



institut**Curie**

***Political Atlas of the World:  
Comprehensive static and dynamic data on  
192 states in 1989-2005***

***Approaches to Atlas data visualization***

***Andrei Zinovyev***

Head of the Team

“Systems biology and  
visualization of multidimensional data”

**Bioinformatics Laboratory  
of Institut Curie (Paris)**

# Political Atlas of the World project (МГИМО, Эксперт, ИОП)

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## STATIC DATA

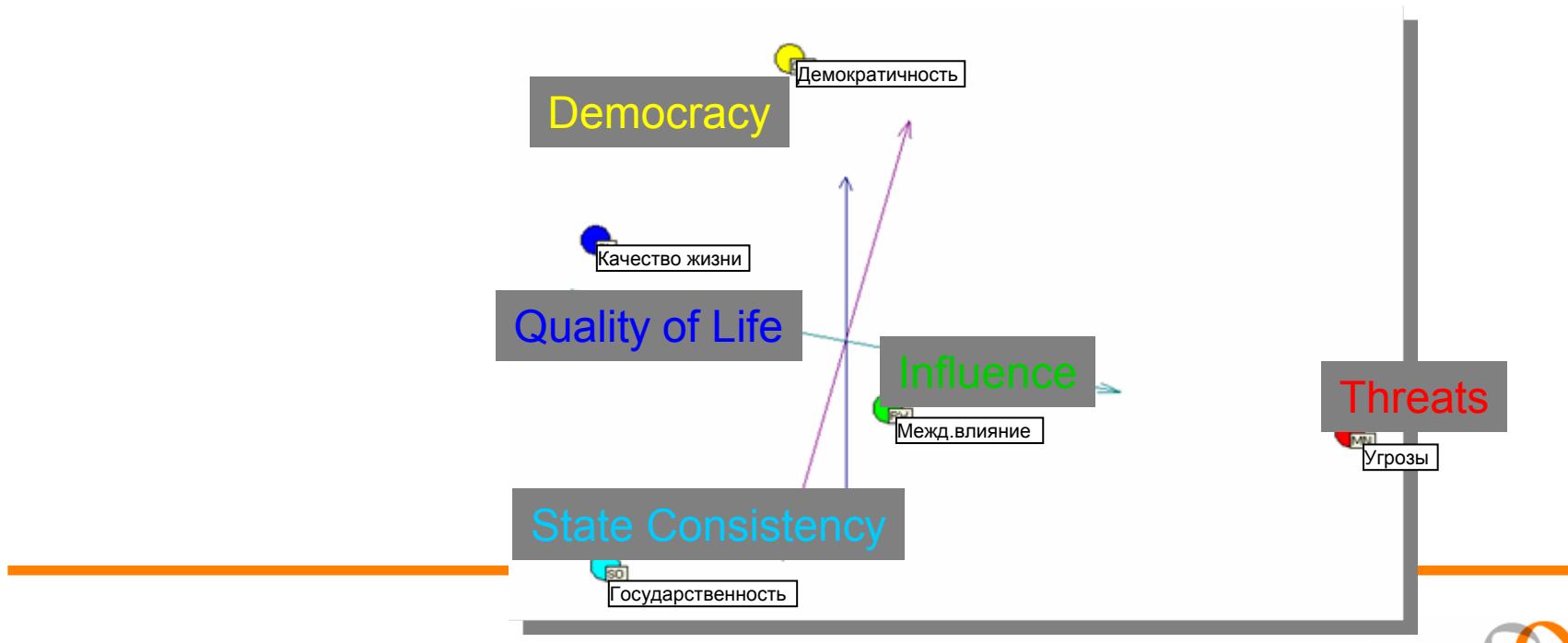
192 states, 79 indicators

1) Using supervised approach, 5 indices were introduced

- (1) Index of state consistency**
  - (2) Index of national threats**
  - (3) Index of capacity for international influence**
  - (4) Quality of life index**
  - (5) Index of institutional basis of democracy**
-

# Four principal components of the static index data

- 1) “Threats” – vs. – “Quality of Life”
- 2) “State Consistency” – vs. – “Democracy”
- 3) “State Consistency” – vs. – “Quality of Life”
- 4) “Influence”



# Political Atlas of the World project (МГИМО, Эксперт, ИОП)

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## DYNAMIC DATA

192 states, 45 indicators

- 1) Time series for the 1989-2005 period
- 2) Missing 6,7% of data values
- 3) Supervised approach is hardly applicable

# Outline of the presentation

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-> *Visualization of multidimensional data, brief introduction*

-> **Static analysis: How to visualize the four-dimensional space of the Political Atlas of the World?**

- 1) Visualizing the ‘political globe’
- 2) Method of ‘elastic sphere’

-> **Dynamic analysis: First lessons from time series data**

- 1) A state as a multidimensional trajectory
  - 2) Global trajectory analysis and measure of state ‘successfulness’
  - 3) Non-linear Quality of Life index
  - 4) Turning points in the state evolution
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# **1) Visualization of multidimensional data**

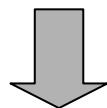
# Quantitative data as multidimensional object

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Table of data

	Feature 1	Feature 2	...	Feature m
Object 1	5.5	2.3		0
Object 2	3.4	4.6		1
...				
Object n	6.7	8.1		0

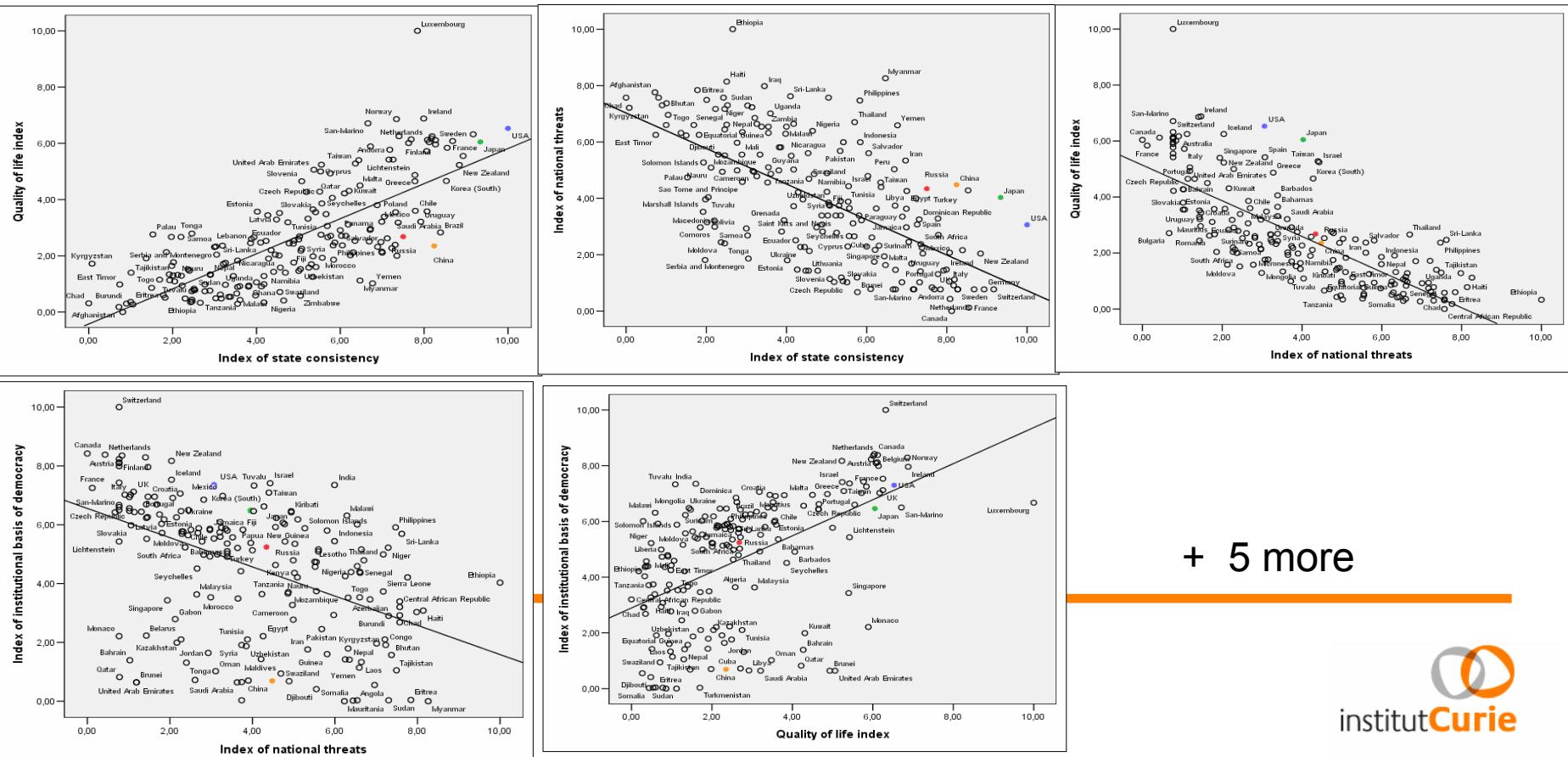
vector in the space  
of dimension  $m$



$n$  vectors in the space  
of dimension  $m$

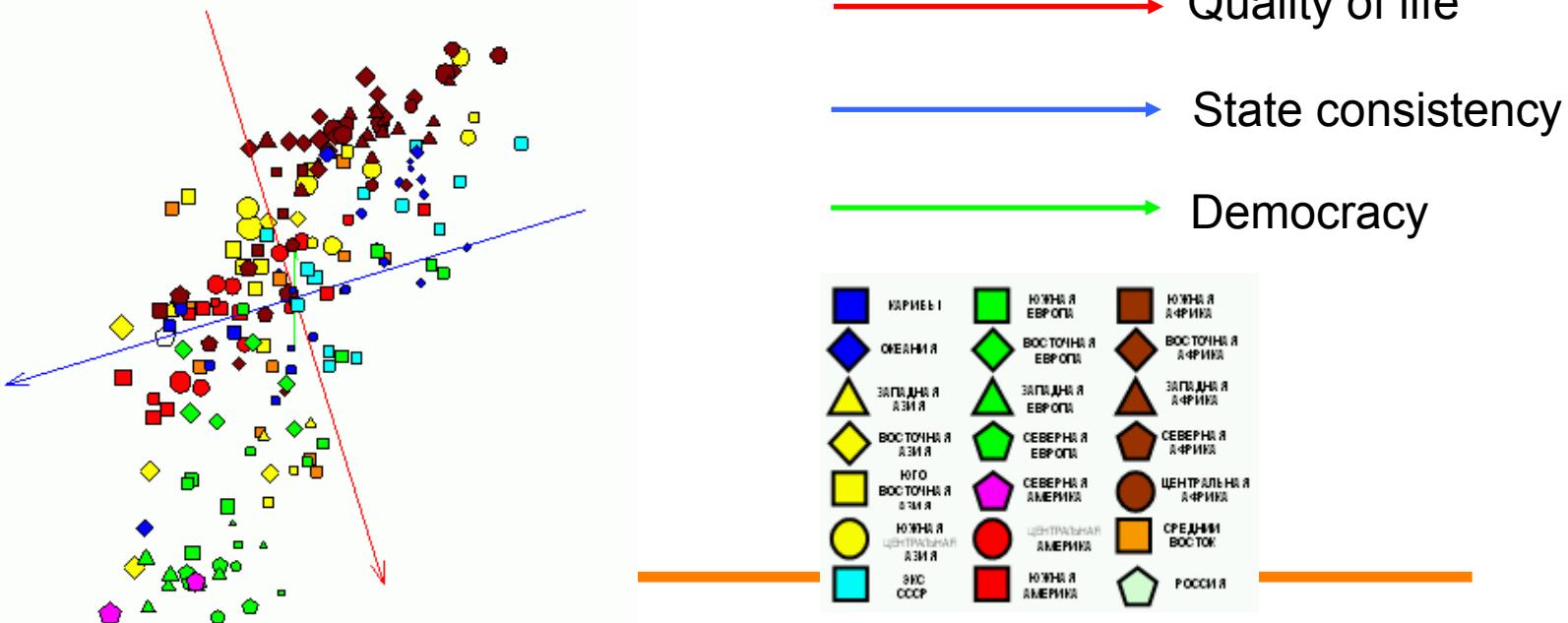
# Graphs and diagrams

NAME	ABBREV	REGION	Quality of Life	Influence	Threats	Stateness	Democracy	POPULATION	AREA	DENSITY
Afghanistan	AFG	SOUTH_CENTRAL_ASIA	0.18	0.09	7.76	0.72	4.21	25824882	652000	40
Angola	AGO	CENTRAL_AFRICA	0.54	0.21	6.54	3.38	0.03	1117537	1246700	9
Albania	ALB	SOUTH_EUROPE	2.47	0.03	3.22	5.87	6.09	3364571	26748	117
Andorra	AND	SOUTH_EUROPE	5.77	0.001	0.77	7.18	7.43	65939	468	141
United Arab Emirates	ARE	MIDDLE_EAST	5.06	0.2	1.19	5.37	0.64	2344402	82860	28
Argentina	ARG	SOUTH_AMERICA	3.58	0.56	2.07	8.07	6.91	36737664	2766890	13
Armenia	ARM	POST_SOVIET	2.13	0.06	2.97	1.85	5.86	3409234	28000	114
Antigua_and_Barbuda	ATG	CARIBBEAN	3.19	0.01	2.97	4.75	4.92	64246	442	145
Australia	AUS	OCEANIA	6.17	0.79	0.91	8.17	7.02	18783551	7686860	2
Austria	AUT	WESTERN_EUROPE	6.08	0.47	0.77	8.68	8.09	8139299	83868	97
Azerbaijan	AZE	POST_SOVIET	1.71	0.11	6.85	3.21	3.46	7908224	88600	91
Burundi	BDI	EASTERN_AFRICA	0.3	0.07	7.3	0.9	2.9	5735937	27830	206
Belgium	BEL	WESTERN_EUROPE	6.14	1.09	0.77	7.69	7.99	10182034	30510	334
Benin	BEN	WESTERN_AFRICA	0.98	0.03	4.99	2.77	2.77	6305667	112620	56
Burkina_Faso	BFA	WESTERN_AFRICA	0.74	0.03	5.97	2.77	2.93	11575986	274200	42
Bangladesh	BGD	SOUTH_CENTRAL_ASIA	1.28	0.27	6.64	4.18	5.16	127117967	144000	883
Bulgaria	BGR	EASTERN_EUROPE	2.71	0.2	0.67	5.77	6.42	8194772	110910	74
Bahrain	BHR	WESTERN_ASIA	4.27	0.05	1.03	5.19	1.39	629090	694	906
Bahamas	BHS	CARIBBEAN	3.65	0.04	3.39	5.35	5.36	283705	13878	20
Bosnia_and_Herzegovina	BH	SOUTH_EUROPE	2.67	0.07	1.81	1.97	5.72	3482495	51129	68
Belarus	BLR	POST_SOVIET	2.44	0.16	1.43	4.78	2.23	10401784	207600	50
Belize	BLZ	CENTRAL_AMERICA	2.69	0.01	3.39	5.03	5.02	235789	22960	10
Bolivia	BOL	SOUTH_AMERICA	1.77	0.08	3.15	2.02	4.99	7982850	1098580	7
Brazil	BRA	SOUTH_AMERICA	2.83	1.01	2.16	8.39	6.25	171853126	8511965	20
Rwanda	RRR	CARIFERAN	4.06	0.02	3.39	5.81	4.91	259191	430	603



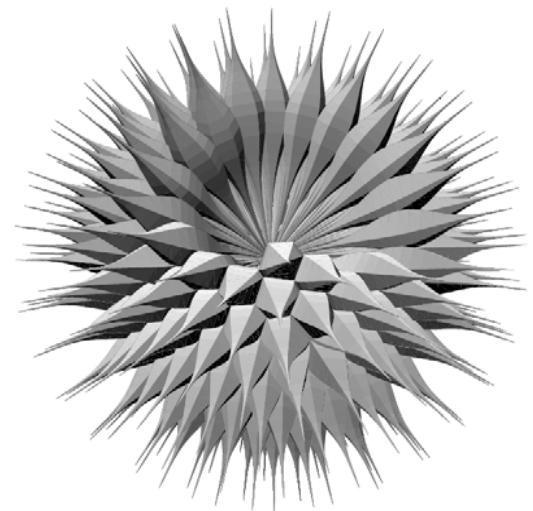
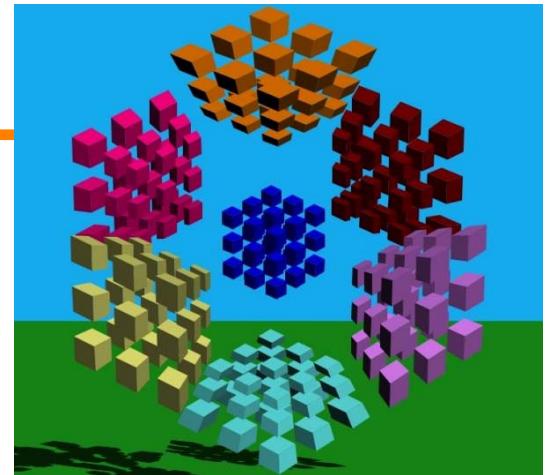
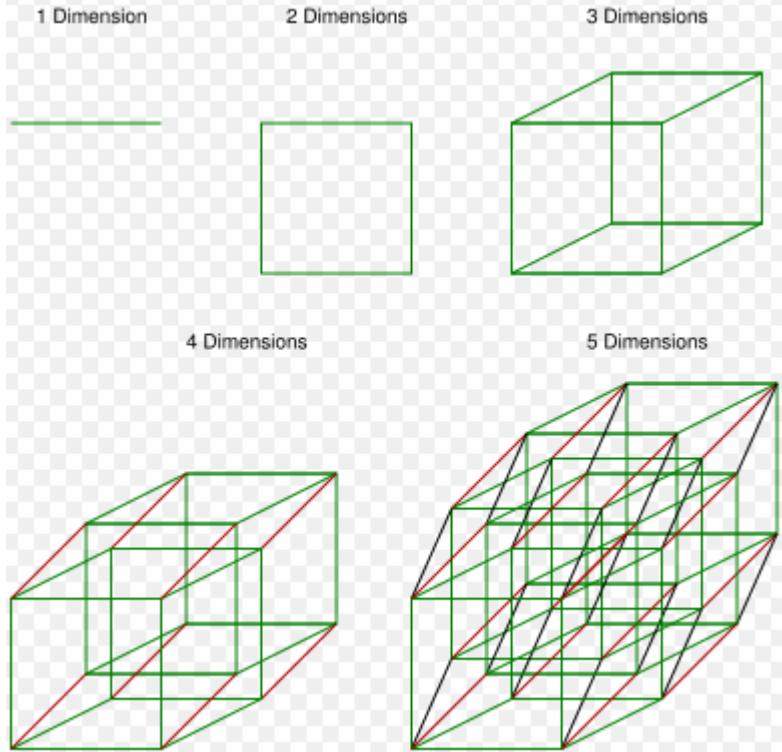
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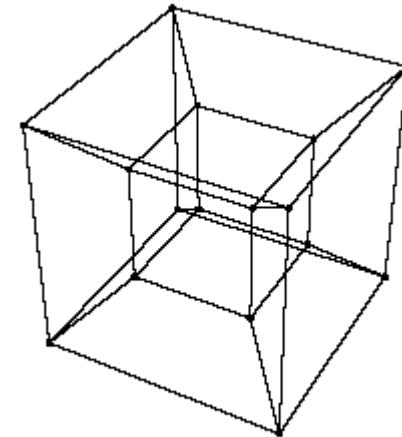
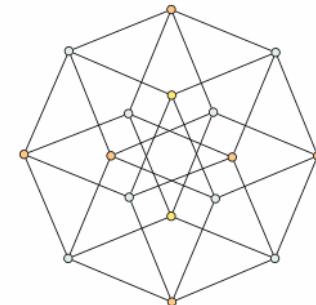
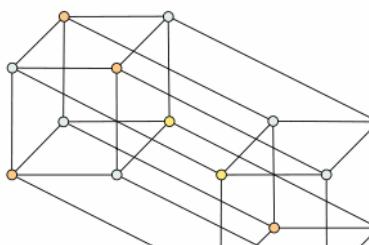
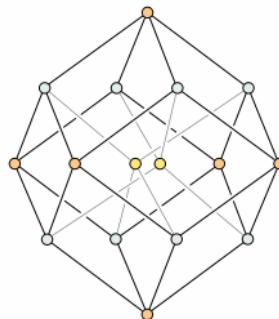
# Multidimensional objects

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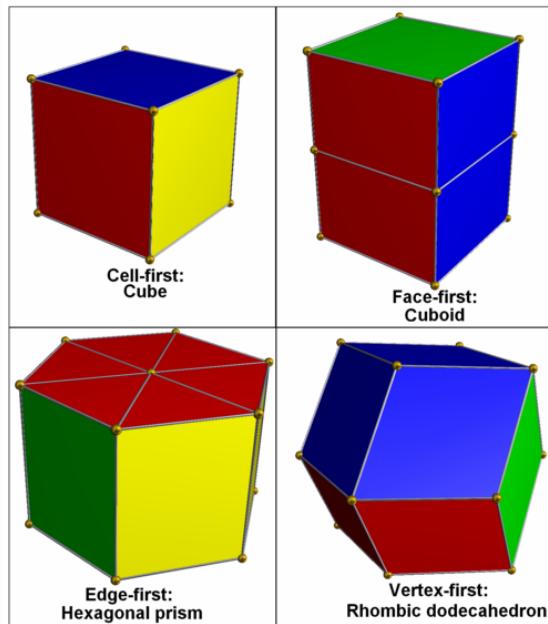


For multidimensional objects it is not possible to visualize all the details – their image depends on the way of projection

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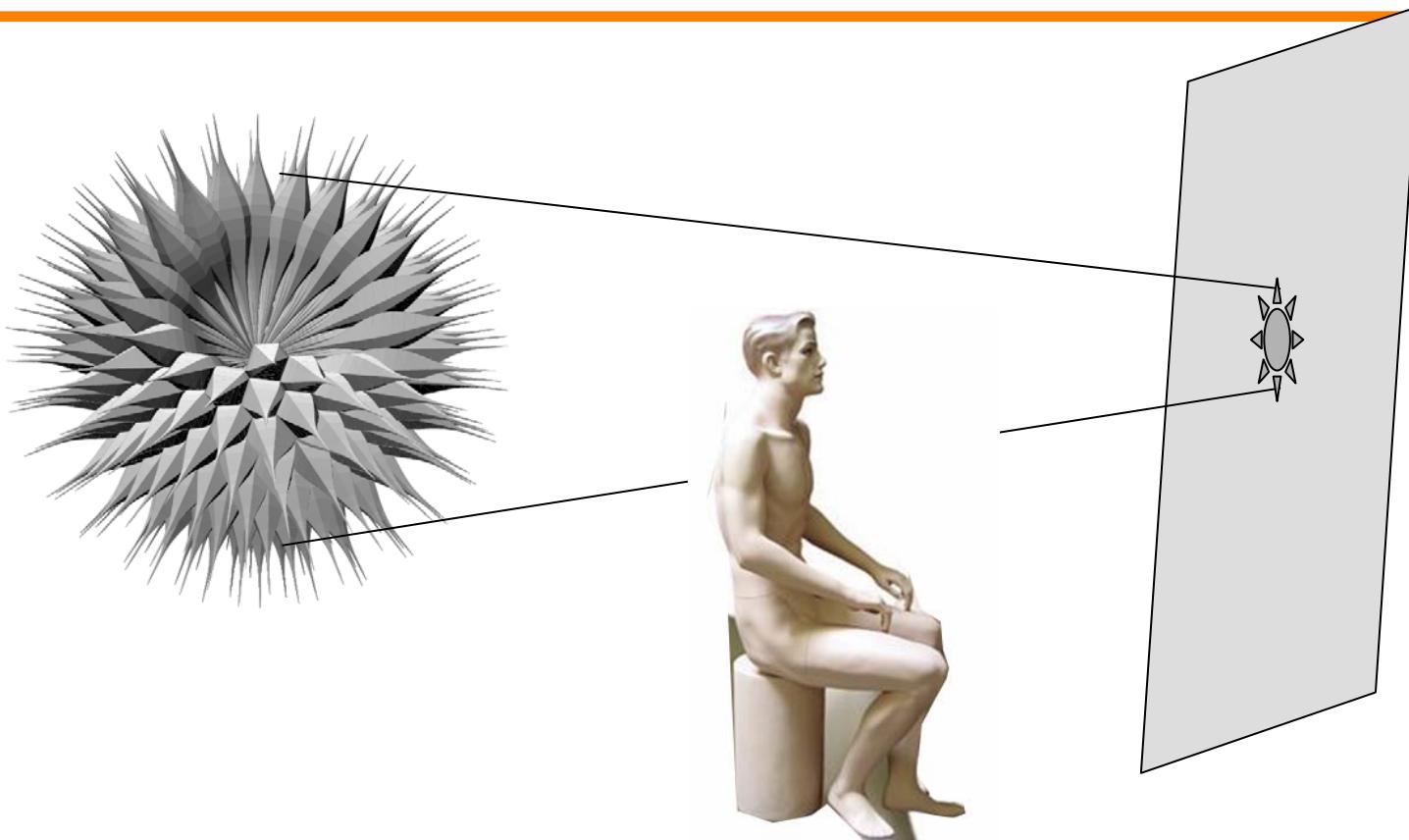


Orthogonal projection envelopes of the tesseract



# Shadows of multidimensionality

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# Carl Pearson (1857-1936) and his ideas

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Linear regression

Correlation coefficient

Normal distribution

Variation properties

Method of principal  
components



# Mean point

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«Mean» state (minimum 0, maximum 10)

<Quality of life> = 2,63 (Romania – 2,62, Thailand – 2,66 / Russia – 2,68)

<Potential of Influence> = 0,37 (Morocco – 0,35, Denmark – 0,4 / Russia – **2,6**)

<Threats> = 3,93 (Vietnam – 3,9, Micronesia - 3,96 / Russia – 4,34)

<Stateness> = 4,9 (Santa-Lucia – 4,9, Algeria – 5,01 / Russia – **7,5**)

<Democracy> = 4,59 (Cambodge – 4,58, Venezuela – 4,63 / Russia – 5,24)

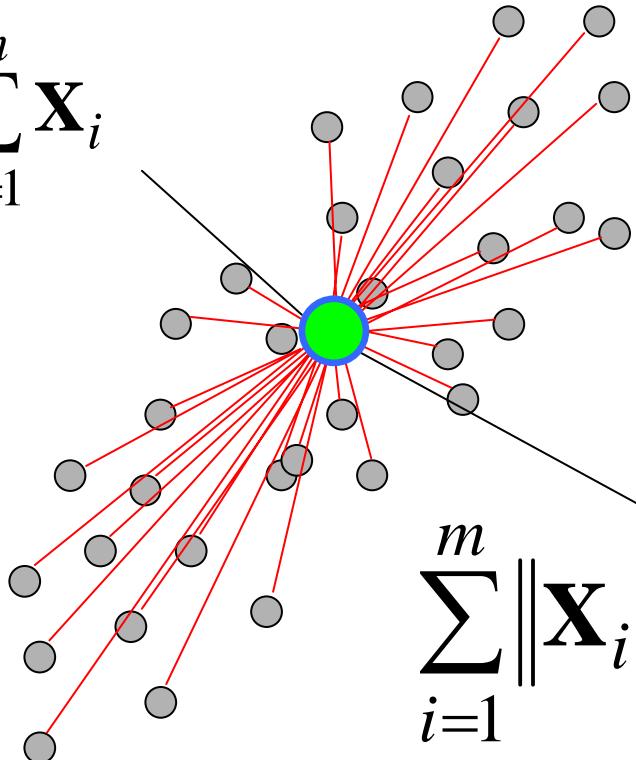
“Closest” to the mean point

	Mean	Algeria	Columbia	Belize
Quality	2,63	2,58	2,71	2,69
Influence	0,37	0,43	0,40	<u>0,01</u>
Threats	3,93	4,23	<u>4,79</u>	3,39
StateCons	4,90	5,01	<u>6,03</u>	5,03
Democracy	4,59	<u>3,64</u>	5,43	5,02

# Mean point of data is the center of gravity

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$$\langle \mathbf{X} \rangle = \frac{1}{m} \sum_{i=1}^m \mathbf{X}_i$$



$$\sum_{i=1}^m \|\mathbf{X}_i - \langle \mathbf{X} \rangle\|^2 \rightarrow \min$$

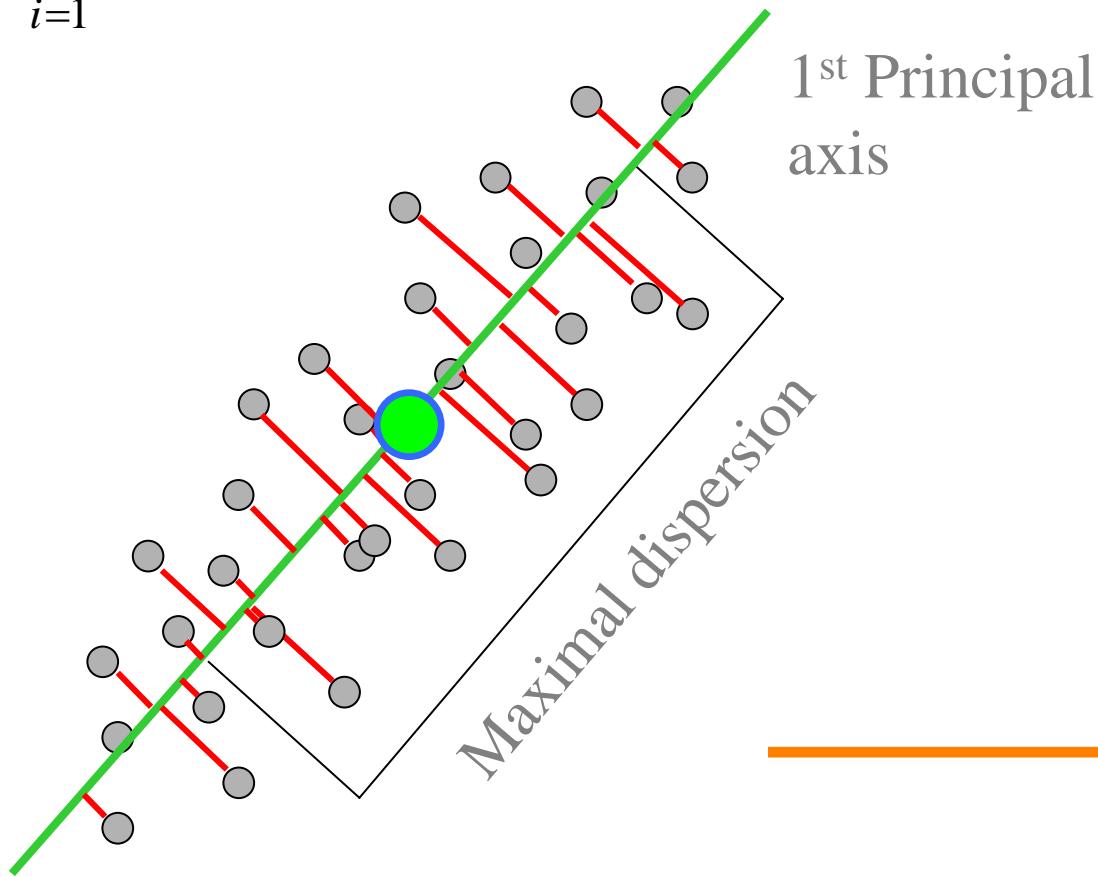
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$$\sum_{i=1}^m \| \text{---} \|^2 \rightarrow \min$$

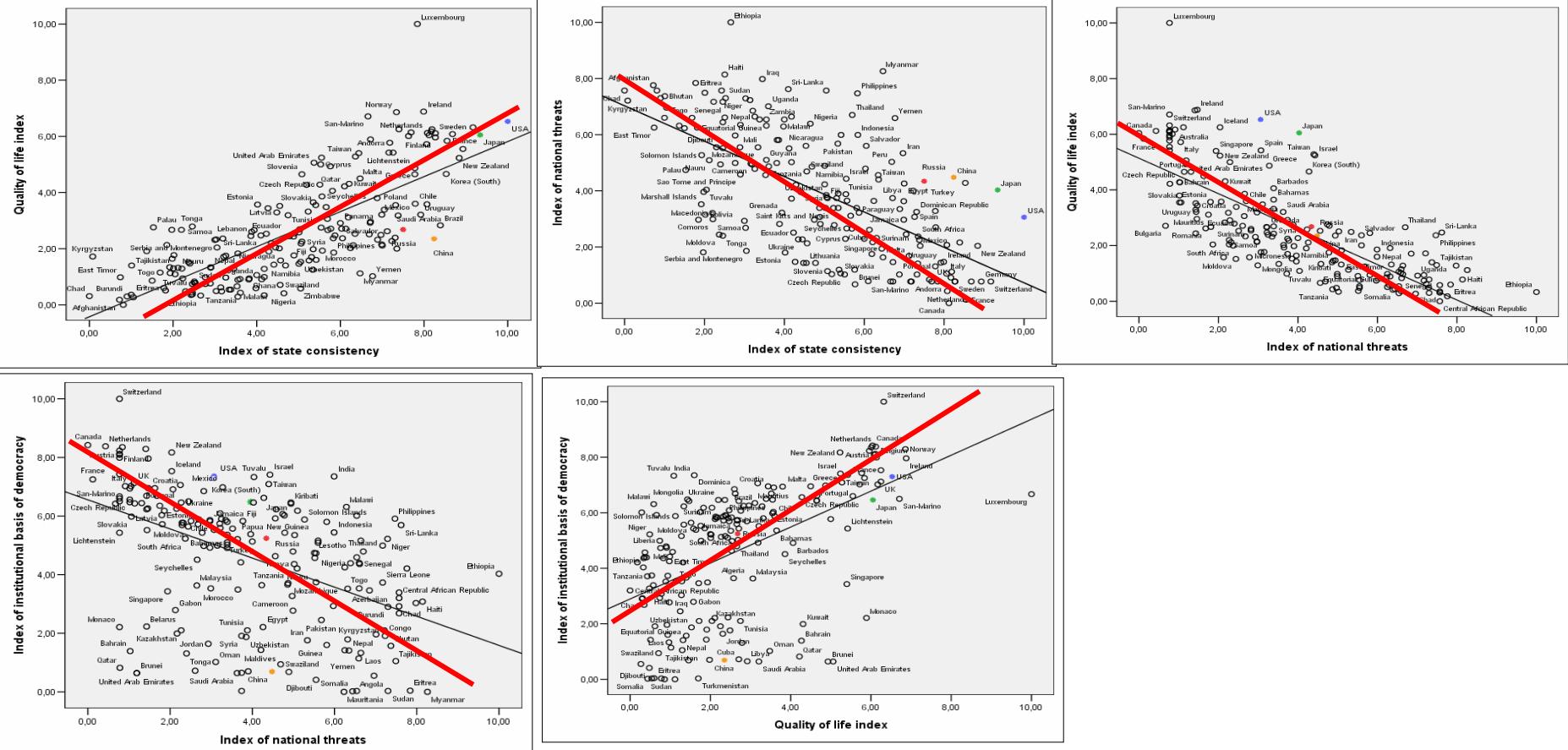
# First principal component is the line ‘closest’ to data

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$$\sum_{i=1}^m \| \text{---} \|^2 \rightarrow \min$$



# The first principal component of Political Atlas of the World



# The meaning of the first principal component

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Life Quality **0,53**

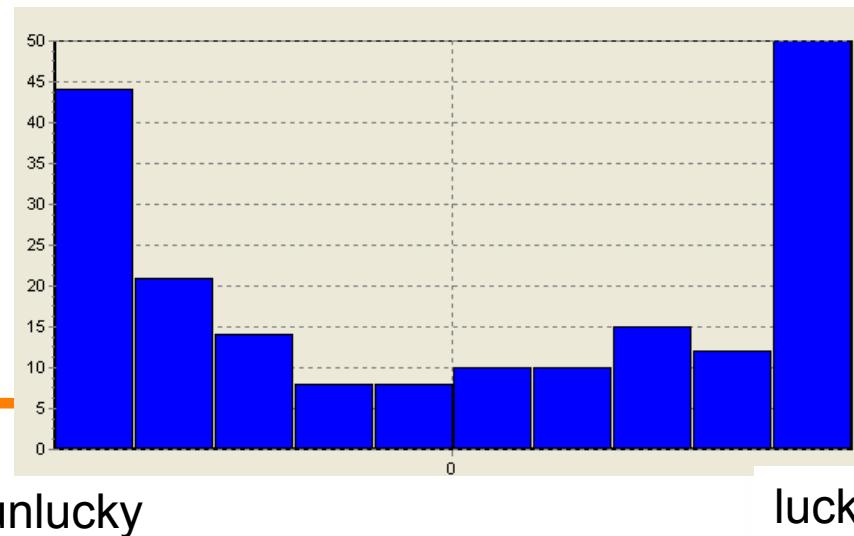
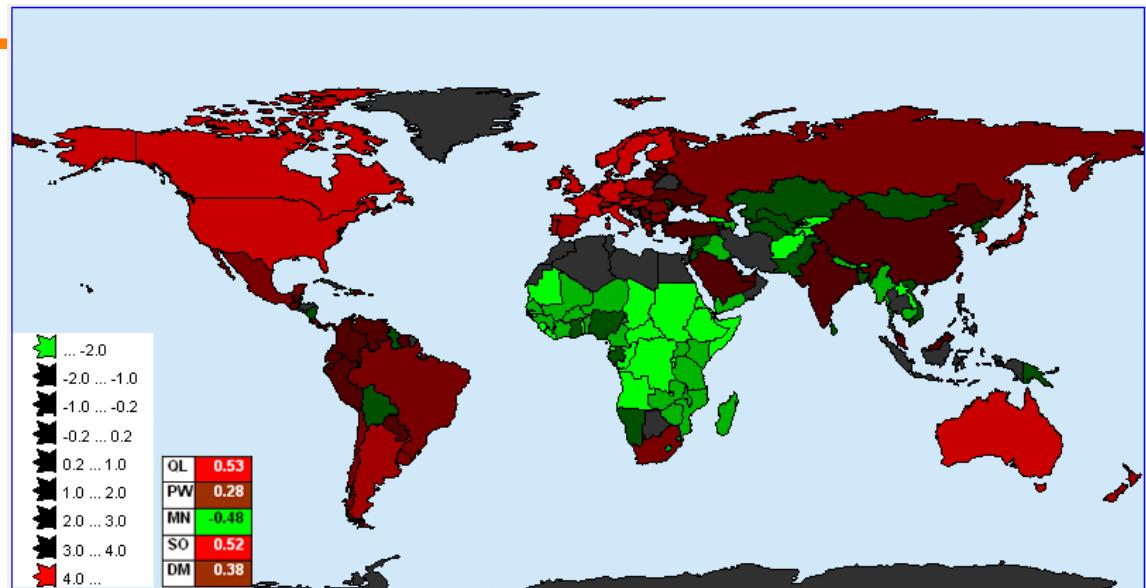
Influence **0,27**

Threats **-0,48**

State Cons **0,51**

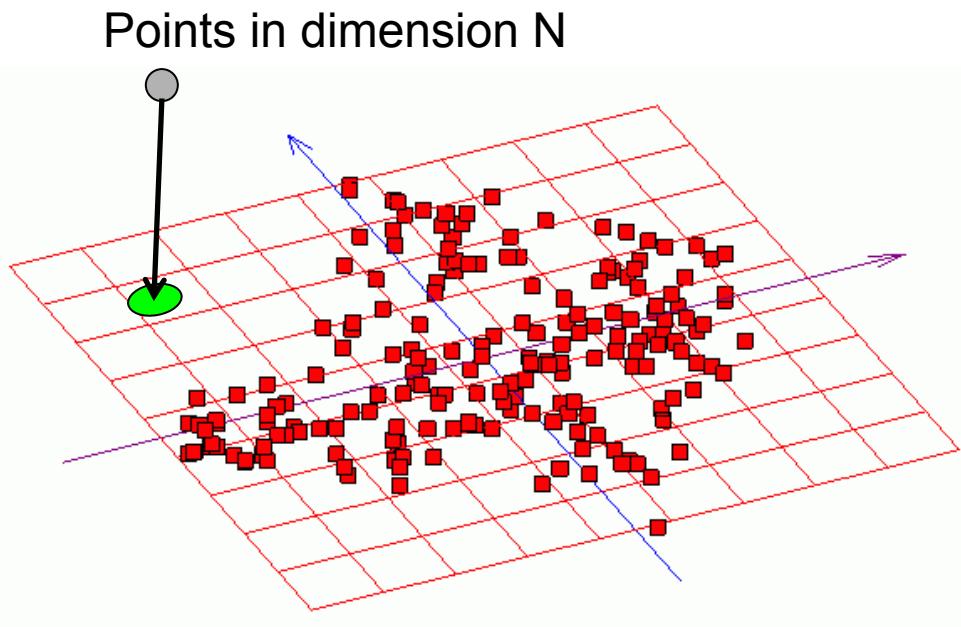
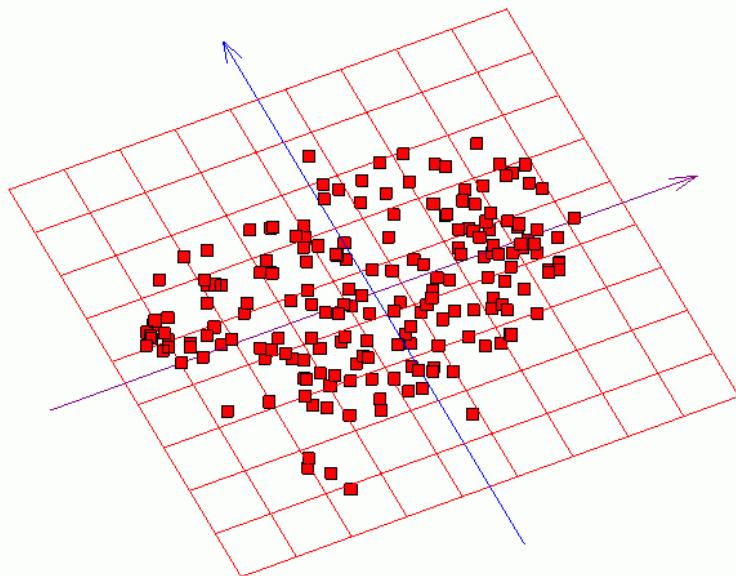
Democracy **0,39**

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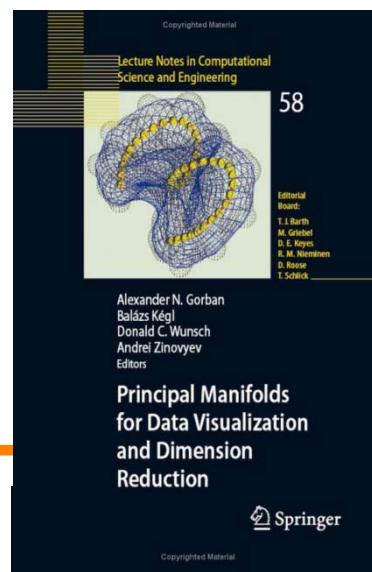
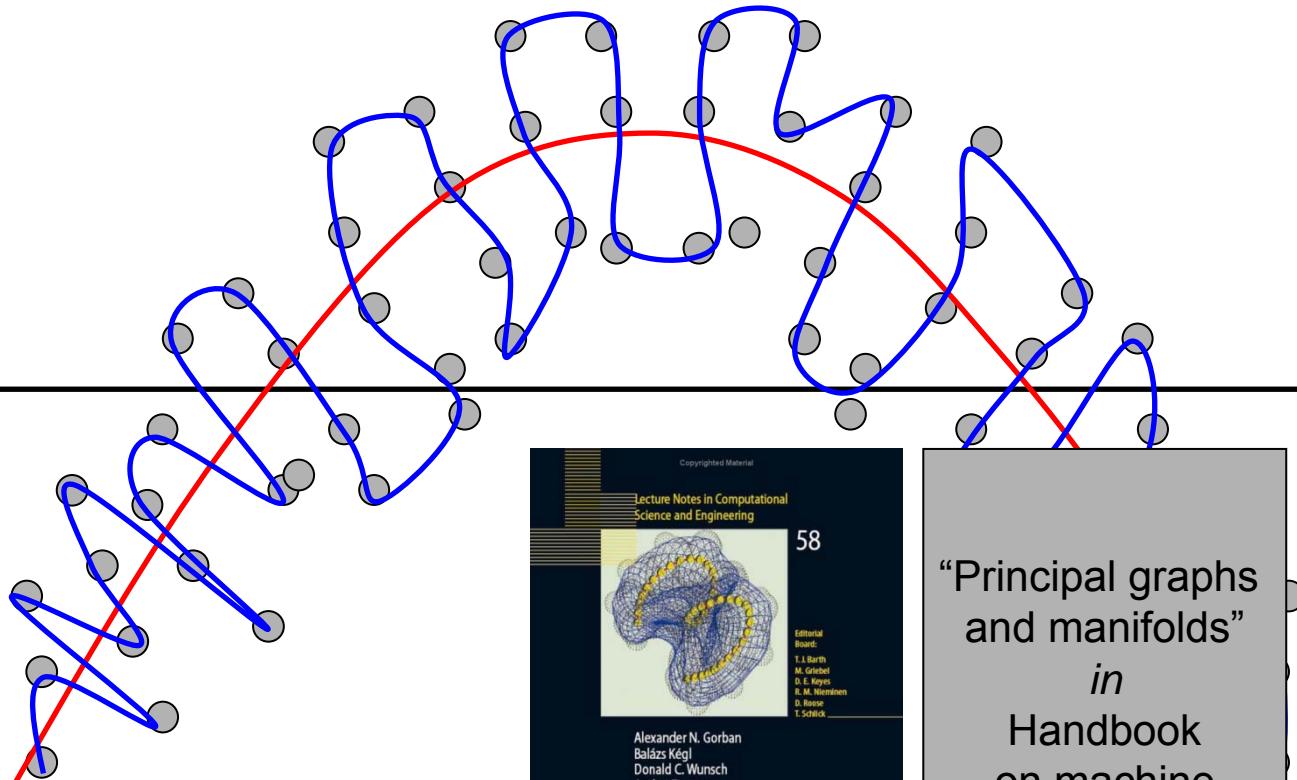
Principal plane is the *optimal flat* screen for *orthogonal* projecting of multidimensional data from dimension N to dimension 2

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# Principal manifolds (non-linear principal components)

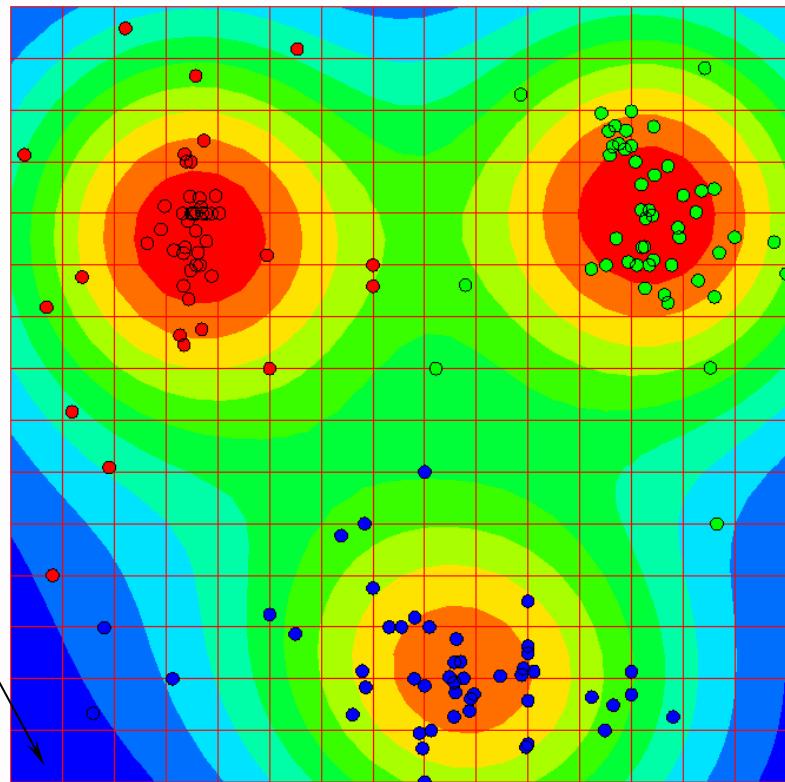
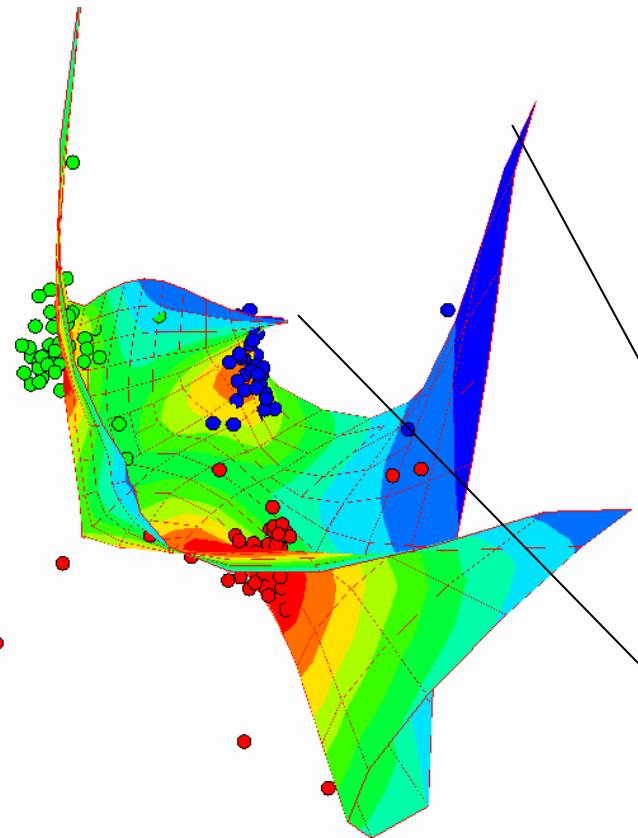
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Published in 2007

“Principal graphs  
and manifolds”  
*in*  
Handbook  
on machine  
learning  
research

To be published in 2009

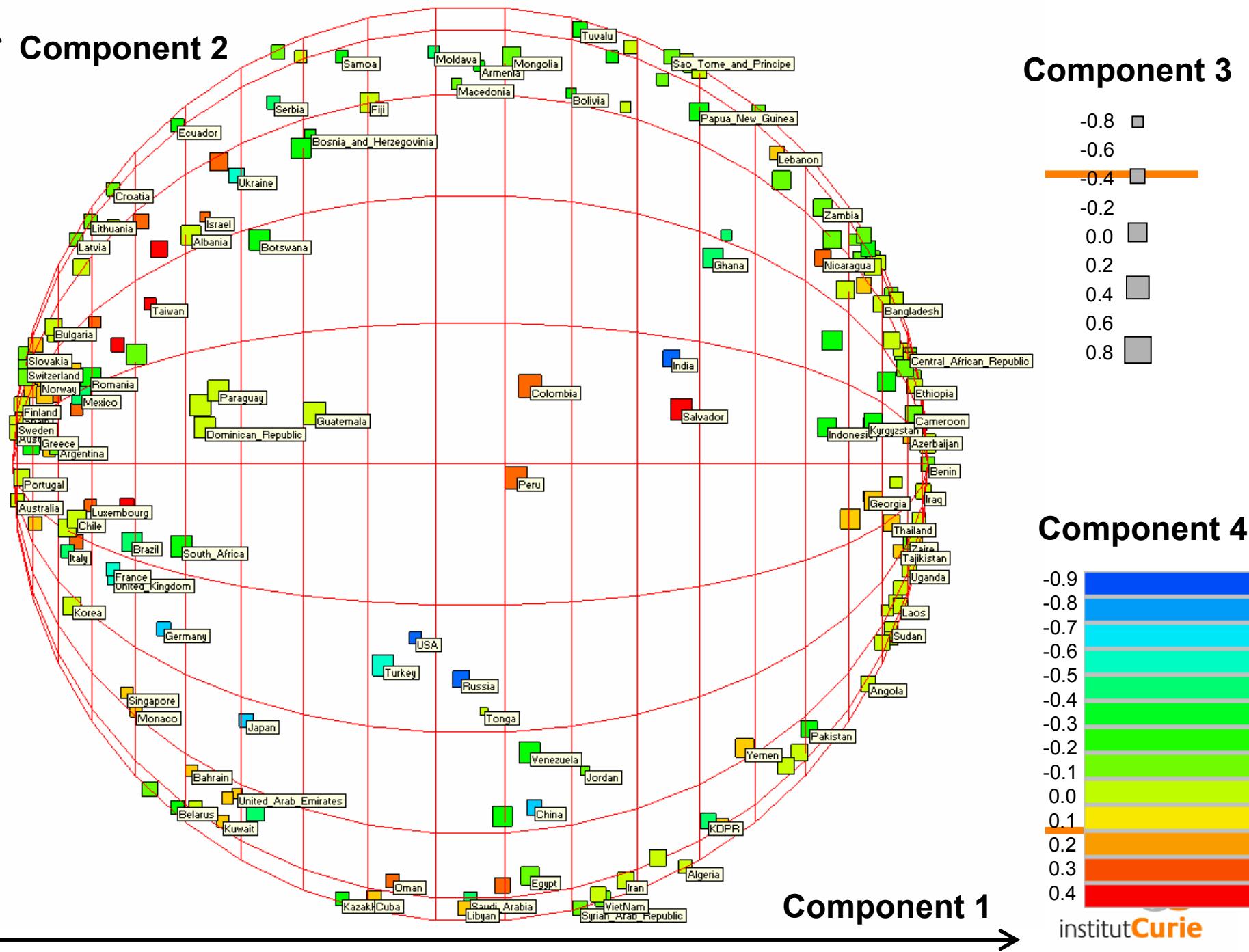


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- How to represent the 4-dimensional space of the Political Atlas of the World?
- 1) using point colors and sizes

↑ Component 2

Component 3

Component 1 →

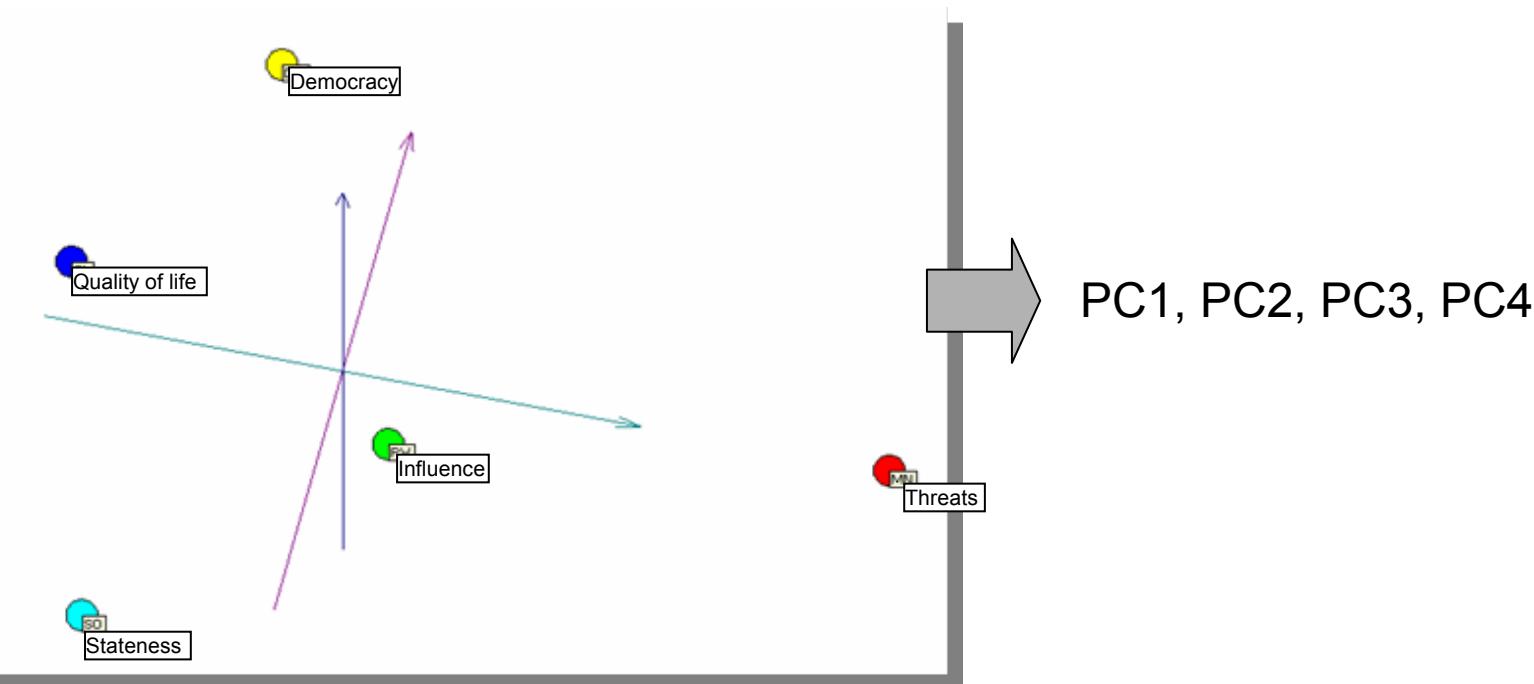


- 
- How to represent the 4-dimensional space of the Political Atlas of the World?

## 2) Using properties of 3D-sphere

# From five indexes to four principal components and three-dimensional sphere

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$$(PC1)^2 + (PC2)^2 + (PC3)^2 + (PC4)^2 = 1$$

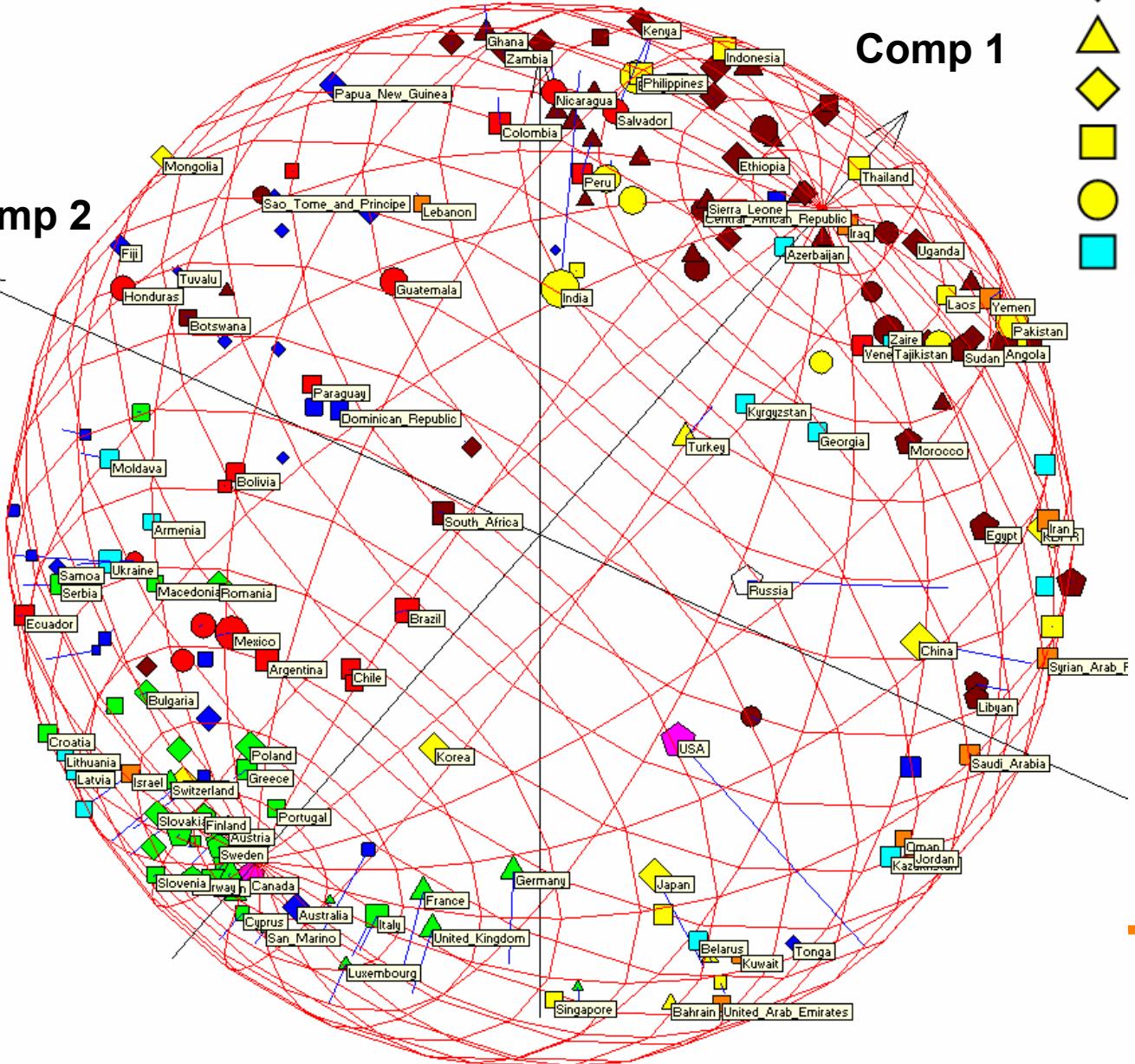
Three-dimensional sphere in four-dimensional space

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# Comp 3

# Comp 1

# Comp 2



## Population

10 000 □  
100 000 □  
1 000 000 □  
10 000 000 □  
100 000 000 □  
1 000 000 000 □

“Strength”  
of Component 4



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## Interactive visualization

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- **<http://atlas.savvy.ru/visatlas/PolitAtlas.exe>**
-

# Cluster analysis : 2 clusters

Component 2

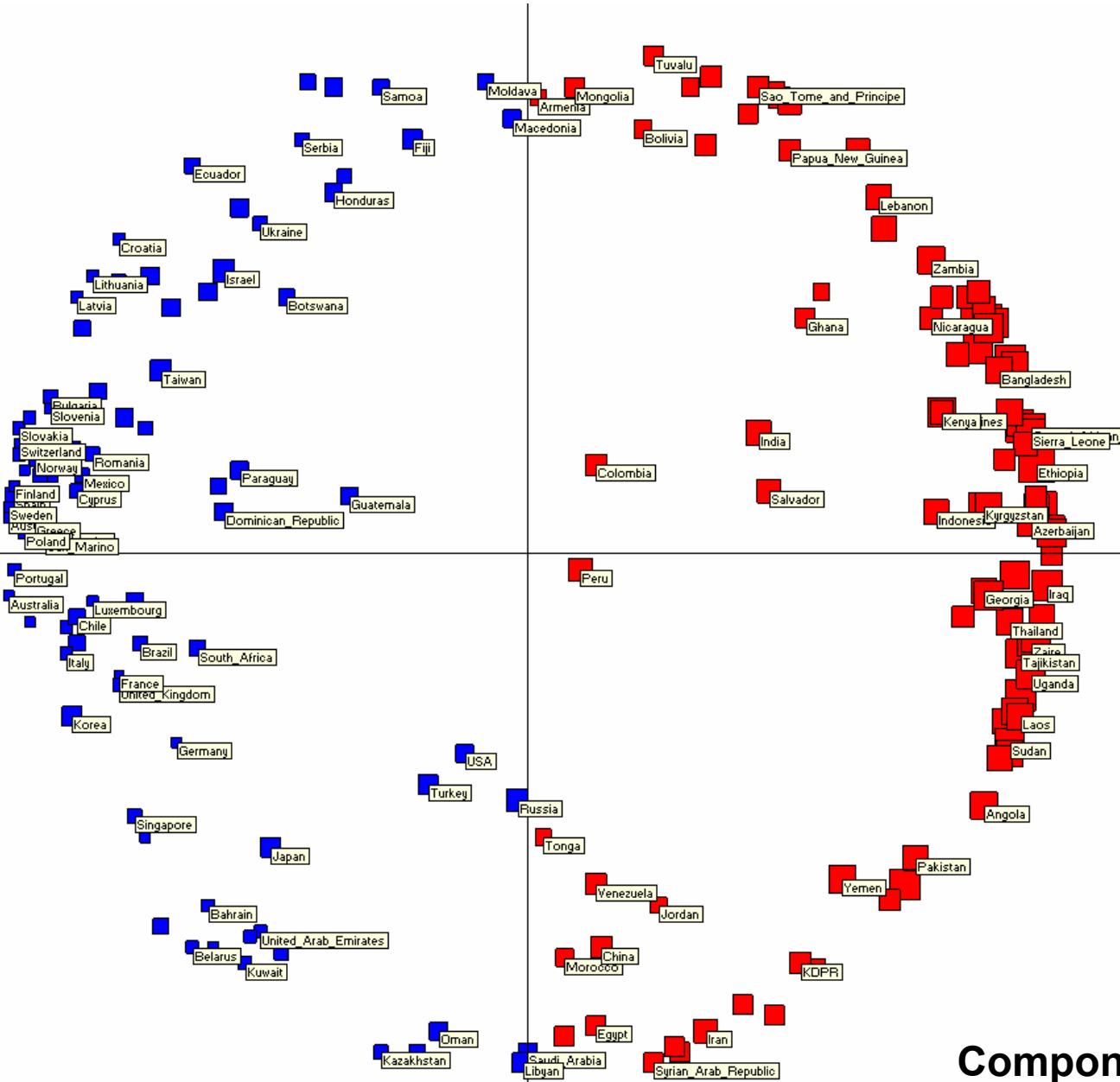
Component 1

**Cluster 1**  
“**Winners**”

**Cluster 2**  
“**Losers**”

‘Threats’ index

- 0 □
- 1 □
- 2 □
- 3 □
- 4 □
- 5 □
- 6 □
- 7 □
- 8 □
- 9 □



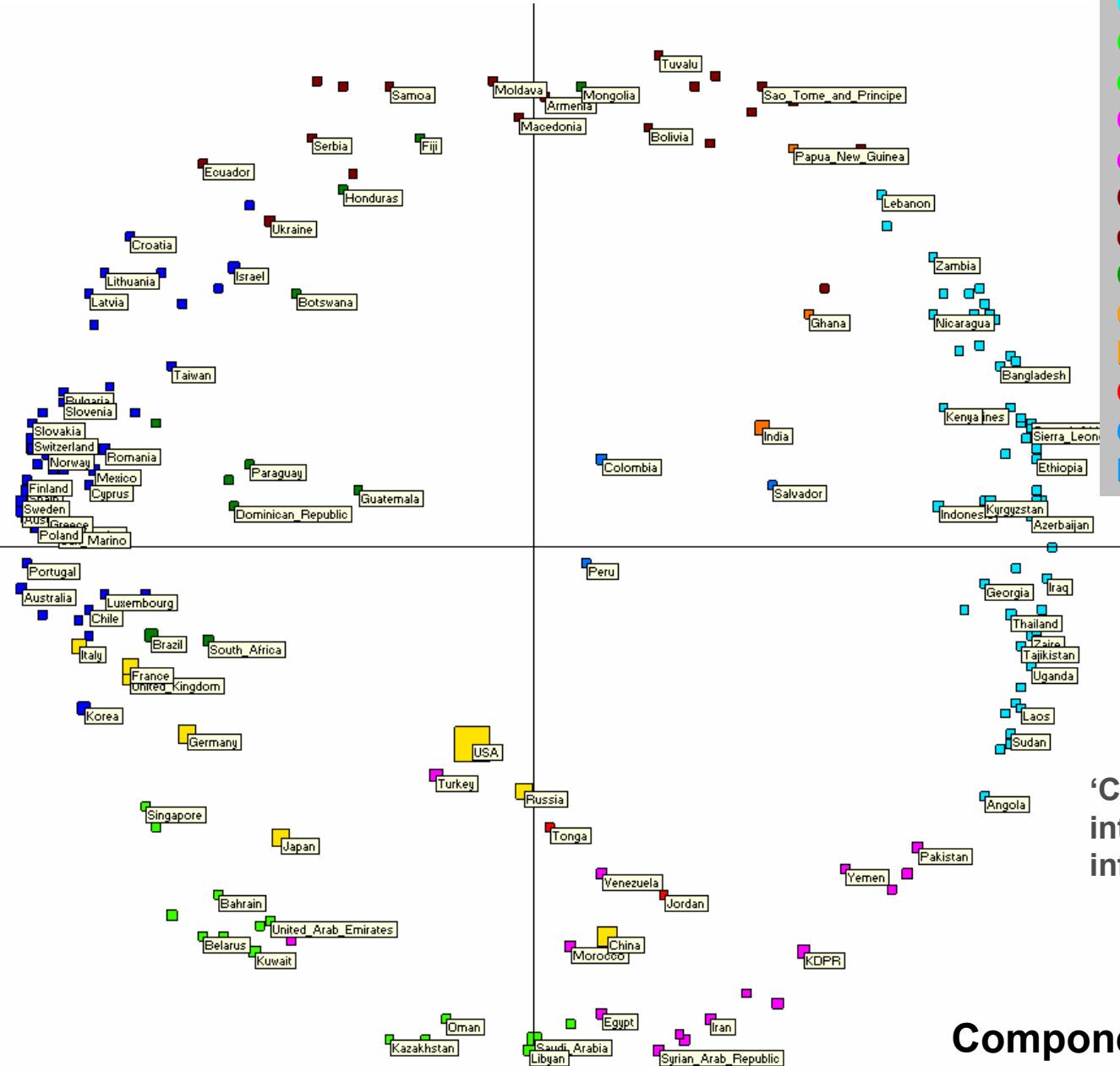
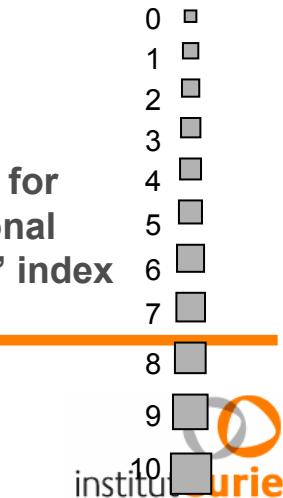
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- Cluster 1: "Big 8"**  
**Cluster 2: 53 'fed' countries**  
**Cluster 3: 58 'authoritaries'**  
**Cluster 4: 15 'strong non-democracies' (1)**  
**Cluster 5: 17 'strong non-democracies' (1)**  
**Cluster 6: 22 'dependent democracies'**  
**Cluster 7: 11 countries**  
**Cluster 8: India, Ghana, Papua New Guinea**  
**Cluster 9: Tonga, Jordan**  
**Cluster 10: Columbia, Perou, Salvador**

## Cluster analysis : 10 clusters

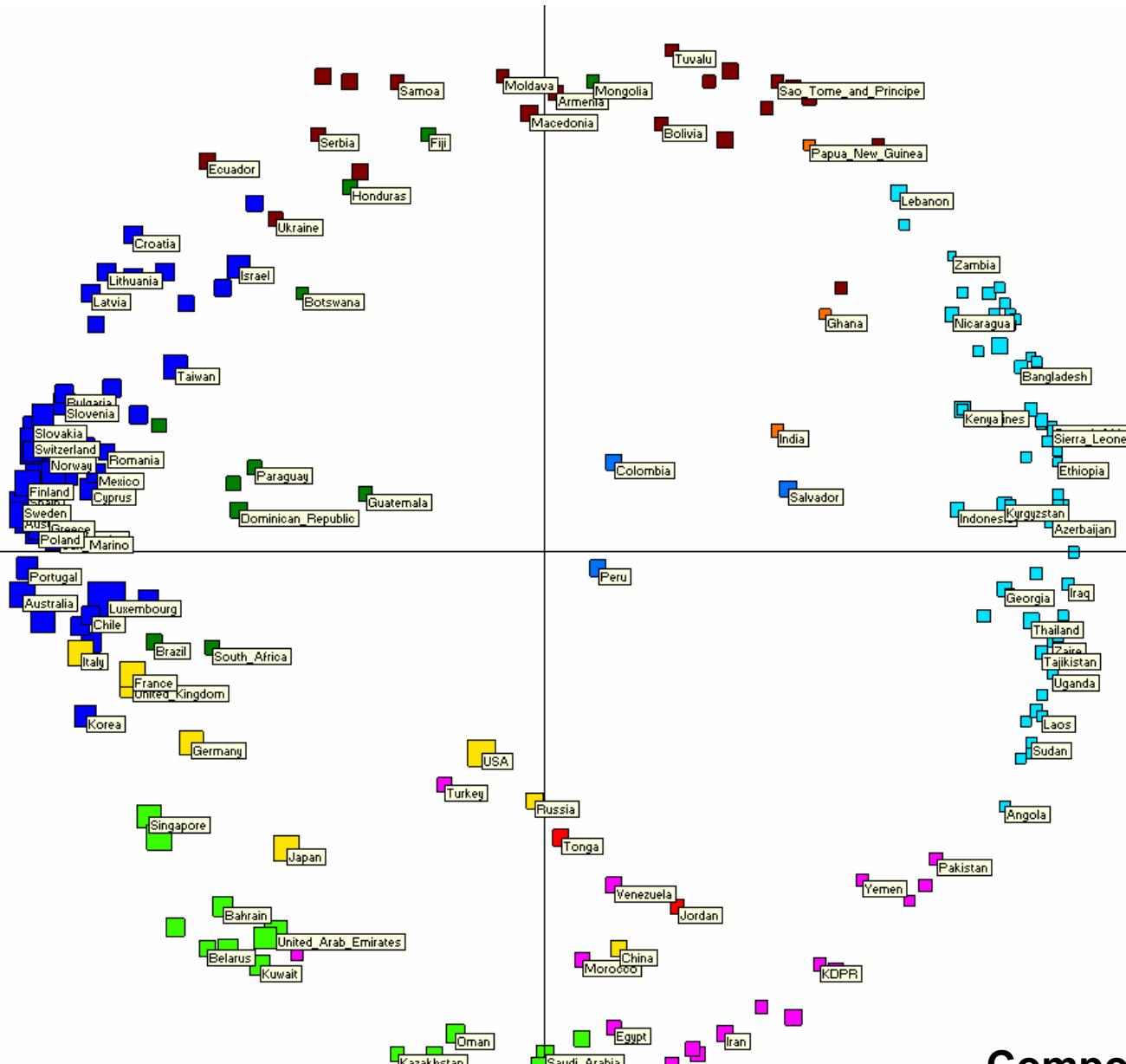
↑ Component 2

Component 1 →



↑ Component 2

## Cluster analysis : 10 clusters



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'Quality of life'  
index

Component 1

0 □  
1 □  
2 □  
3 □  
4 □  
5 □  
6 □  
7 □  
8 □  
9 □  
10 □

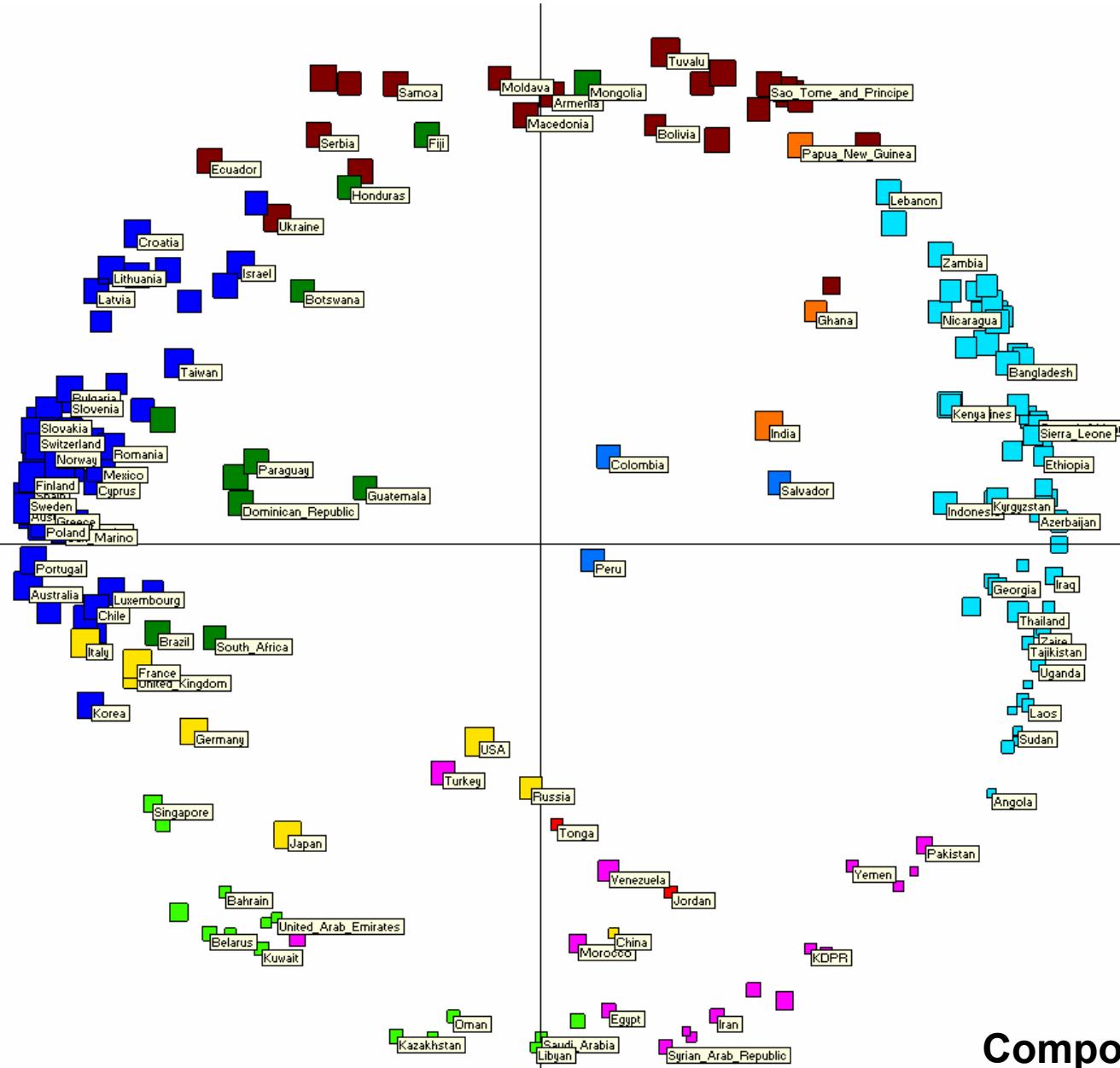
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## Cluster analysis : 10 clusters

↑ Component 2

Component 1 →



'Democracy'  
index

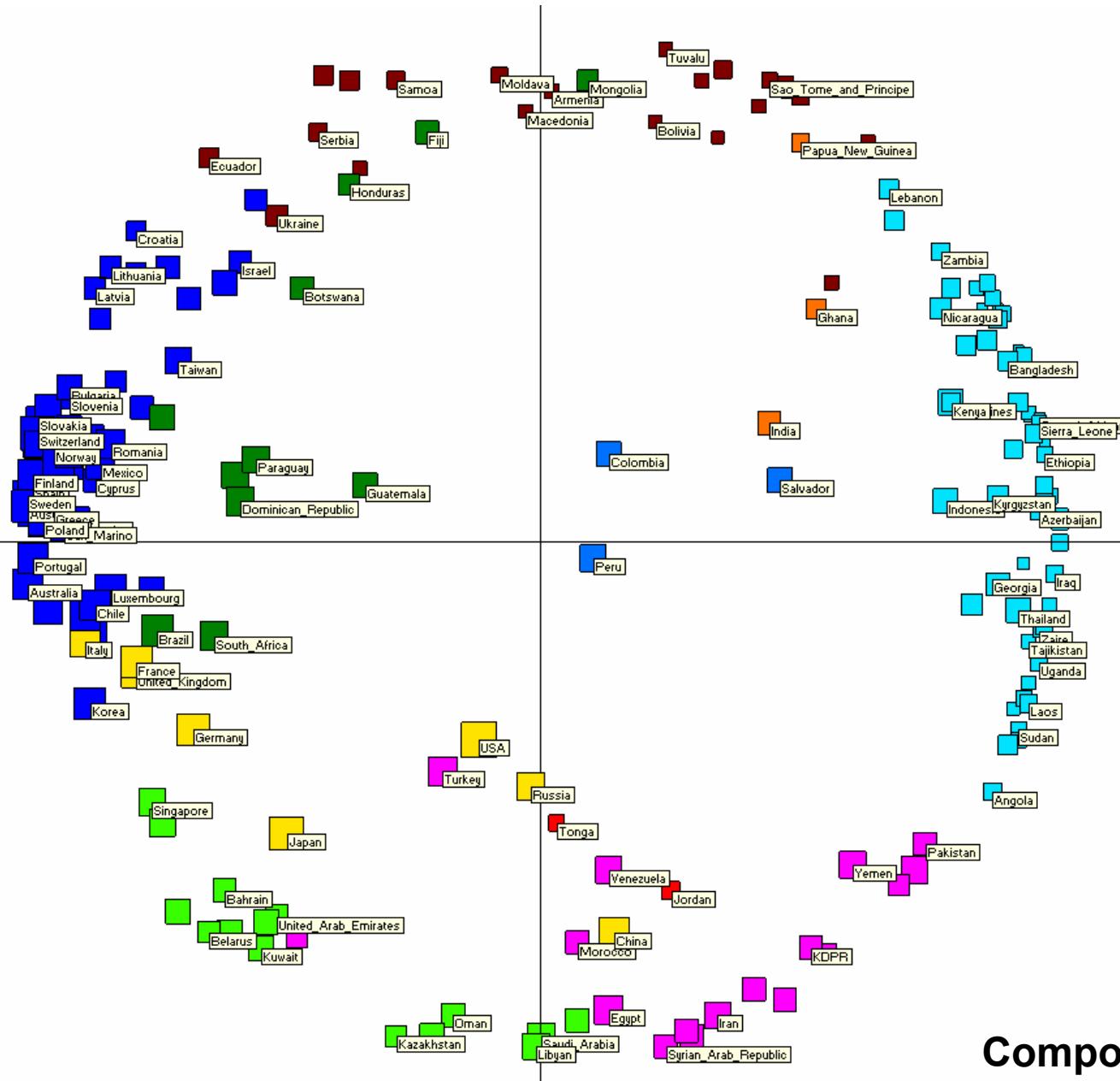


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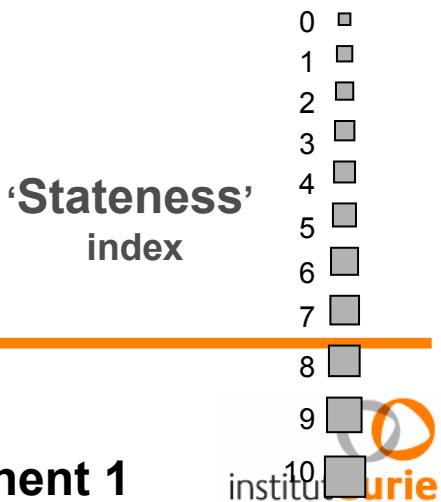
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↑ Component 2

Component 1 →

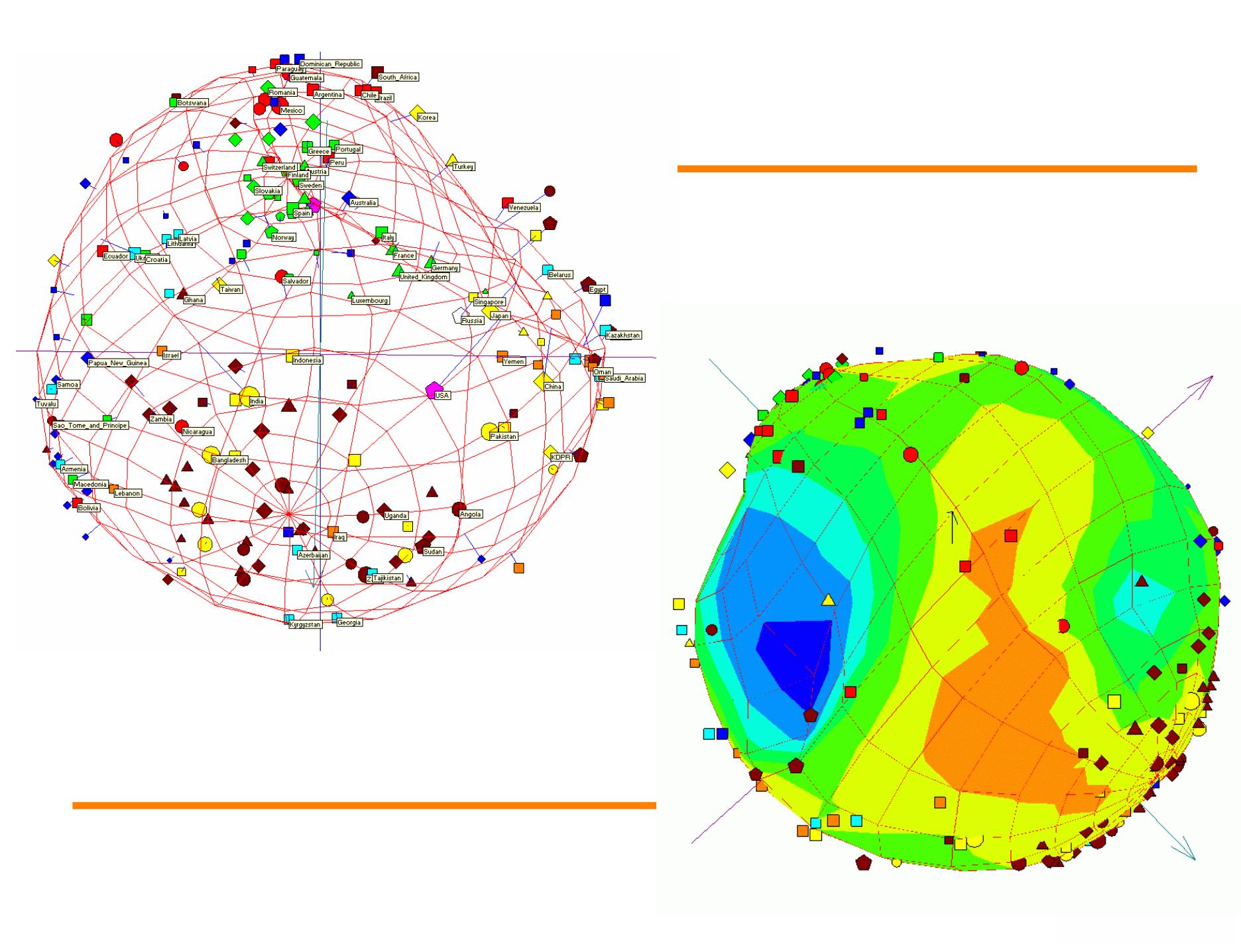


'Stateness'  
index



- 
- How to represent the 4-dimensional space of the Political Atlas of the World?

### 3) Using ‘elastic sphere’

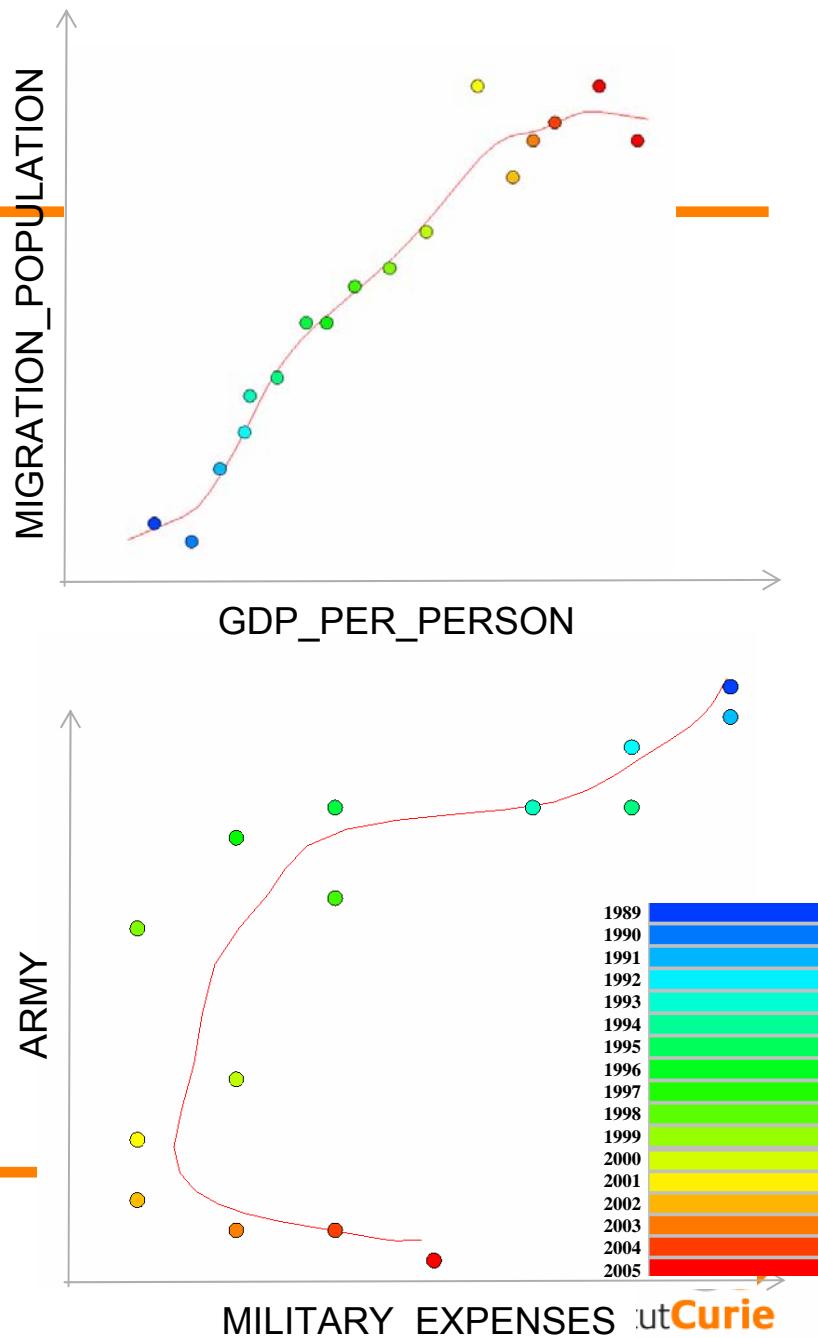
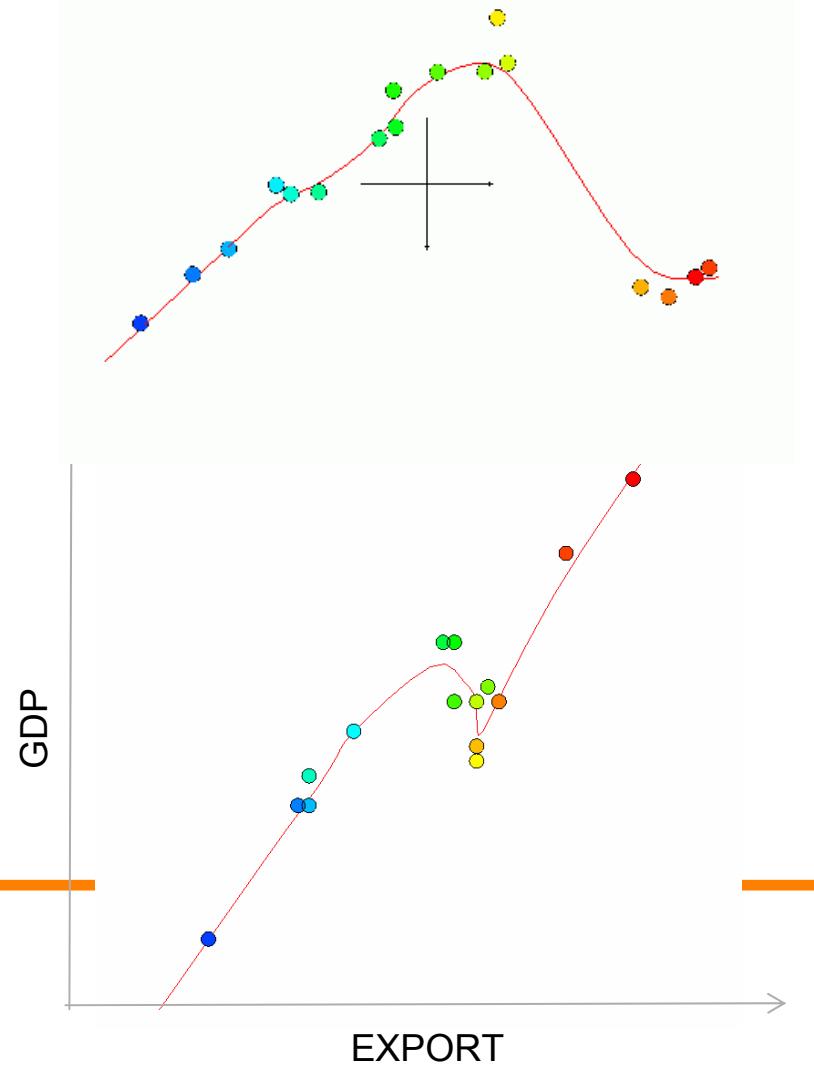


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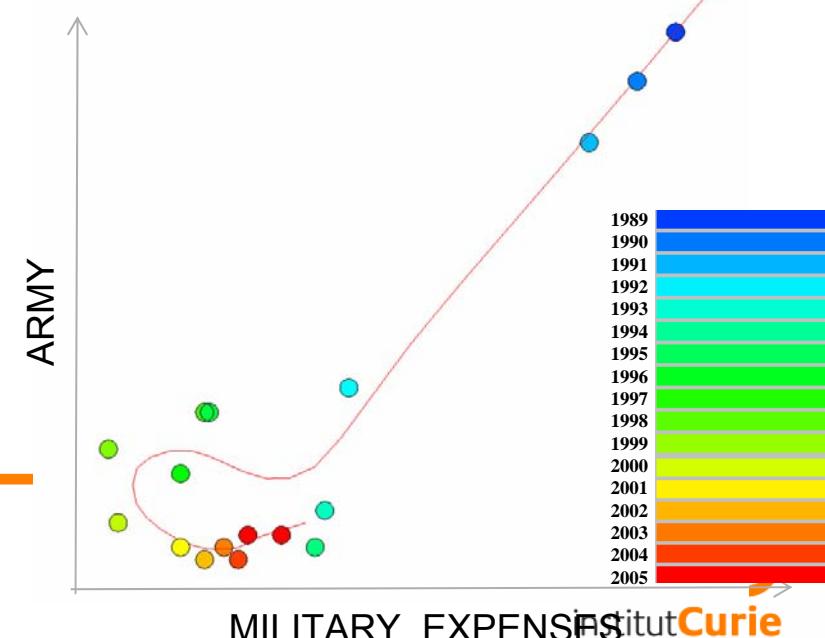
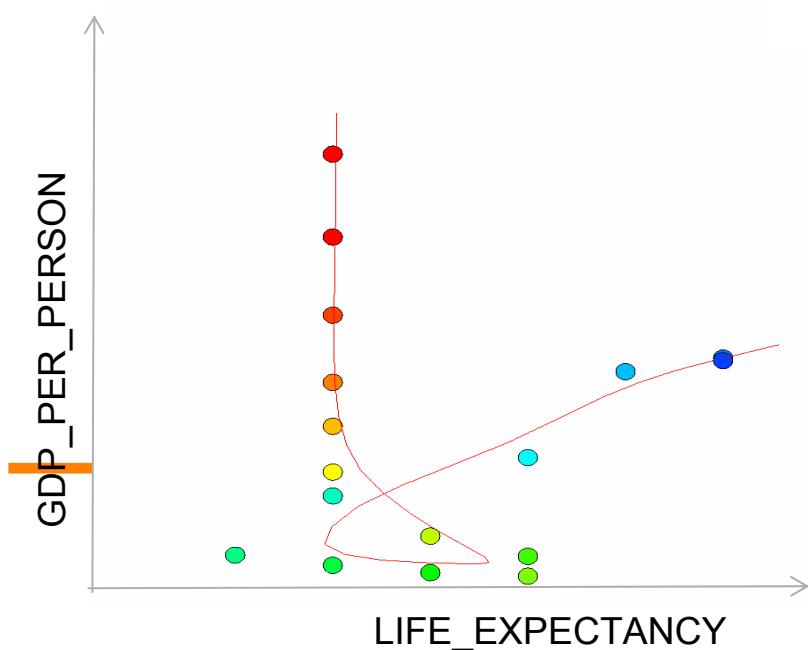
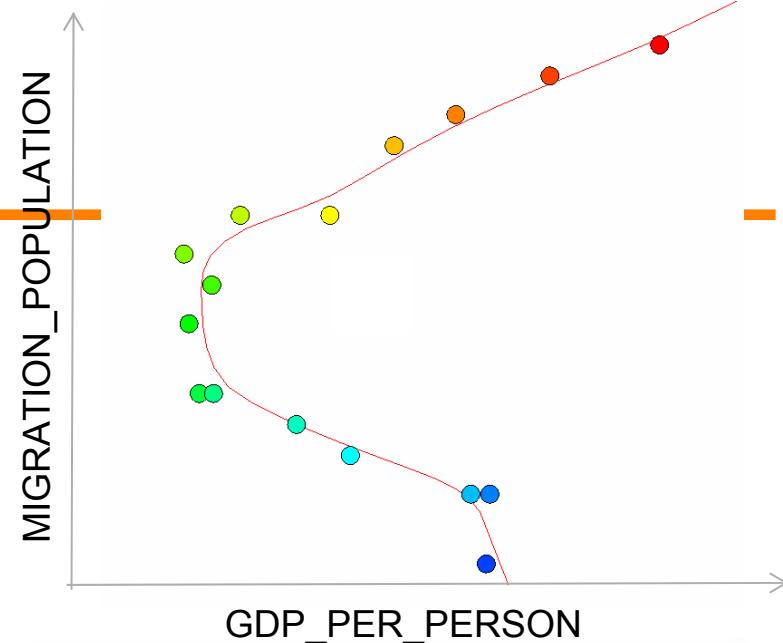
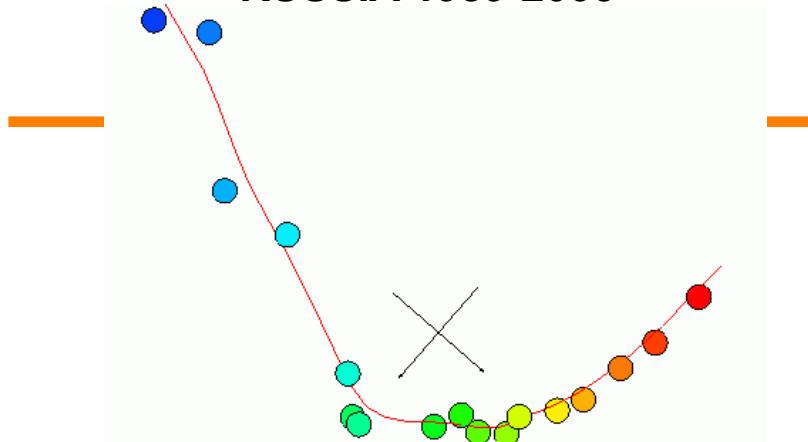
***Dynamic analysis (1989-2005):***  
***First lessons from time series data***

# STATE AS MULTIDIMENSIONAL TRAJECTORY FRANCE 1989-2005

Projection into 3 principal components

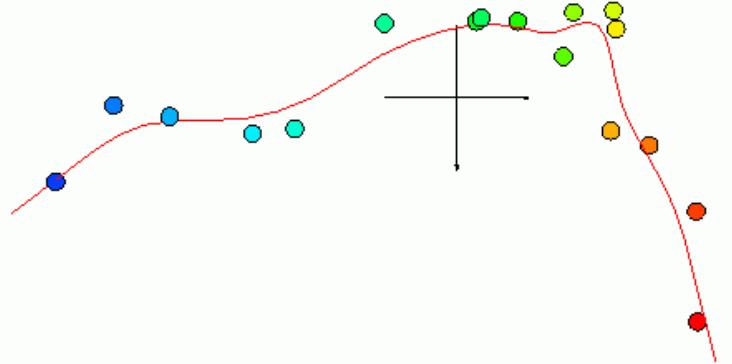


# STATE AS MULTIDIMENSIONAL TRAJECTORY RUSSIA 1989-2005

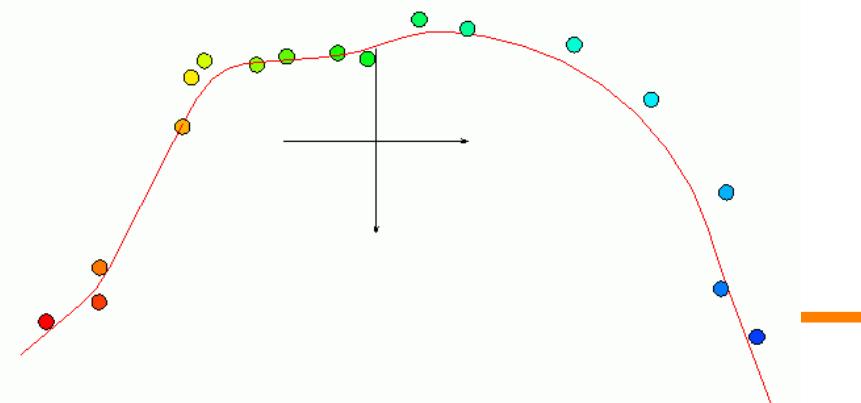


GERMANY

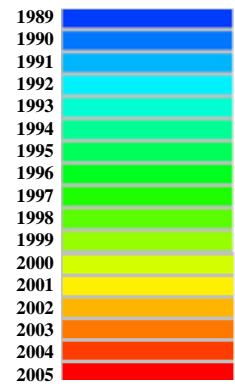
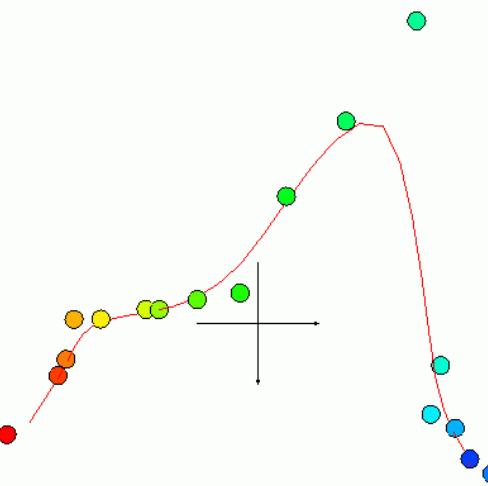
BELGIUM



USA



RWANDA

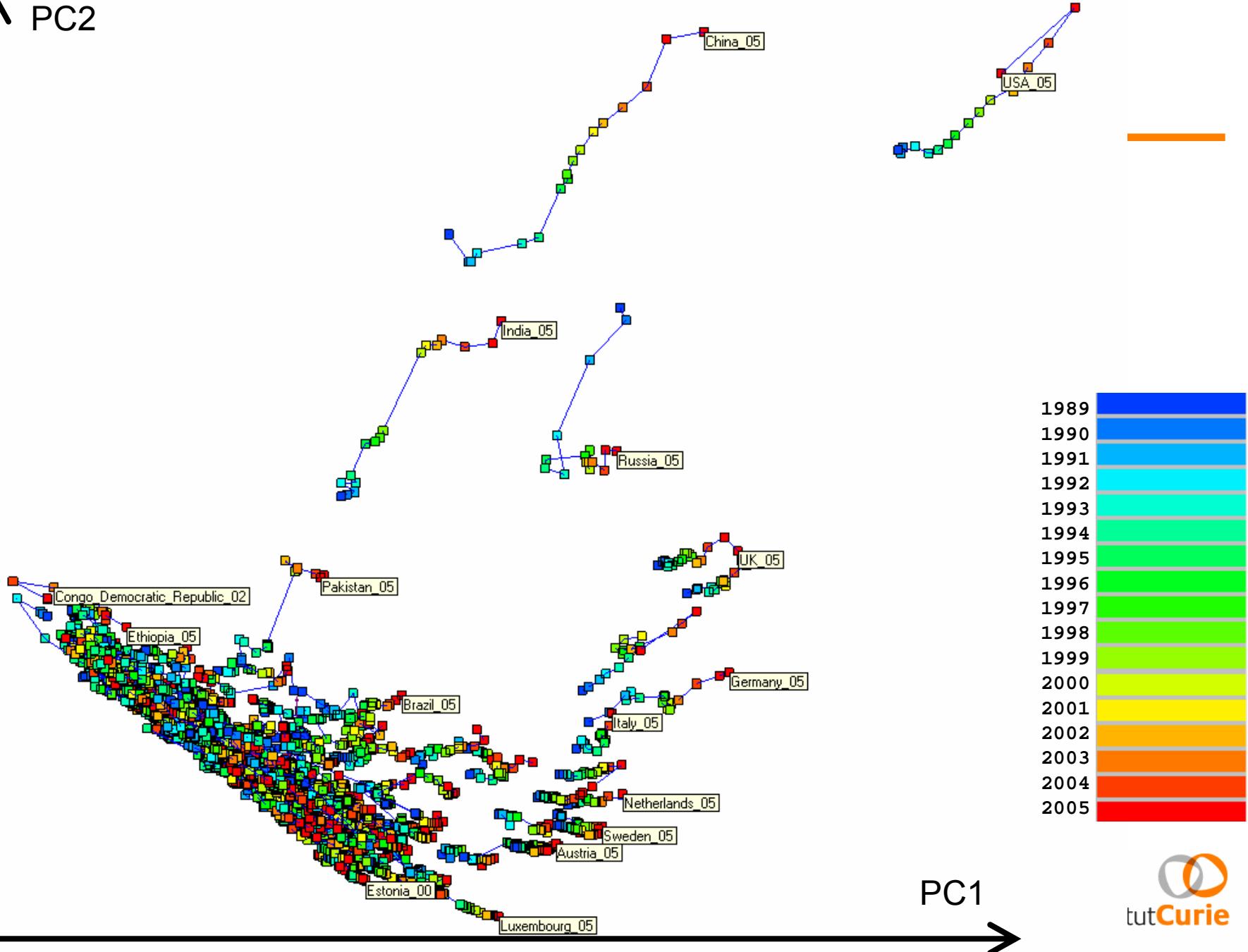


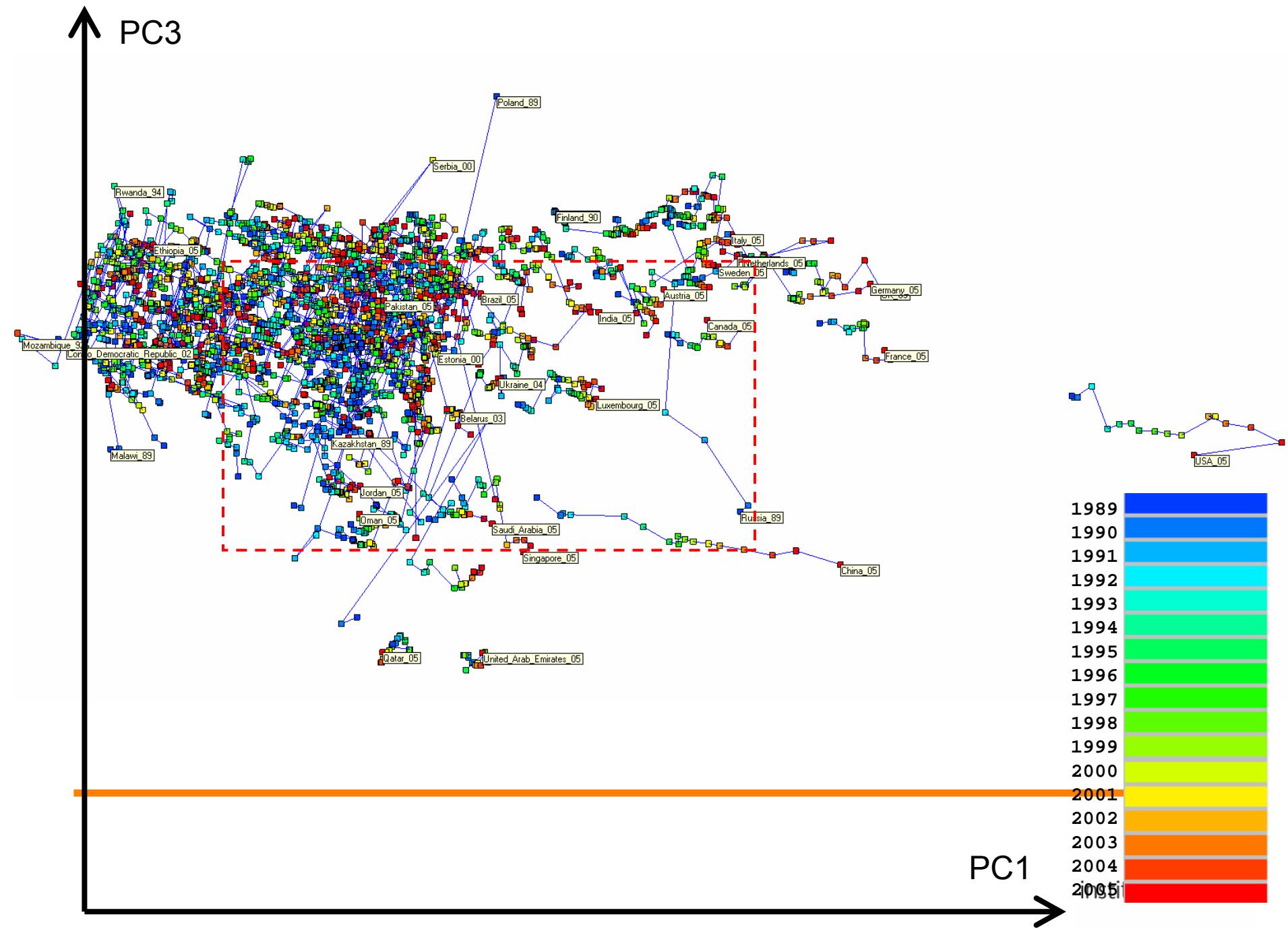
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# **Topic 1. Global trends in multidimensional trajectories of states**

What are the most general trends in the trajectories direction?

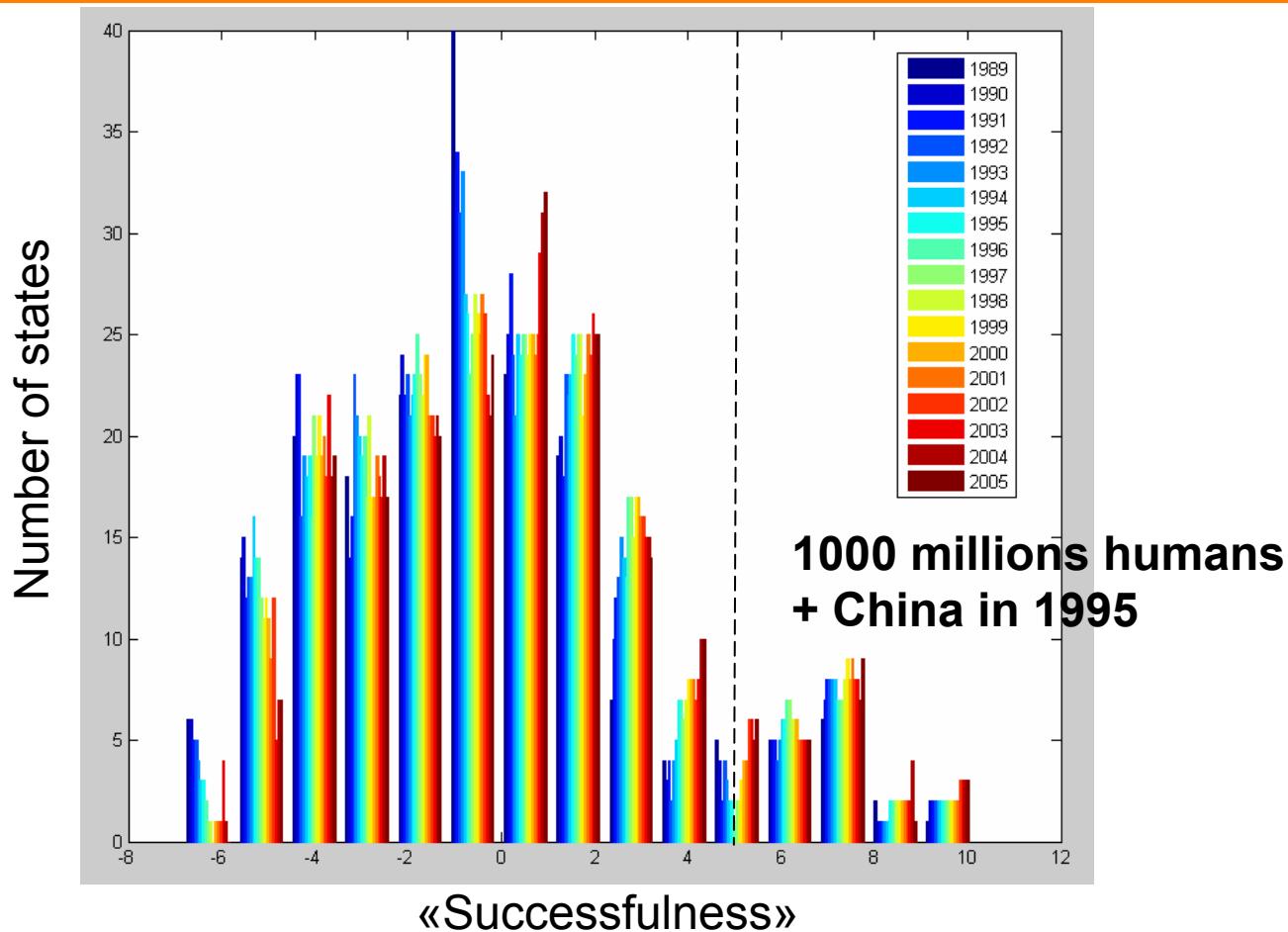
PC2

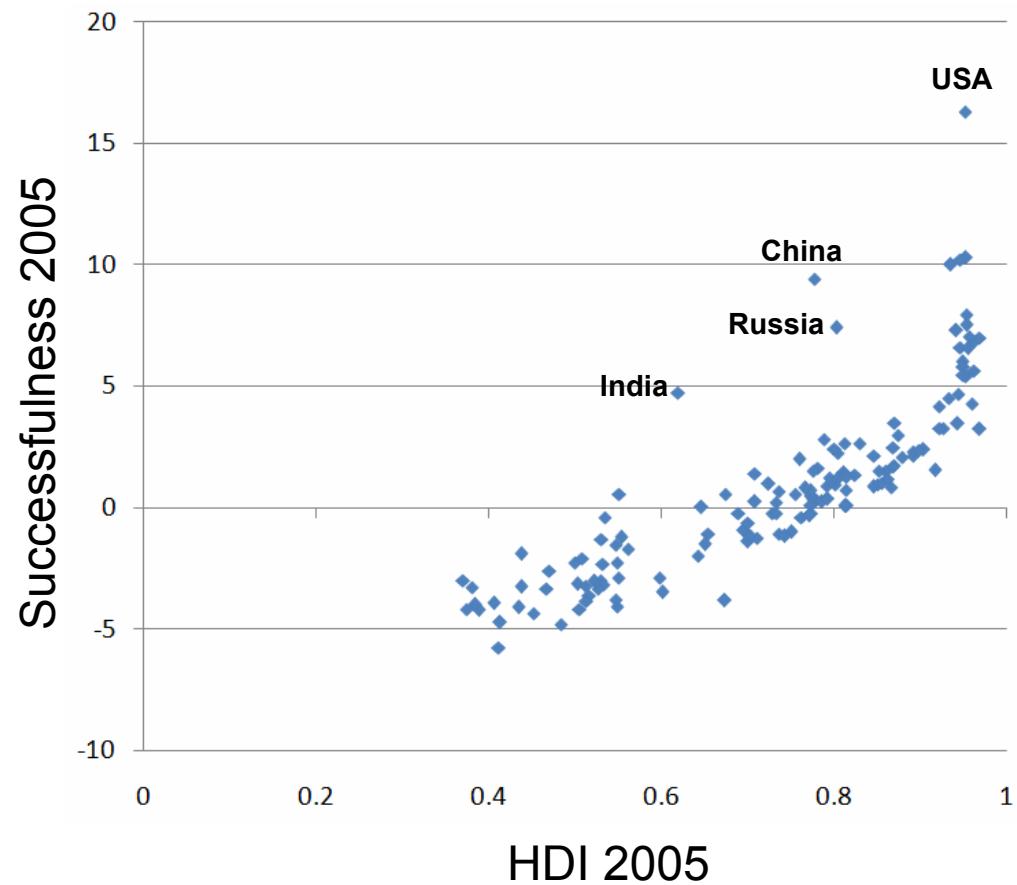




FEATURE	CATEGORY	PC1	PC2	PC3
INFLUENCE_FACTORS	Influence	0.24	0.16	0.04
GDP_PERPERSON	QualityOfLife	0.24	-0.09	-0.02
LIFE_EXPECTANCY	QualityOfLife	0.22	-0.16	-0.03
EXTERNAL_AID	State Consistency	0.21	-0.09	-0.05
COMPETITION_PERIOD	Democracy	0.21	-0.05	0.17
PARIS_CLUB	Influence	0.21	0.05	0.14
EXPORT	Influence	0.21	0.19	0.01
AVIATION_MODERN	Influence	0.2	0.08	-0.03
NOBEL_PRIZES	Influence	0.19	0.08	0.11
EXTERNAL_DEBT	State Consistency	0.18	-0.09	-0.09
WATER_POPULATION	Threats	0.18	-0.15	-0.05
ELECTRICITY_CONSUM	Influence	0.17	0.28	-0.06
GDP	Influence	0.17	0.23	-0.02
ELECTION_INVLVMT	Democracy	0.15	-0.1	0.36
MILITARY_EXPENSES	Influence	0.15	0.22	-0.05
UN_MEMBERSHIP	Influence	0.14	0.27	-0.06
NUCLEAR_WEAPON	Influence	0.14	0.26	-0.07
SUVER_PERIOD	State Consistency	0.13	0.06	0.23
POPULATION_URBAN	Influence	0.12	0.3	-0.05
COMPETITION_PARLAMENT	Democracy	0.12	-0.08	0.38
COMPETITION_PRESIDENCE	Democracy	0.11	-0.06	0.38
ARMY	Influence	0.1	0.29	-0.08
MIGRATION_PROBLEM	Threats	0.09	-0.08	-0.34
INTERNAL_CONFLICTS	State Consistency	0.08	-0.17	-0.08
MIGRATION_POPULATION	Threats	0.08	-0.12	-0.43
POPULATION	Influence	0.07	0.27	-0.05
POPULATION_REDUCION	Threats	0.02	-0.06	0.03
RELIGION_FRAGMENTATION	State Consistency	0	0.06	-0.07
EXTERNAL_AGRESSION	Threats	0	0.08	0
PRESENCE_EXT_MILITARY	State Consistency	-0.04	0.04	0.09
NEGATIVE_SALDO	Threats	-0.09	0.03	0.09
ANTIGOVERNMENT_MOVES	Threats	-0.1	0.16	0.1
POPULATION_REDFR	Threats	-0.1	0.06	-0.13
CATASTROPH_THREAT	Threats	-0.1	0.14	0.05
COUP_DETAT	Threats	-0.14	0.09	0.19
ETNOS_HOMOGENITY	State Consistency	-0.14	0.08	-0.13
EXTERNAL_AID_ABS	State Consistency	-0.14	0.07	0.03
TUBERCULOSIS_INCID	QualityOfLife	-0.17	0.14	0.06
WATER_PROBLEM	Threats	-0.19	0.15	0.05
STARVATION_PROBLEM	Threats	-0.19	0.15	0.08
STARVATION_POPULATION	Threats	-0.2	0.16	0.06
INFANCE_MORTALITY	QualityOfLife	-0.22	0.18	0.04

# ‘Successfulness’ index?



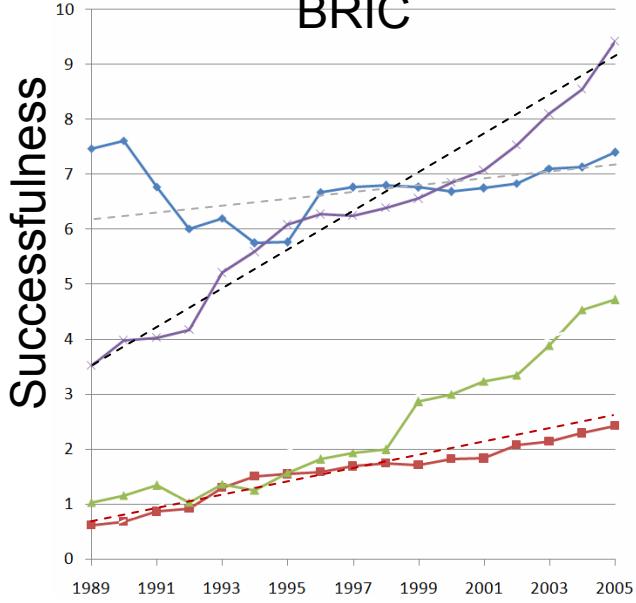


## 'Successfulness' spectrum

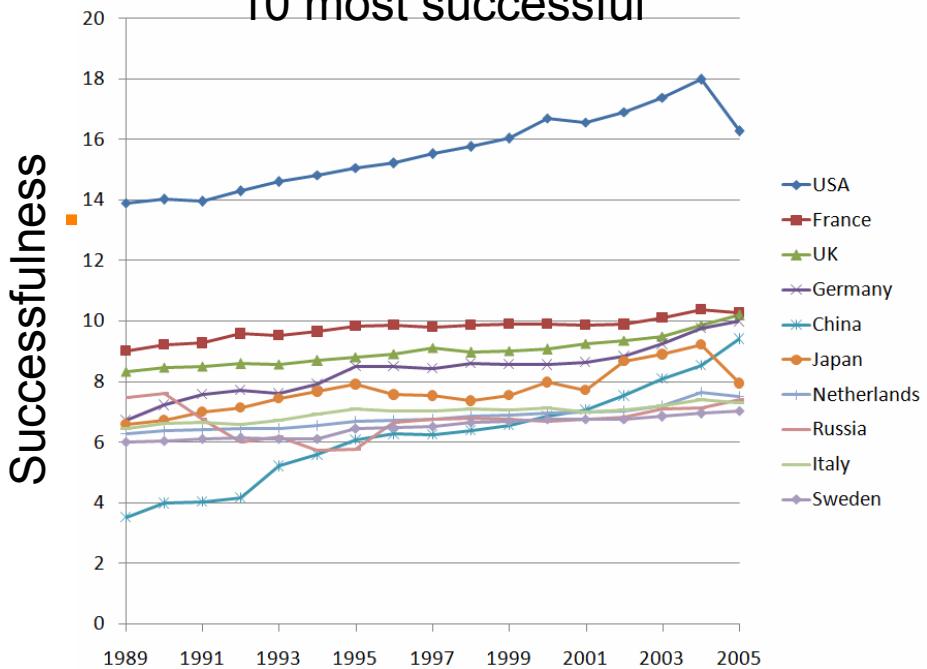
Russia	Positive contribution	Negative contribution	Switzerland	Positive contribution	Negative contribution
1990	INFLUENCE_FACTORS UN_MEMBERSHIP NOBEL_PRIZES MILITARY_EXPENSES NUCLEAR_WEAPON ELECTRICITY_CONSUM	ELECTION_INVLVMT COMPETITION_PARLAMENT	1990	NOBEL_PRIZES PARIS_CLUB INFLUENCE_FACTORS GDP_PERPERSON COMPETITION_PERIOD	ETNOS_HOMOGENUTY
1994	INFLUENCE_FACTORS UN_MEMBERSHIP NOBEL_PRIZES NUCLEAR_WEAPON	INTERNAL_CONFLICTS COMPETITION_PERIOD COUP_DETAT	1994	NOBEL_PRIZES PARIS_CLUB INFLUENCE_FACTORS GDP_PERPERSON COMPETITION_PERIOD	ETNOS_HOMOGENUTY
2000	INFLUENCE_FACTORS UN_MEMBERSHIP NOBEL_PRIZES PARIS_CLUB NUCLEAR_WEAPON	INTERNAL_CONFLICTS COUP_DETAT	2000	GDP_PERPERSON NOBEL_PRIZES PARIS_CLUB INFLUENCE_FACTORS	ETNOS_HOMOGENUTY
2005	INFLUENCE_FACTORS UN_MEMBERSHIP NOBEL_PRIZES PARIS_CLUB NUCLEAR_WEAPON	COUP_DETAT ANTIGOVERMENT_MOVES	2005	GDP_PERPERSON NOBEL_PRIZES PARIS_CLUB INFLUENCE_FACTORS	ETNOS_HOMOGENUTY



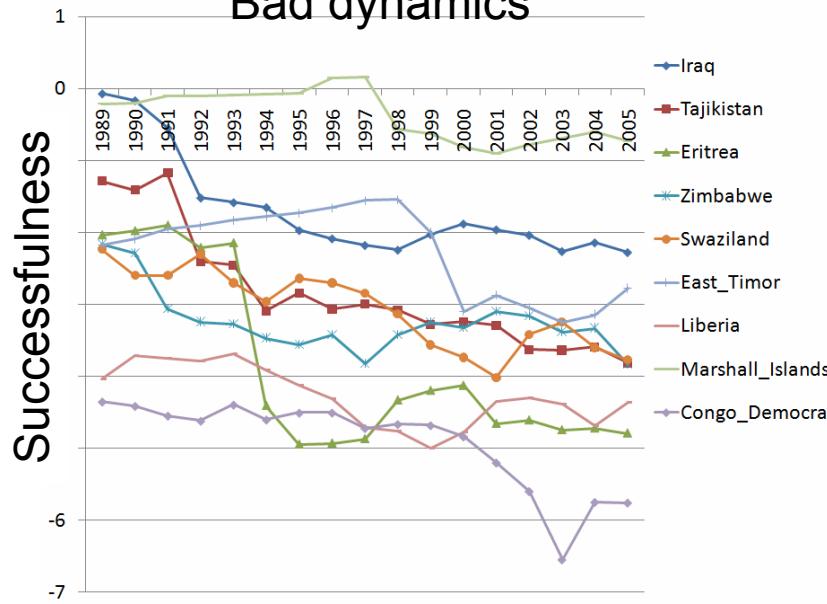
## BRIC



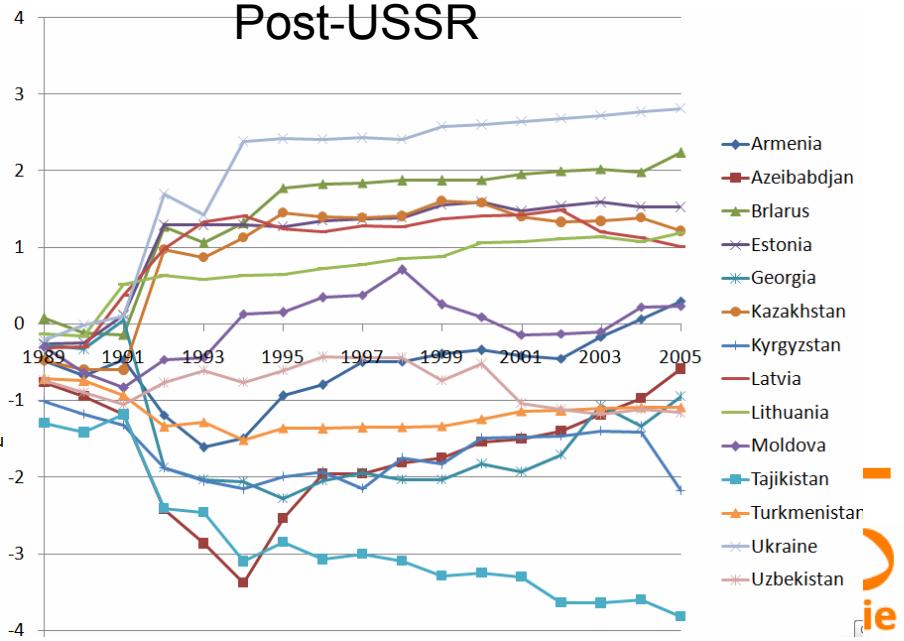
## 10 most successful



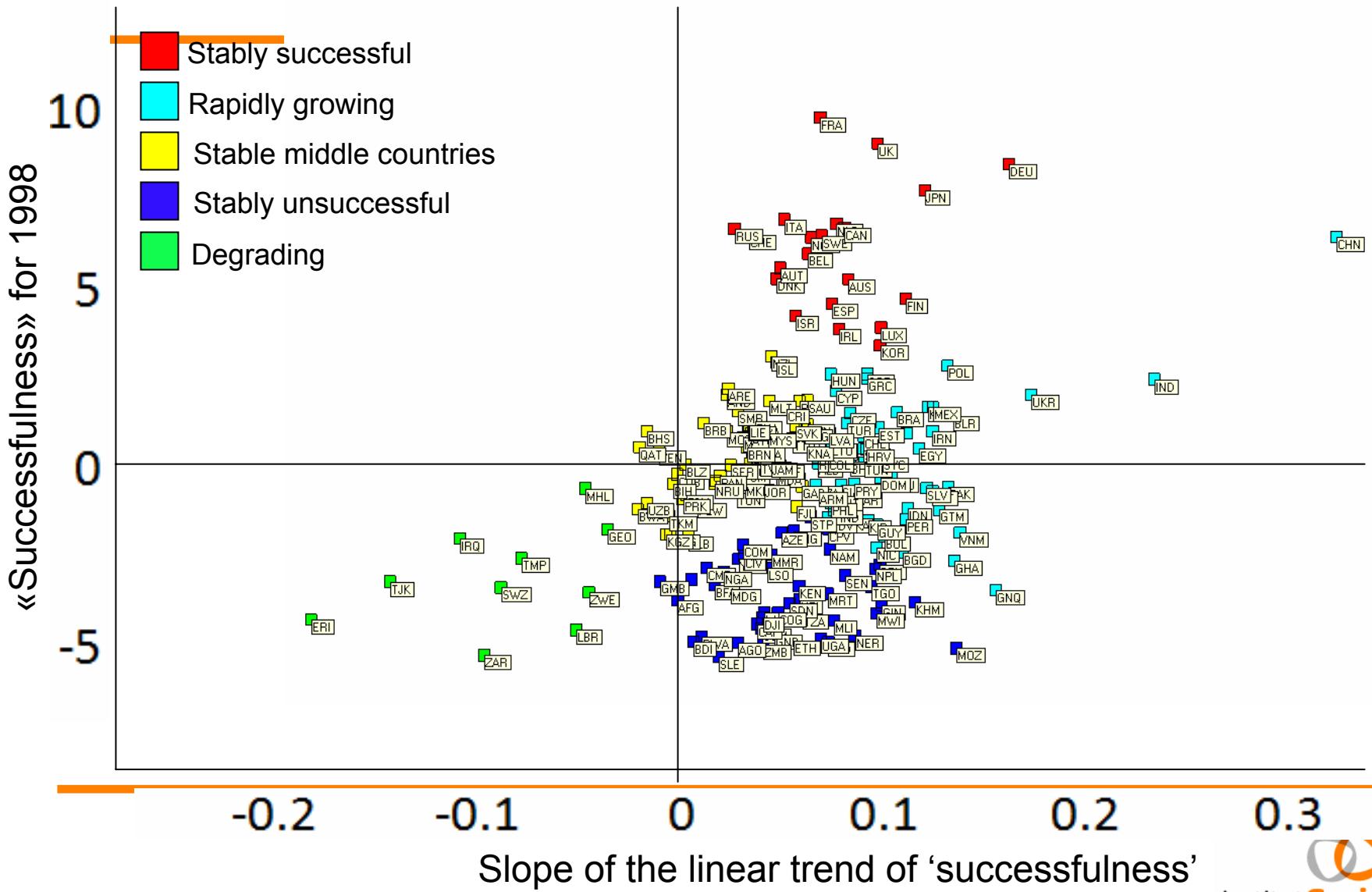
## Bad dynamics



## Post-USSR



15

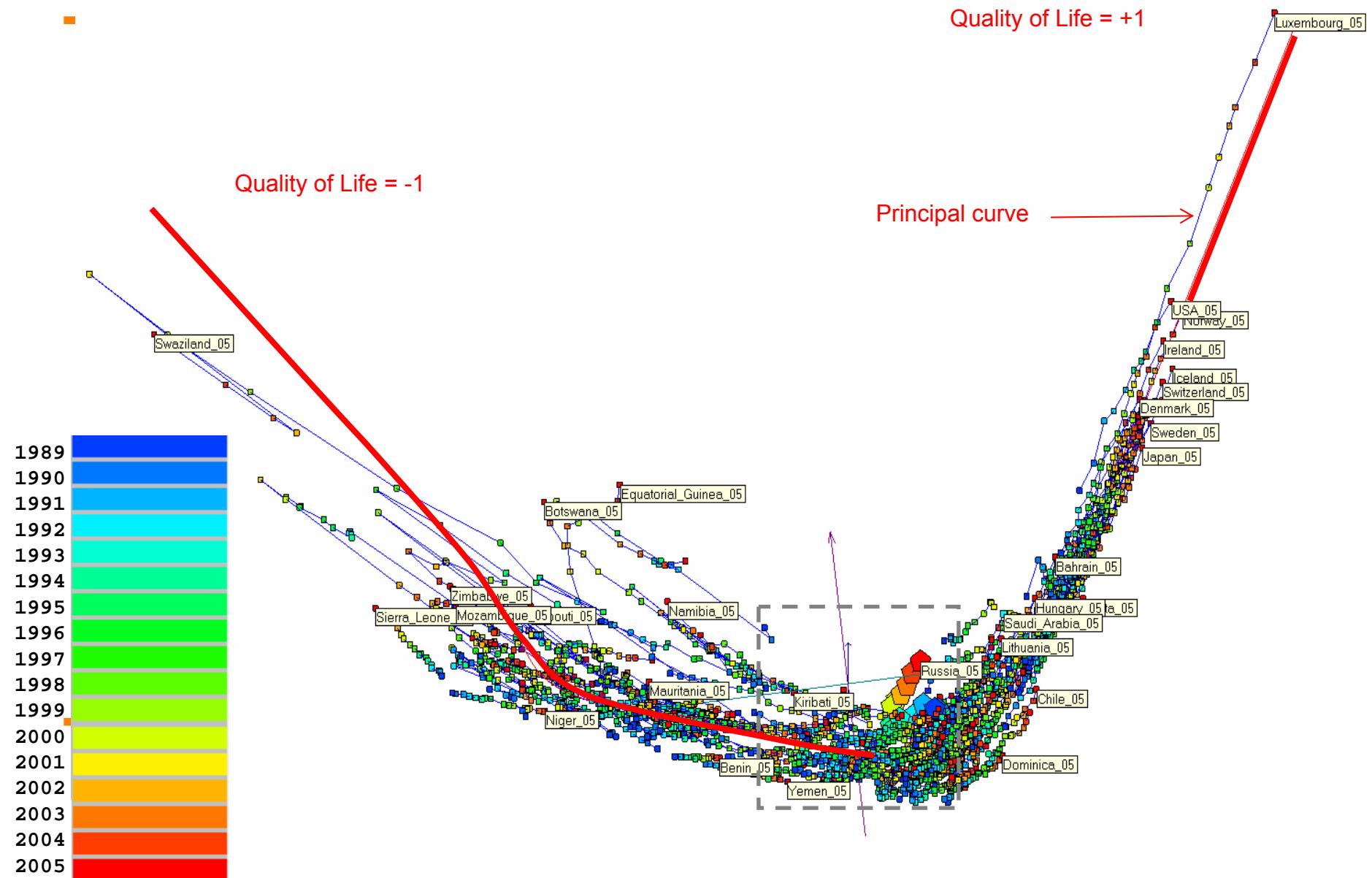


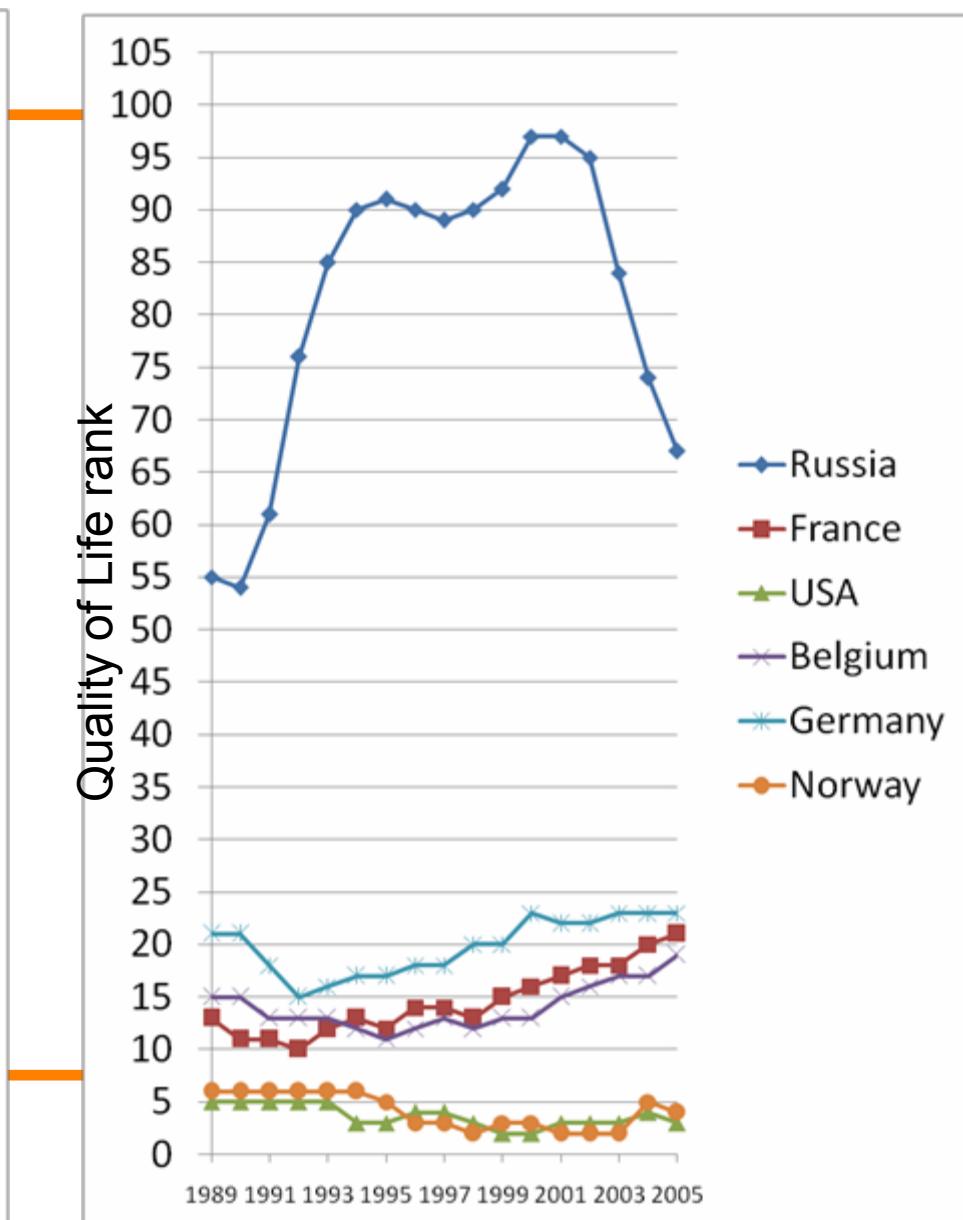
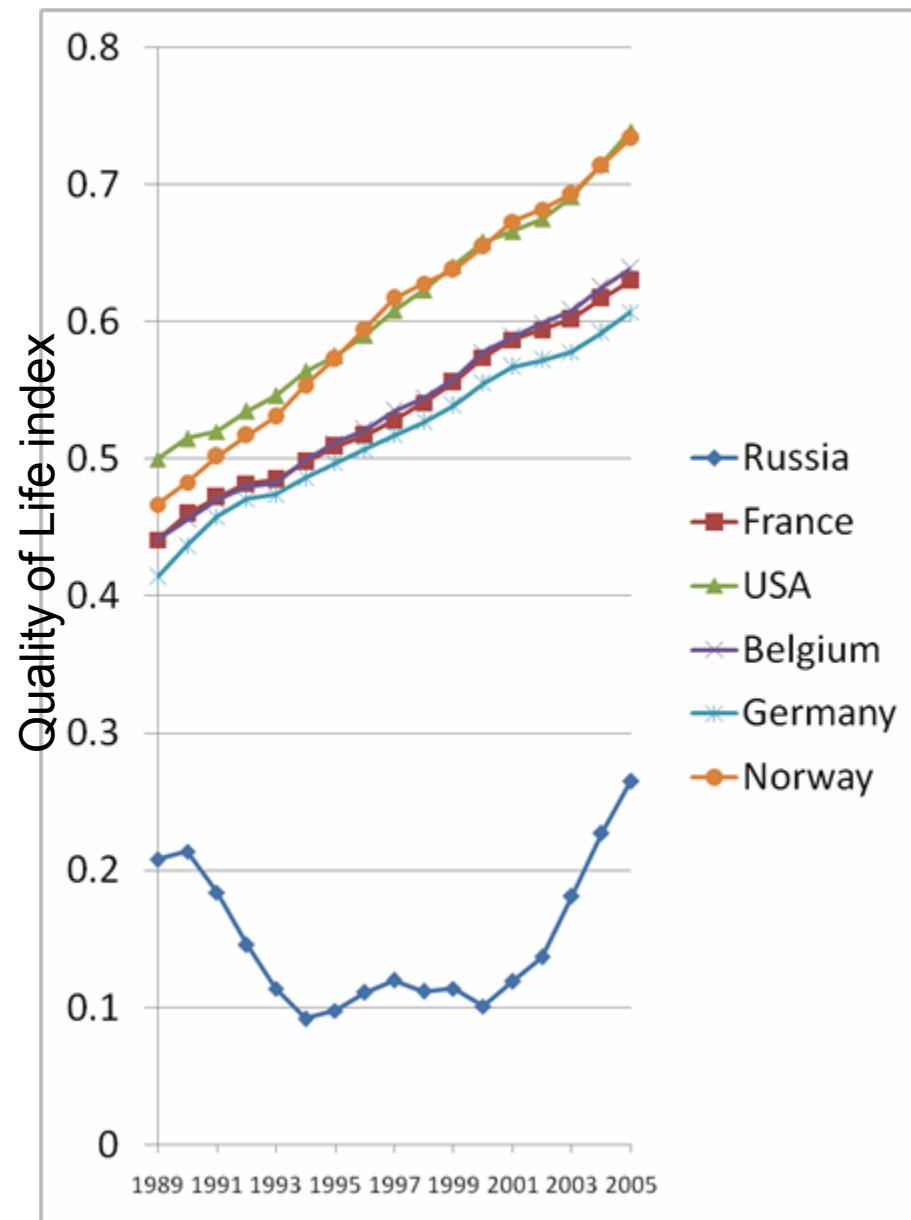
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## **Topic 2. Non-linear index of quality of life**

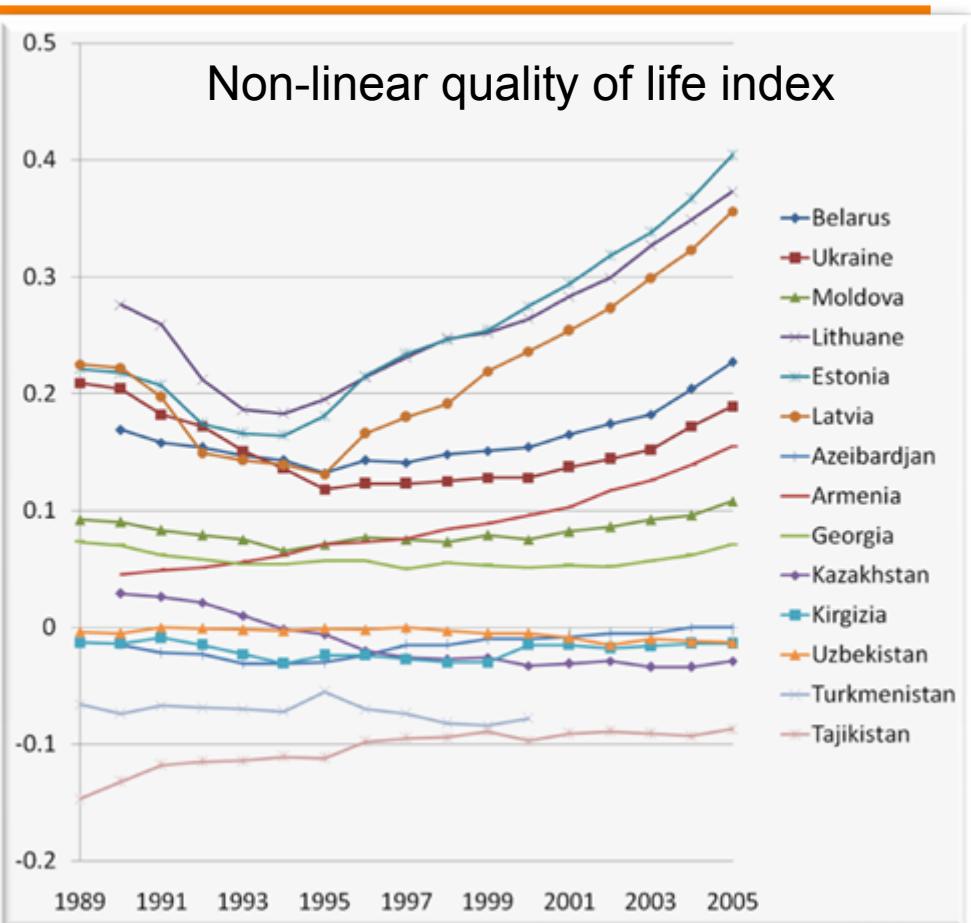
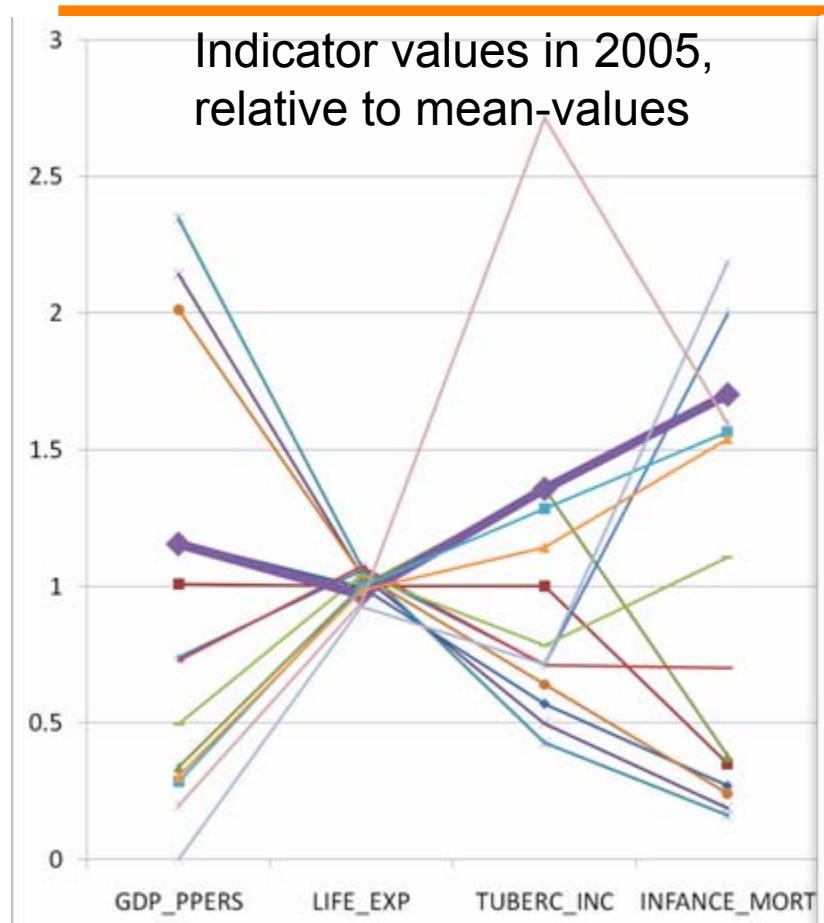
How to combine 4 features into one in the most objective way?

- 1) GROSS PRODUCT PER PERSON
- 2) LIFE SPAN EXPECTATION
- 3) INFANCE MORTALITY
- 4) TUBERCULOSIS INCIDENCE





# Kazakhstan's problems: high GDP PER PERSON and high TUBERCULOSIS INCIDENCE and INFANCE\_MORTALITY

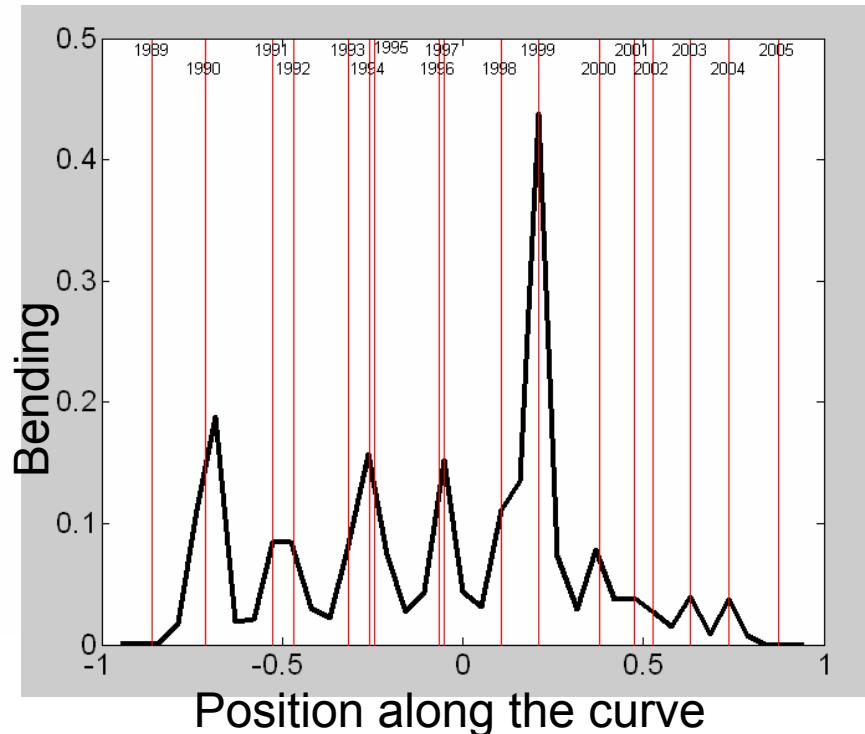
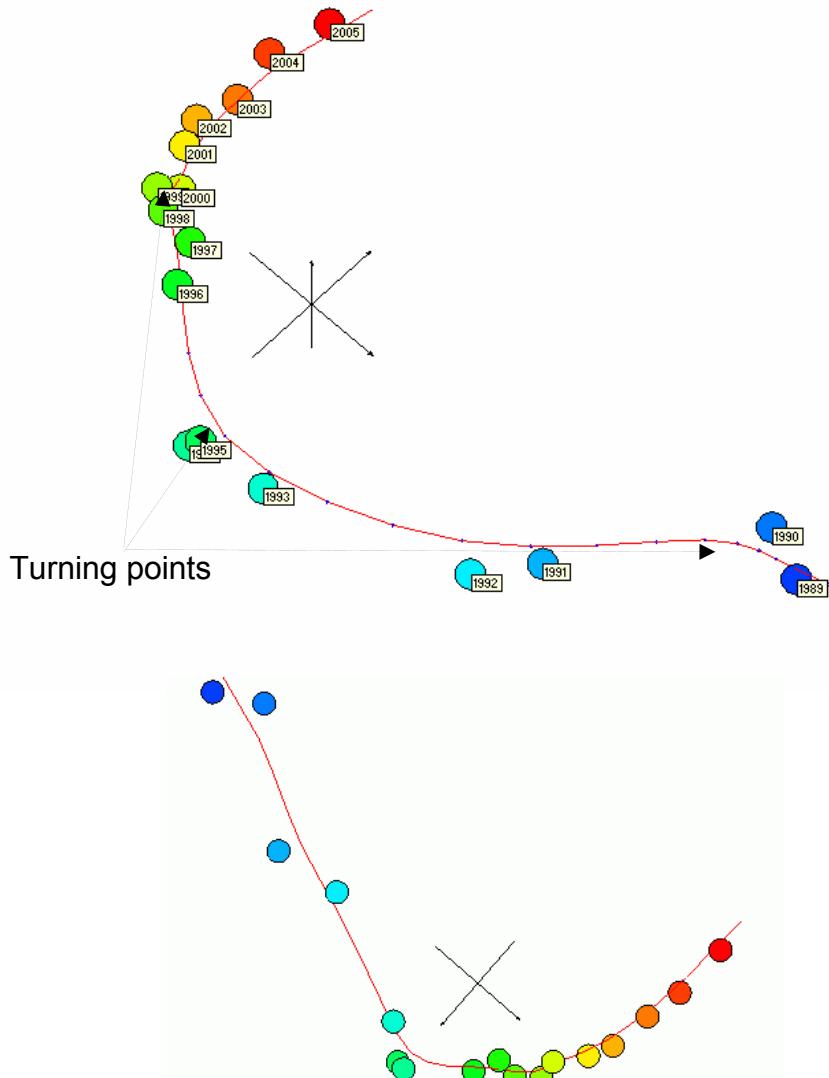


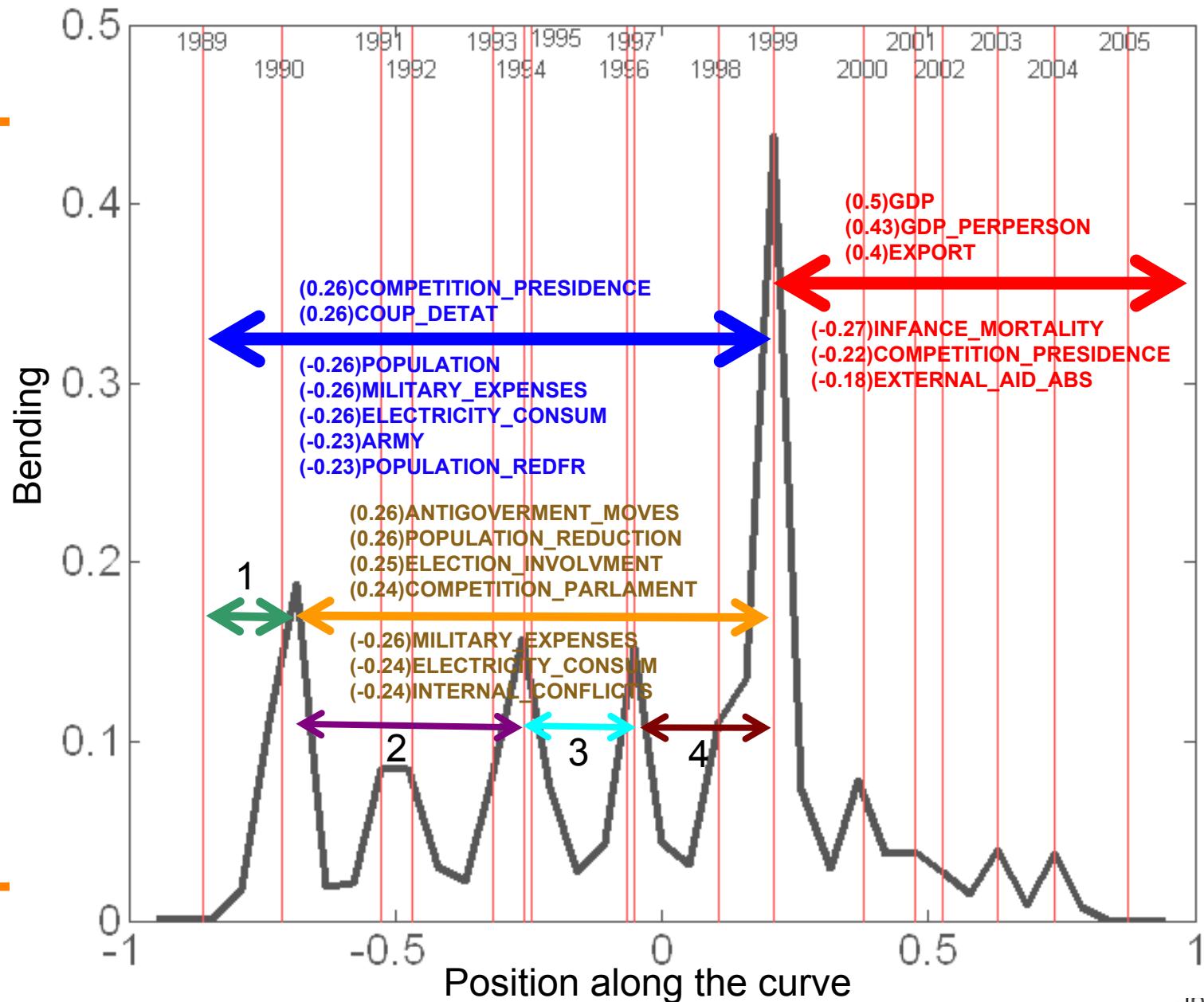
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## **Topic 3. “Turning points” on the multidimensional trajectories**

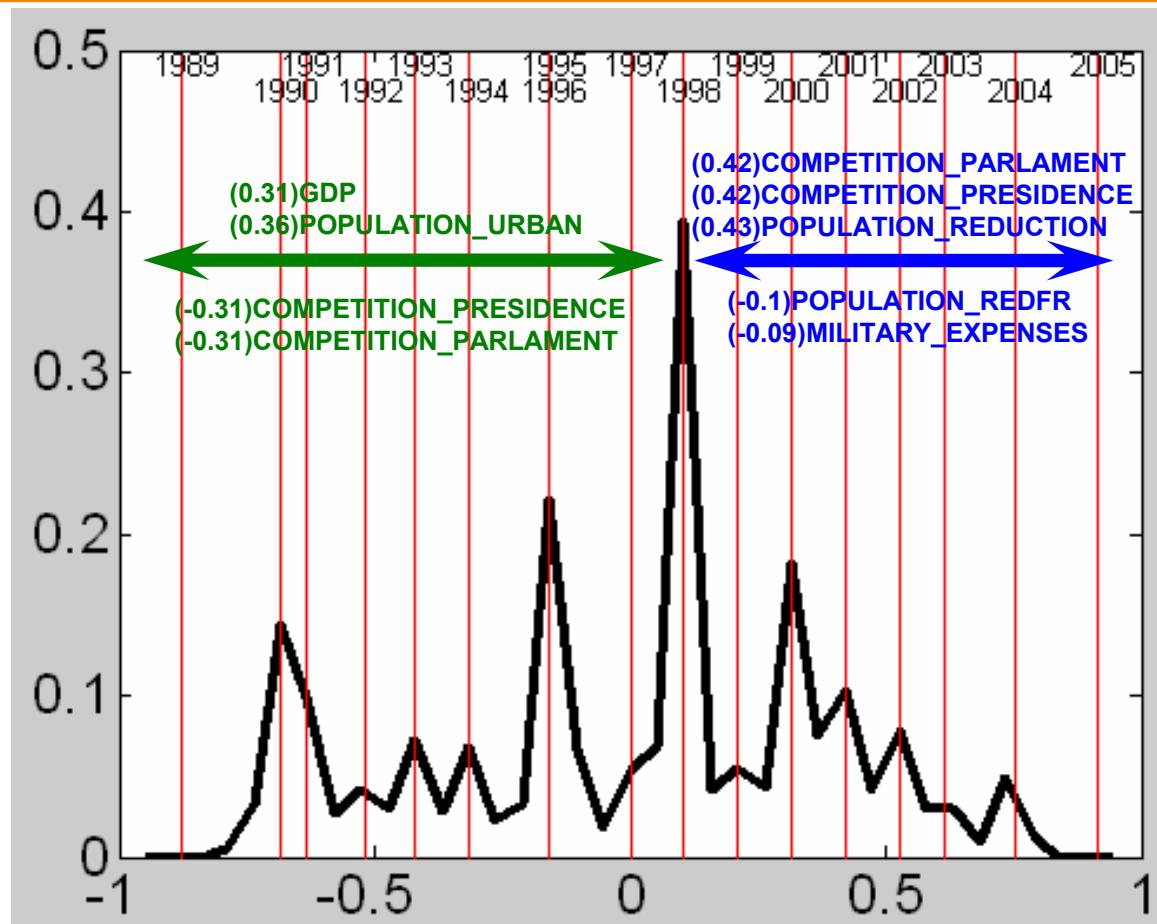
When a state history is mostly affected by some  
(internal or external) factors?

# RUSSIA in the 1989-2005

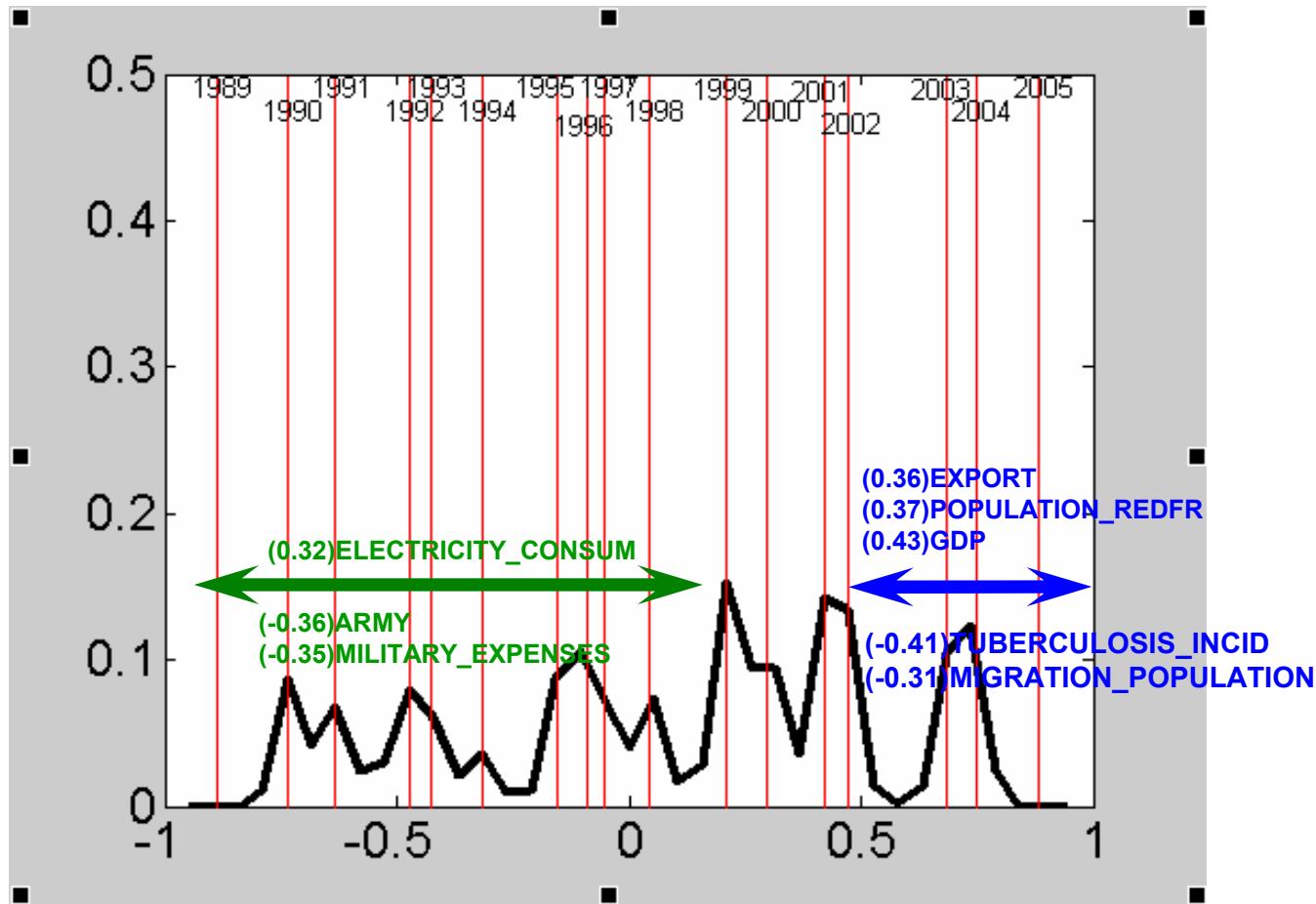




## GERMANY in 1989-2005



## BELGIUM in 1989-2005



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# **Topic 4. Verhulst local models**

# Predict the future from today and the past

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$$X_{t+1} = F(X_t, X_{t-1}, X_{t-2}, \dots)$$

Simplest models (predictions):

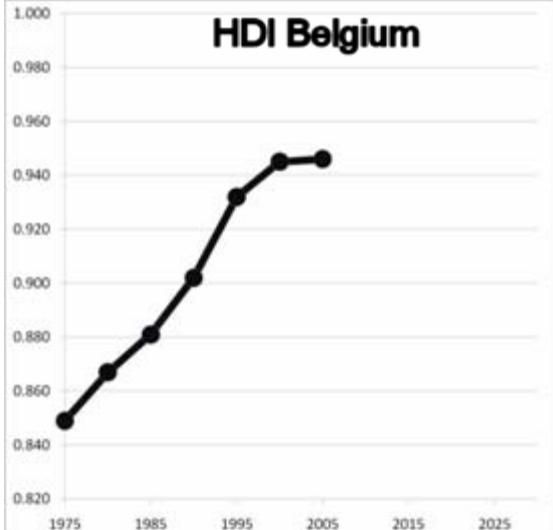
- 1)  $X_{t+1} = A = \text{const}$  (tomorrow is the same as today)
- 2)  $X_{t+1} = X_t + A$  (additive improvement or degrading – linear trend)
- 3)  $X_{t+1} = A \cdot X_t$  (proportional improvement – exponential growth/decline)

All of them are ‘trivial’ (linear)

The simplest non-trivial (non-linear) model

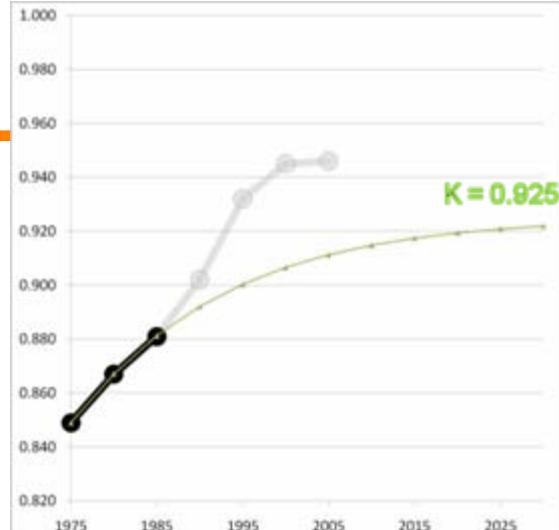
- 4)  $X_{t+1} = X_t + A \cdot X_t \cdot (X_t - K)$  – Verhulst’s model  
Leads to several possible solutions  
(saturation, exponential, periodic, chaotic)

## HDI Belgium



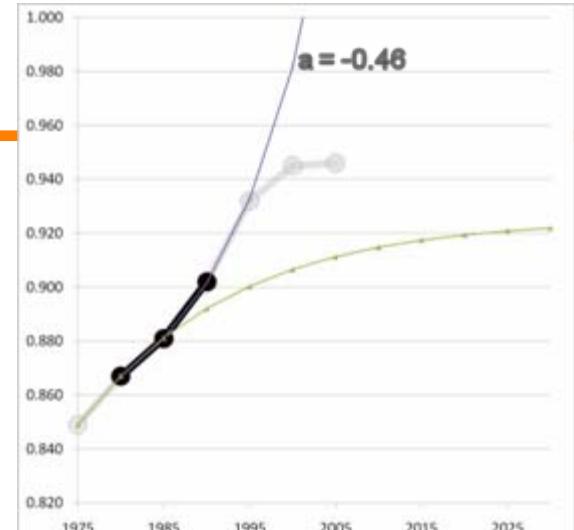
Исходный временной ряд

*Initial time series*



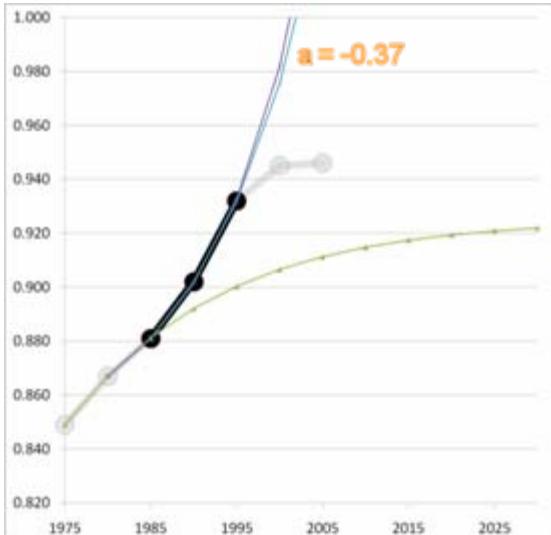
В 1985 г. делается прогноз на основе значений трех лет (1975-1985) о том, что к 2030г. ИЧР выйдет на 0.925 (значение **K**). Однако, уже в 1990 рост ИЧР опережает прогноз (играет роль какой-то внешний фактор)

*In 1985 one makes a prognosis based on the HDI values during the last three years (1975-1985) about that towards 2030 HDI will gradually achieve 0.925 (**K** value). However, already in 1990 HDI becomes higher than predicted (some external factor plays a role).*



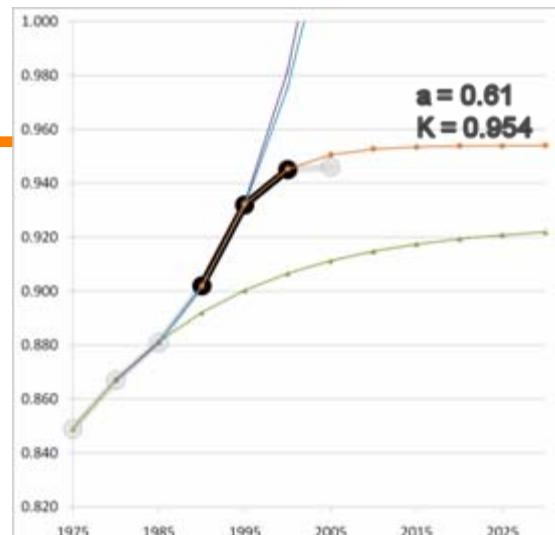
В 1990г. прогноз уточняется с использованием периода 1980-1990. Предсказывается неограниченный экспоненциальный рост ( $a < 0$ ) и в 1995г. прогноз сбывается.

*In 1990 the prognosis is corrected with use of the (1980-1990) period. One predicts unlimited growth ( $a < 0$ ) and in 1995 HDI achieves the predicted value.*



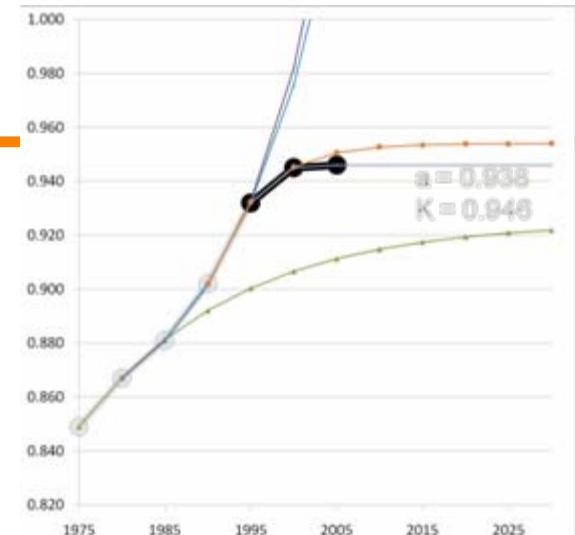
В 1995г. прогноз качественно остается прежним – экспоненциальный рост с чуть меньшими темпами (значение  $a$ ). Однако, в 2000г. этот прогноз оказывается слишком оптимистичен (какой-то внешний фактор резко ограничивает рост).

*In 1995 the prognosis qualitatively remains the same: exponential growth with slightly slower speed ( $a$  value). However, in 2000 this prognosis happens to be too optimistic (some external factor now limits the growth)*



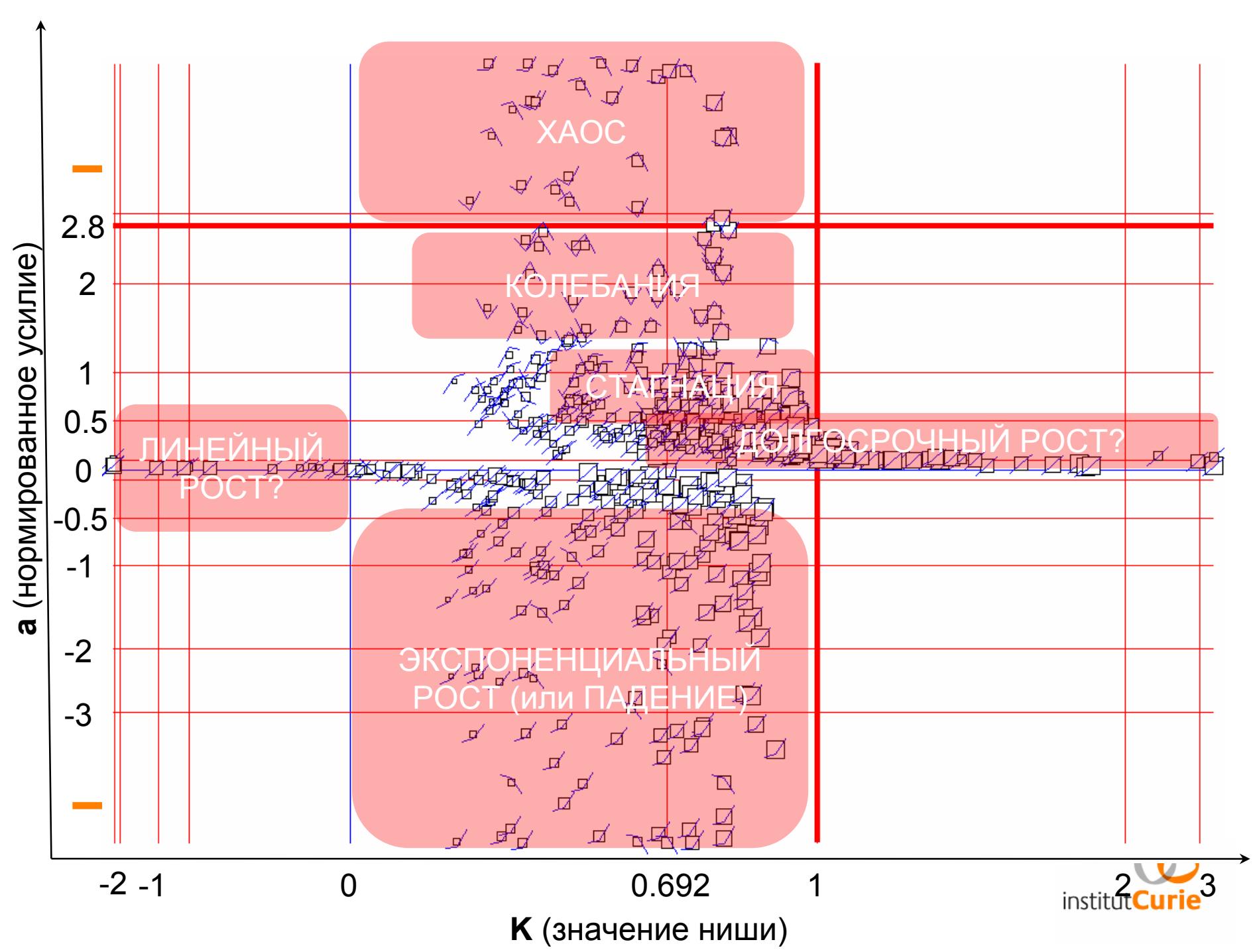
В 2000г. на основе периода (1990-2000) прогнозируется быстрая (значение  $a$ ) стагнация к значению ИЧР 0.954 (значение  $K$ ). Однако, даже этот прогноз к 2005г. оказывается слишком оптимистичен.

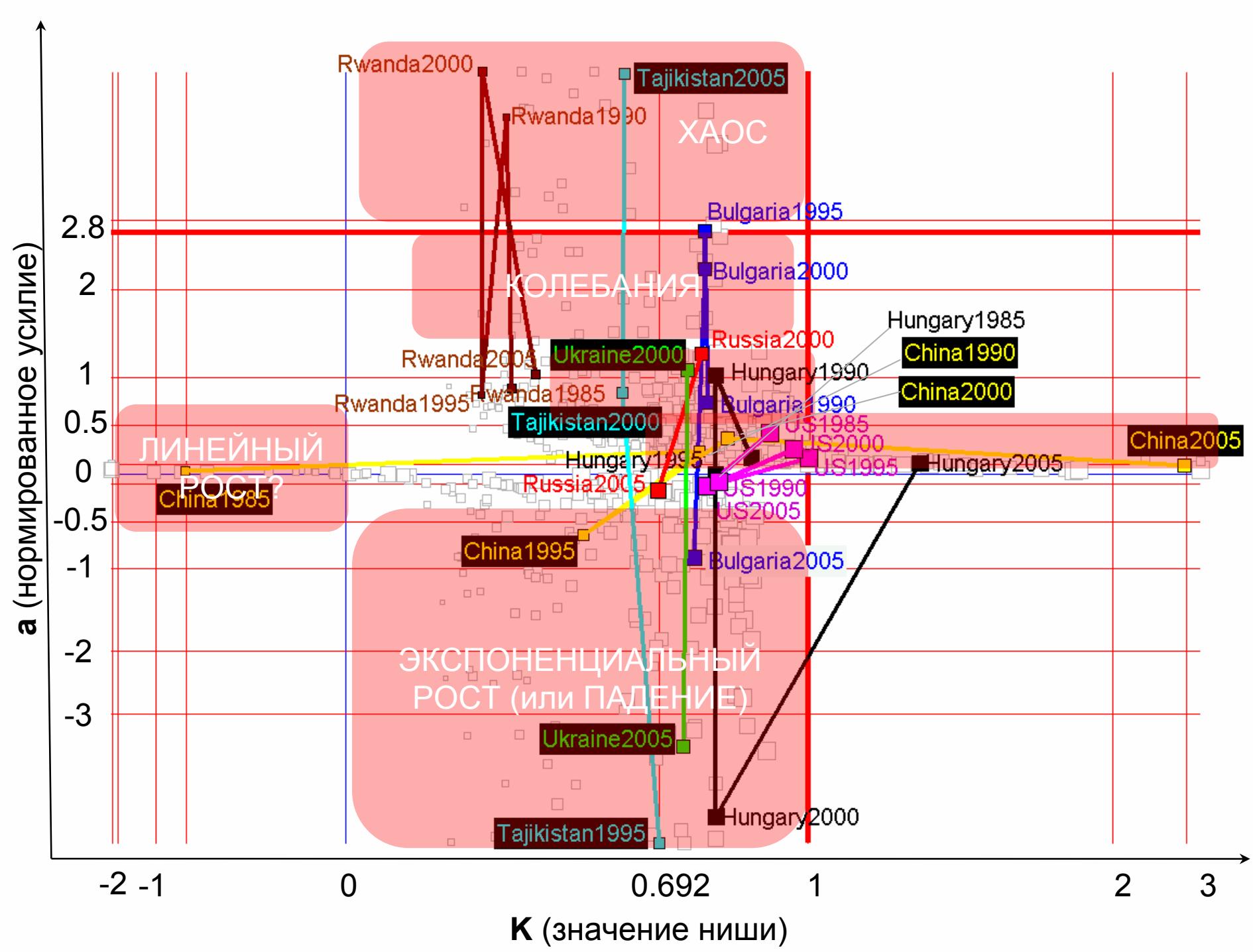
*In 2000 based on the (1990-2000) period one predicts rapid ( $a$  value) stagnation to the HDI values 0.954 ( $K$  value). However, even this prognosis happens to be too optimistic towards 2005.*



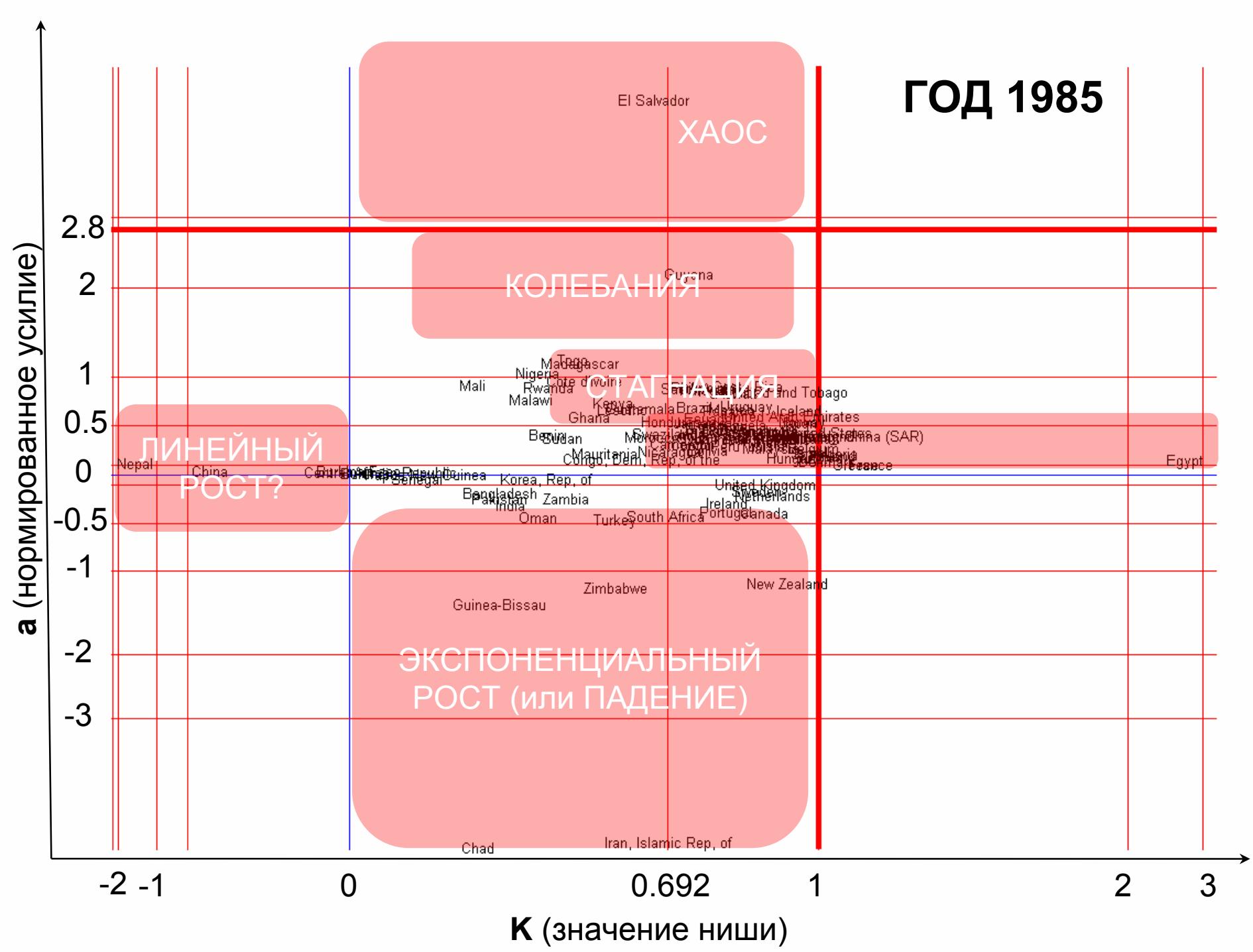
В 2005г. прогноз корректируется: далее предсказывается полная стагнация со значением ИЧР в 0.946 (достигнут предел роста)

*In 2005 the prognosis is corrected: further one predicts complete stagnation with HDI value 0.946 (growth limit has been reached).*

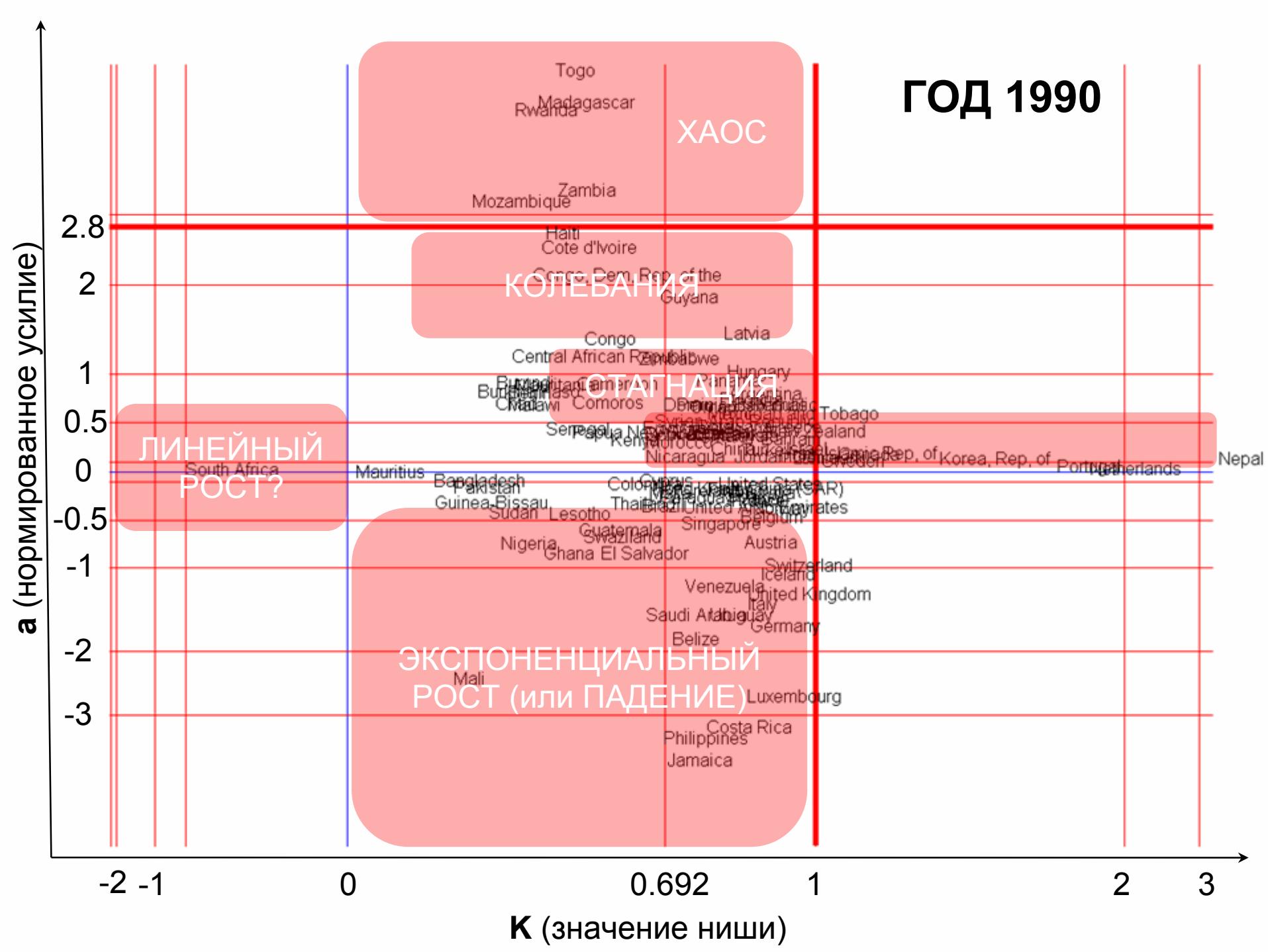




**ГОД 1985**



**ГОД 1990**



**ГОД 1995**

