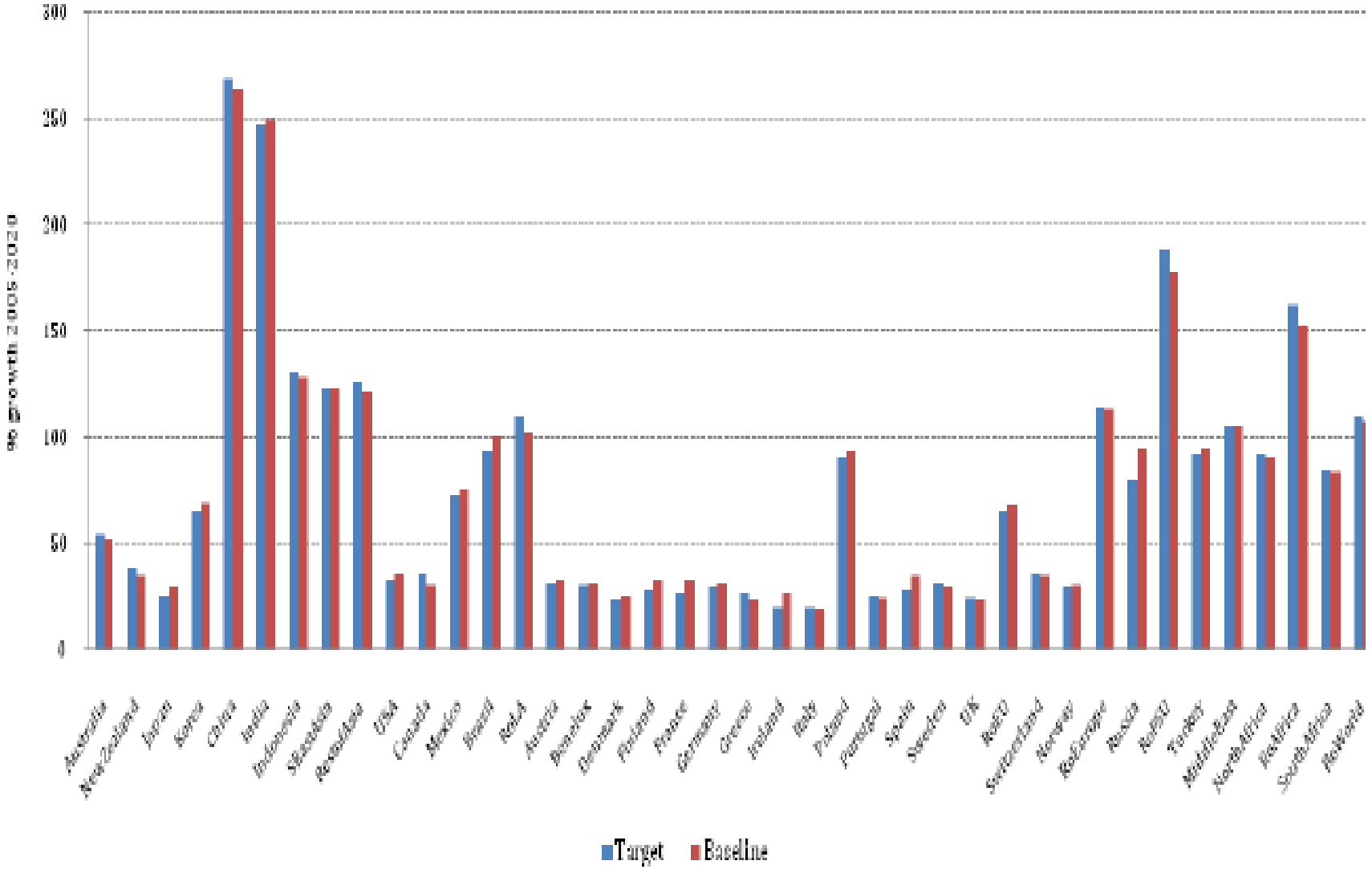


THE BASELINE SCENARIO

Main variables and reference sources in the baseline scenario

Variable	Reference source
Population	UN World Population Prospect (2010 revision) – medium fertility variant
Fossil fuel prices	Eurelectric (2010)
GDP	2005-2009 = World Bank (WDI 2010) 2010-2020 = MMC_G10 scenario Med Pop - Medium Growth - Fast Convergence (Conv) developed within the RoSE project + World Economic Outlook 2010 (IMF, 2010) for downscaling at country level
Energy intensity	2005-2009 = IEA (2010) 2010-2020 = endogenous
CO_2 emissions	2005-2009 = IEA (2010) 2010-2020 = endogenous
Public debt	IMF (2010)

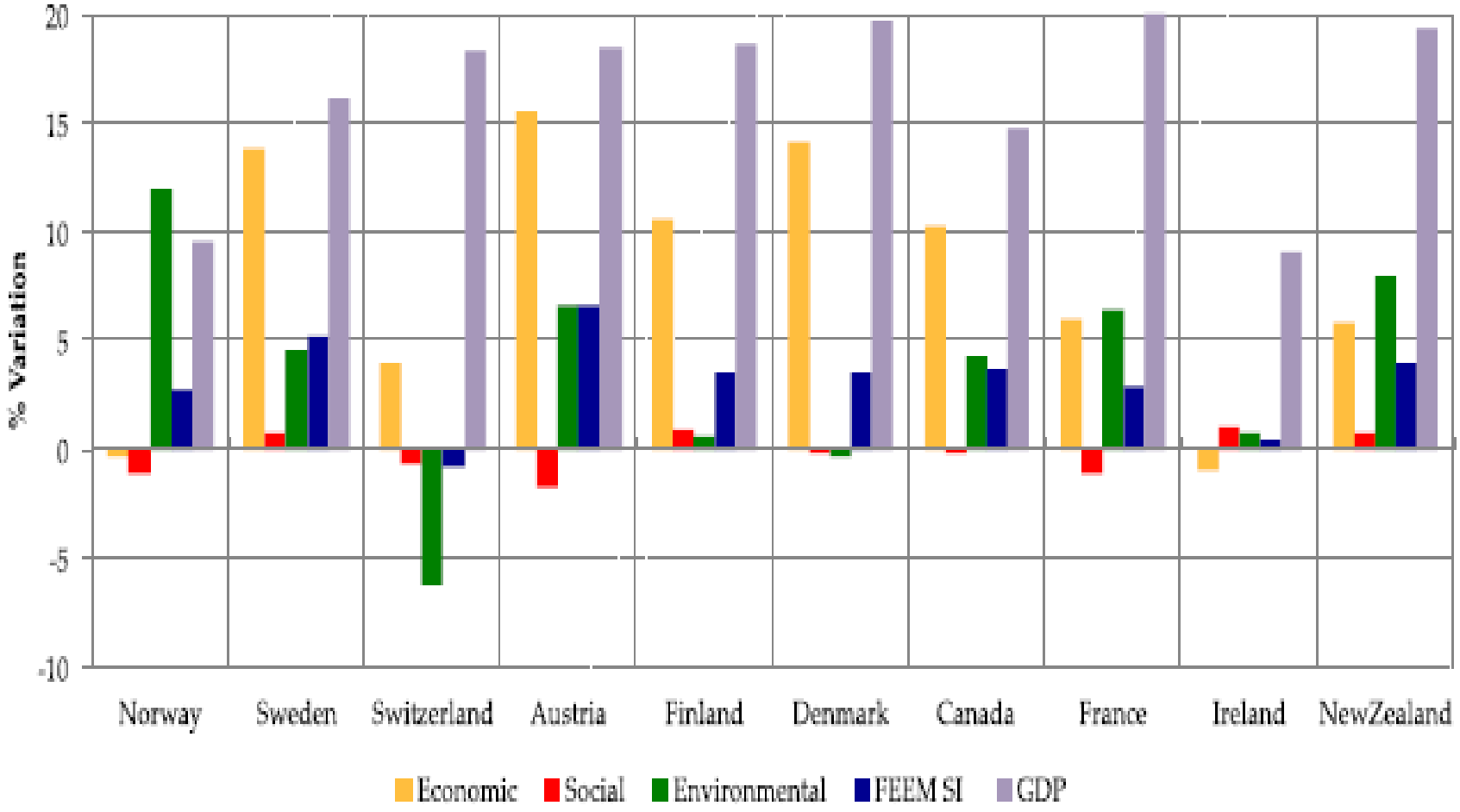
GDP growth 2005-2020



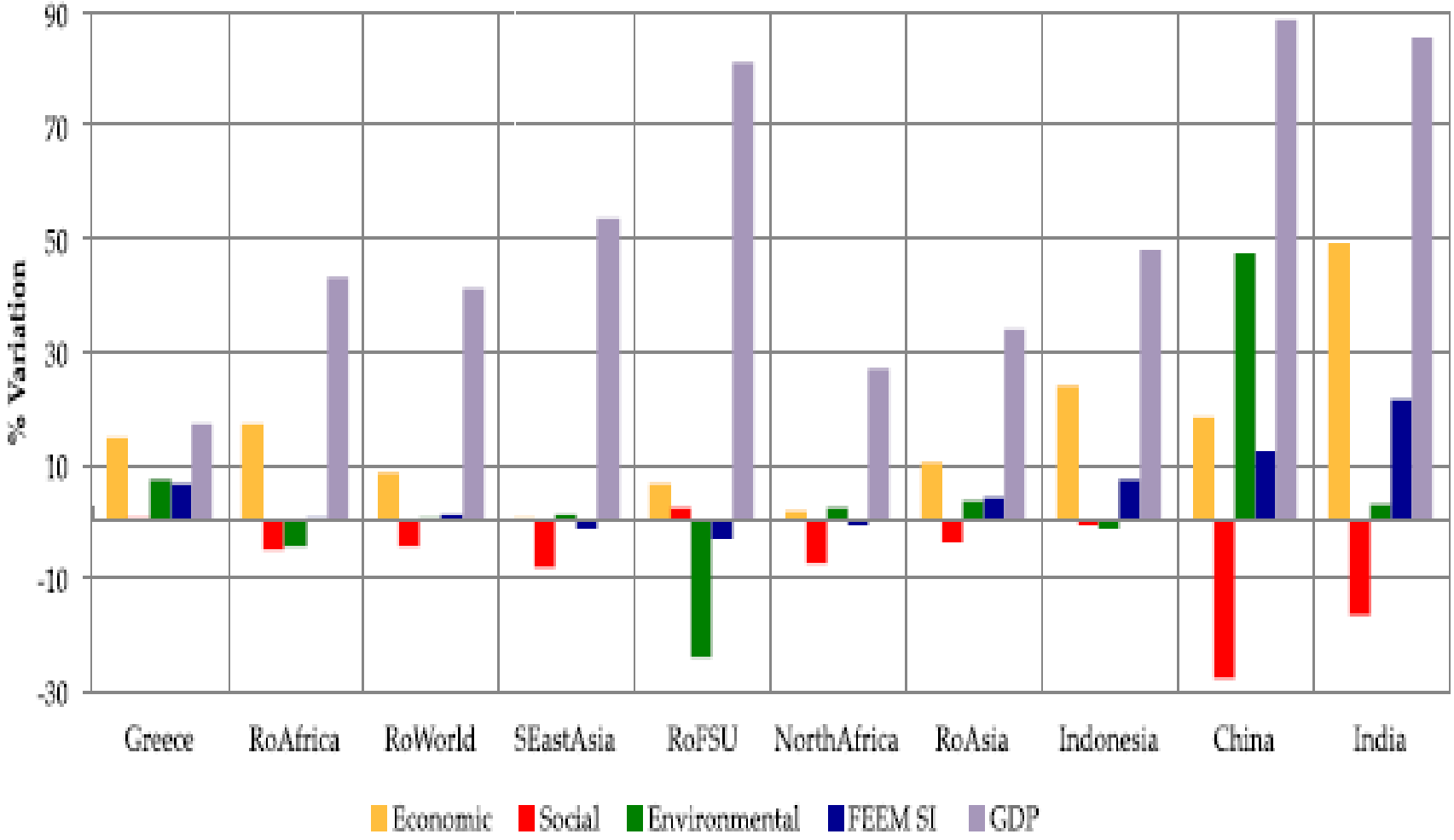
SUSTAINABILITY PICTURE: 2020 vs 2011

Rank 2011	Country	FEEM SI 2011	Δ RANK	FEEM SI 2020	Country	Rank 2020
1	Norway	0.82	=	0.85	Norway	1
2	Sweden	0.77	=	0.81	Sweden	2
3	Switzerland	0.70	-1	0.74	Austria	3
4	Austria	0.69	1	0.70	Switzerland	4
5	Finland	0.66	=	0.68	Finland	5
6	Denmark	0.65	=	0.68	Denmark	6
7	Canada	0.64	=	0.67	Canada	7
8	France	0.63	=	0.65	France	8
9	Ireland	0.62	-1	0.63	NewZealand	9
10	NewZealand	0.61	1	0.62	Ireland	10
11	USA	0.55	-6	0.58	Germany	11
12	Australia	0.55	=	0.58	Australia	12
13	Brazil	0.55	-2	0.56	Benelux	13
14	UK	0.53	=	0.55	UK	14
15	RoEurope	0.53	-1	0.54	Brazil	15
16	Germany	0.53	5	0.54	RoEurope	16
17	Portugal	0.52	-2	0.53	USA	17
18	RoLA	0.51	=	0.53	RoLA	18
19	Spain	0.50	-2	0.53	Portugal	19
20	Benelux	0.50	7	0.51	RoEU	20
21	Russia	0.49	-5	0.50	Spain	21
22	RoEU	0.49	2	0.50	Italy	22
23	Mexico	0.49	-2	0.49	Korea	23
24	Korea	0.48	1	0.49	Japan	24
25	Italy	0.47	3	0.48	Mexico	25
26	Japan	0.46	2	0.48	Russia	26
27	Turkey	0.45	=	0.48	Turkey	27
28	MiddleEast	0.45	=	0.47	MiddleEast	28
29	Poland	0.43	=	0.44	Poland	29
30	SouthAfrica	0.43	=	0.43	SouthAfrica	30
31	Greece	0.40	=	0.43	Greece	31
32	RoAfrica	0.40	=	0.40	RoAfrica	32
33	RoWorld	0.39	=	0.39	RoWorld	33
34	SEastAsia	0.37	=	0.36	SEastAsia	34
35	RoFSU	0.37	=	0.36	RoFSU	35
36	NorthAfrica	0.34	=	0.34	NorthAfrica	36
37	RoAsia	0.33	=	0.34	RoAsia	37
38	Indonesia	0.30	-1	0.32	China	38
39	China	0.29	1	0.32	Indonesia	39
40	India	0.24	=	0.29	India	40

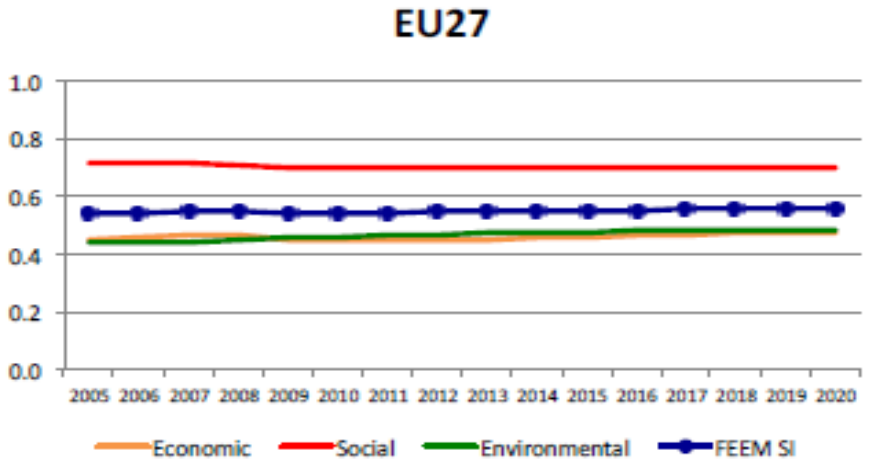
SUSTAINABILITY TRENDS: TOP TEN

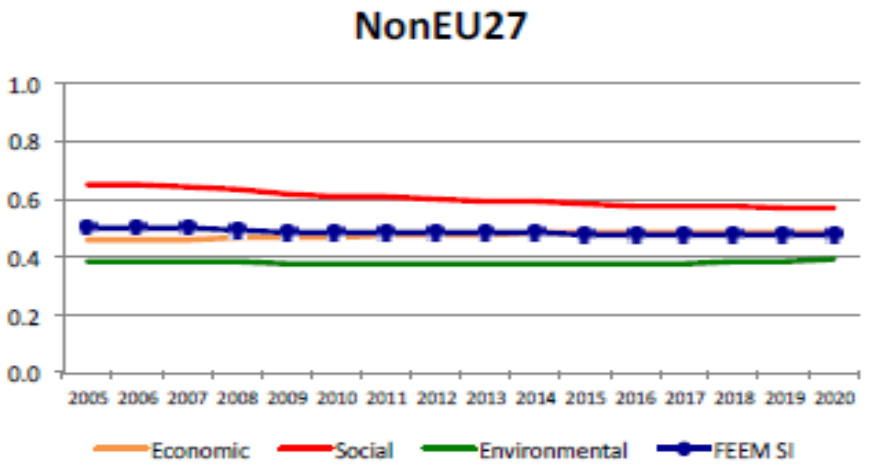


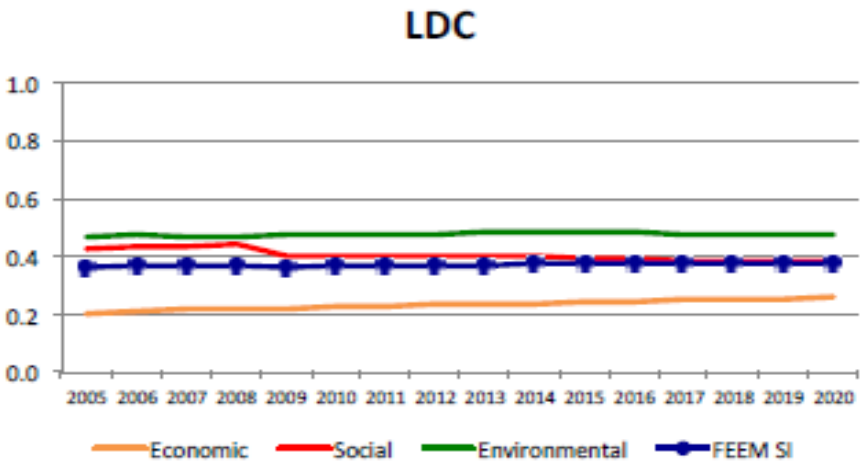
SUSTAINABILITY TRENDS: BOTTOM TEN

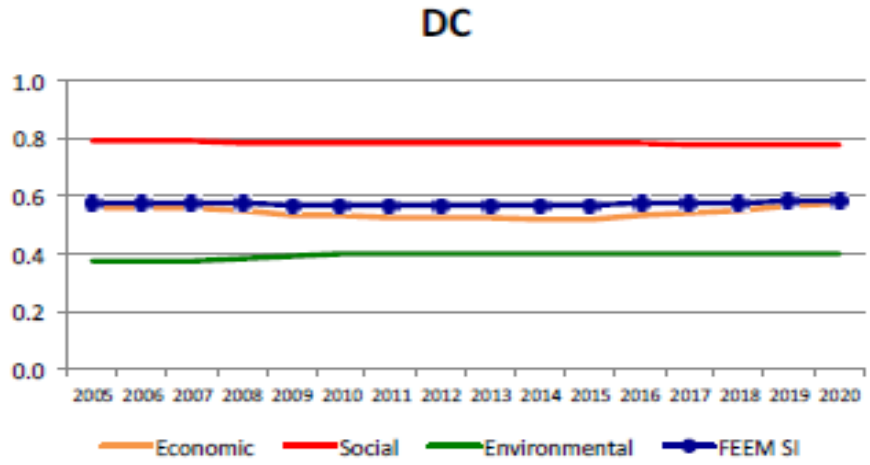


SUSTAINABILITY TRENDS: AGGREGATES







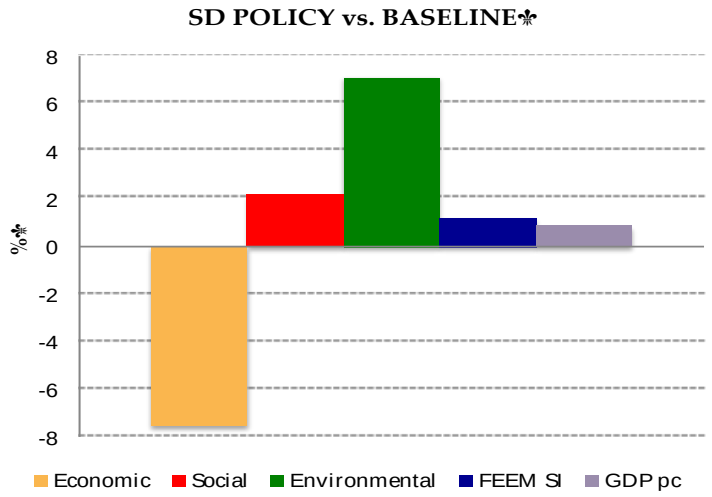


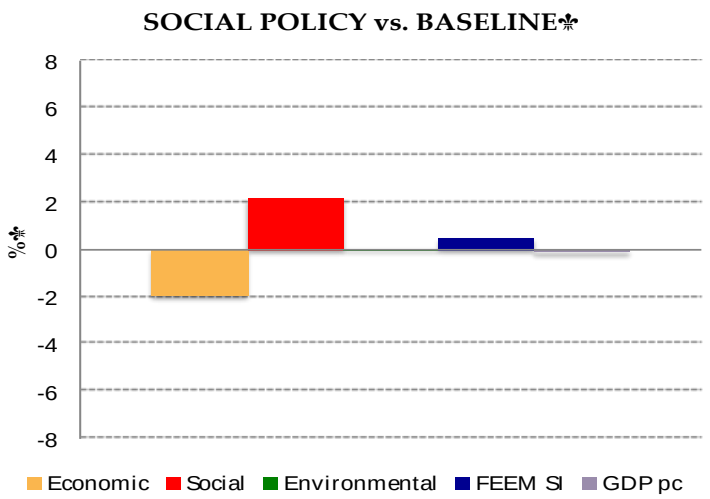
COUNTERFACTUALS => SUSTAINABLE POLICIES

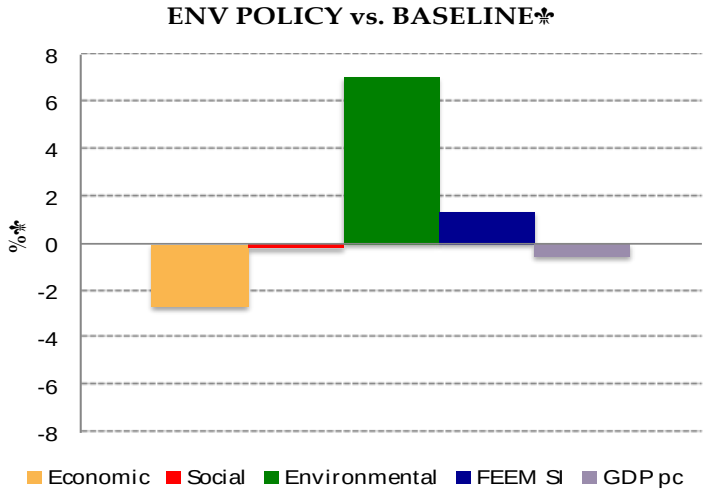
Climate Policy: Cancun Agreements - High-pledges

Countries	Emissions reduction in 2020	Base Year
Australia	-11%	1990
Brazil	-38.9%	BaU
Canada	2.52%	1990
China	Carbon intensity of output -45%	2005
EU27	-30%	1990
India	Carbon intensity of output -25%	2005
Indonesia	-26%	BaU
Japan	-25%	1990
Korea	-30%	BaU
Mexico	-30%	BaU
New Zealand	-20%	1990
Norway	-40%	1990
Russia	-25%	1990
South Africa	-34%	BaU
USA	-3%	1990
Global target	*-8%*	*1990*

POLICY EFFECTS: WORLD

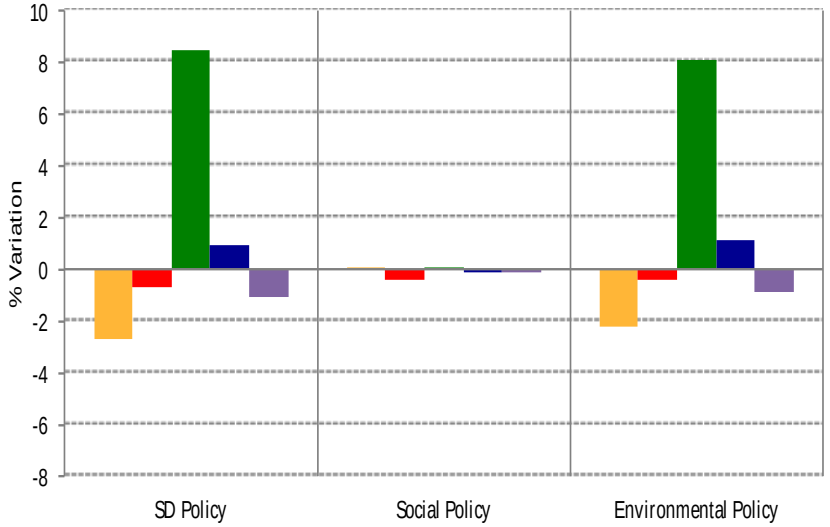




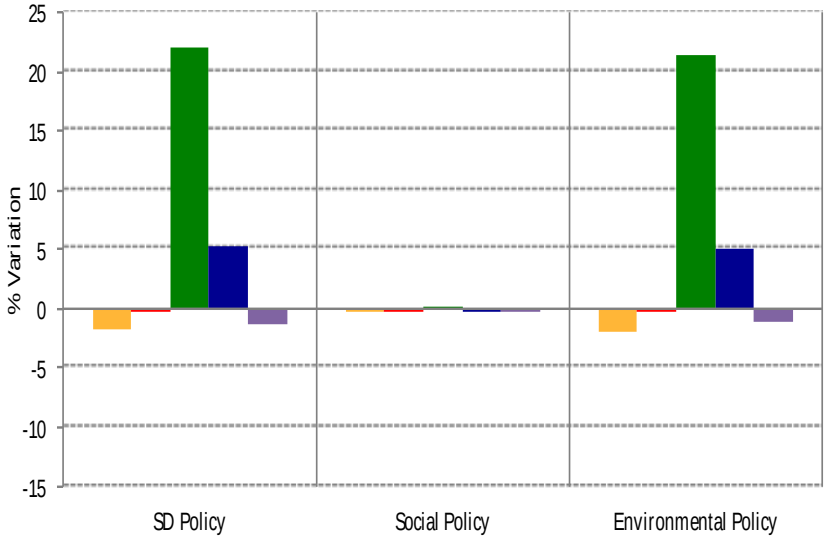


POLICY EFFECTS: REGIONAL AGGREGATES

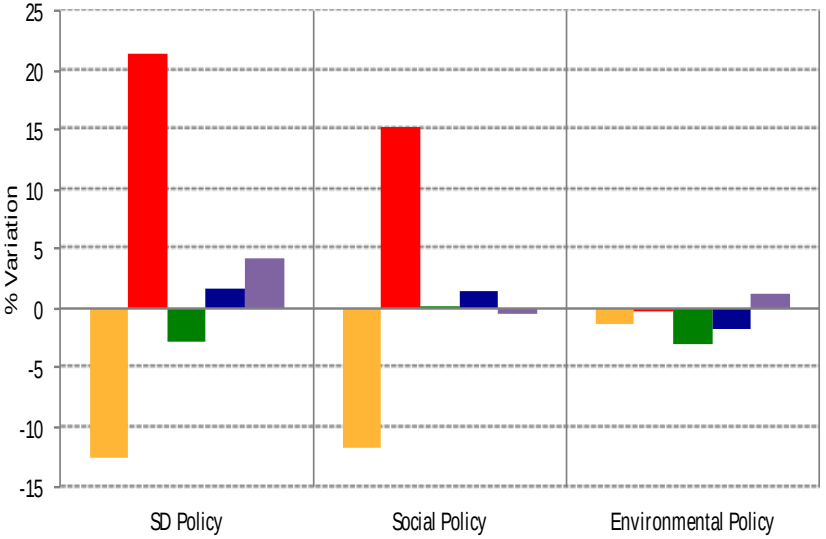
EU27



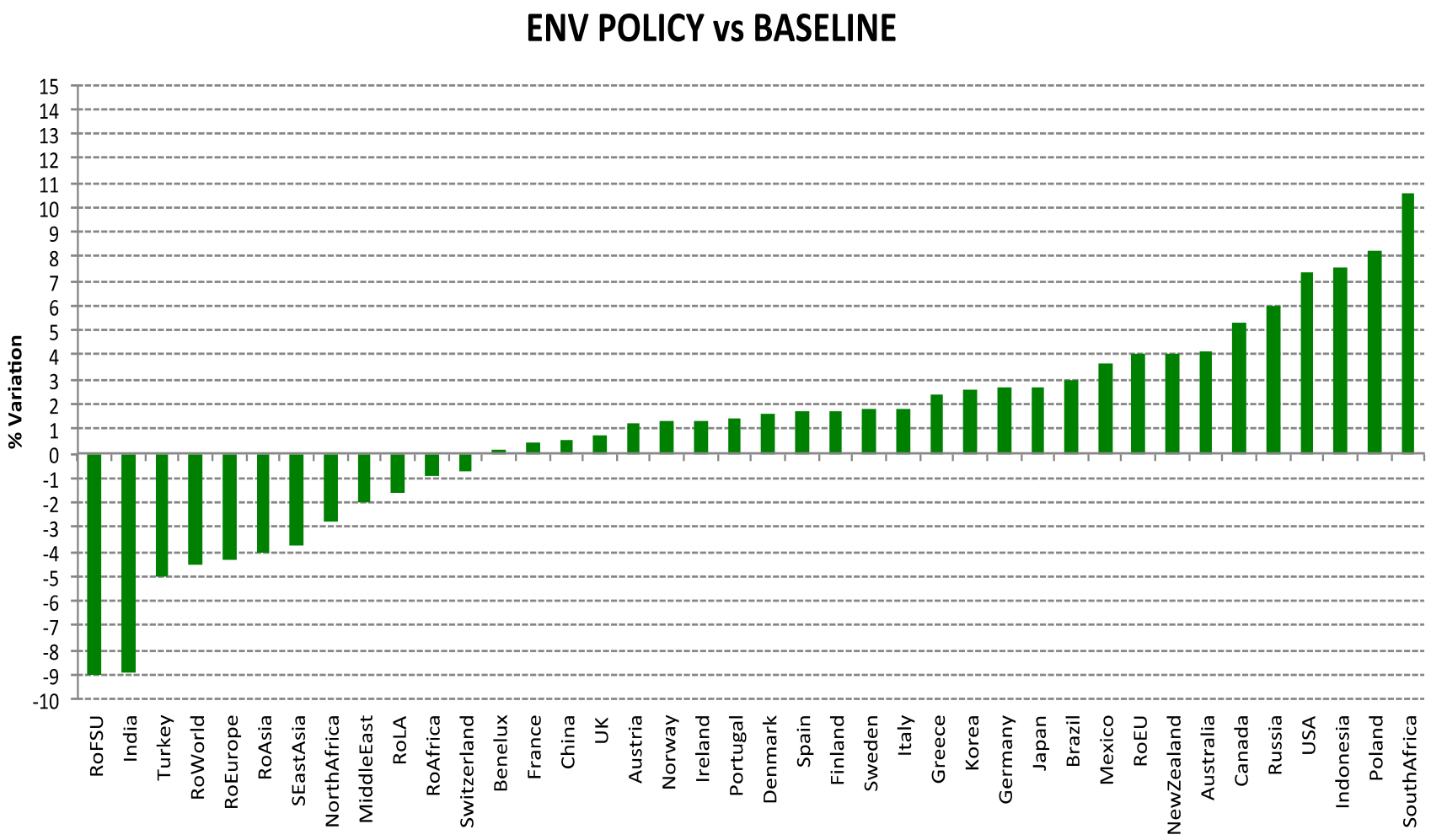
DC



LDC



POLICY EFFECTS: REGIONAL AGGREGATES



CONCLUSIONS

- A nex composite index to assess future sustainability worldwide is proposed
- The approach allows considering higher order effects deriving from changes in economic system (also due to policies for sustainability)
- In the next decade, sustainability at world level is expected to decrease, mainly due to the social component deterioration (decoupling between GDP and sustainability)
- *Ad hoc* sectoral policies are expected to increase sustainability at world level (higher benefits than costs in terms of sustainability)
- An integrated policy for SD implies best outcomes worldwide

FEEM SUSTAINABILITY INDEX

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FEEM SUSTAINABILITY INDEX

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Thank you for your attention!

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