DYNAMIC MULTIDIMENSIONAL SCALING

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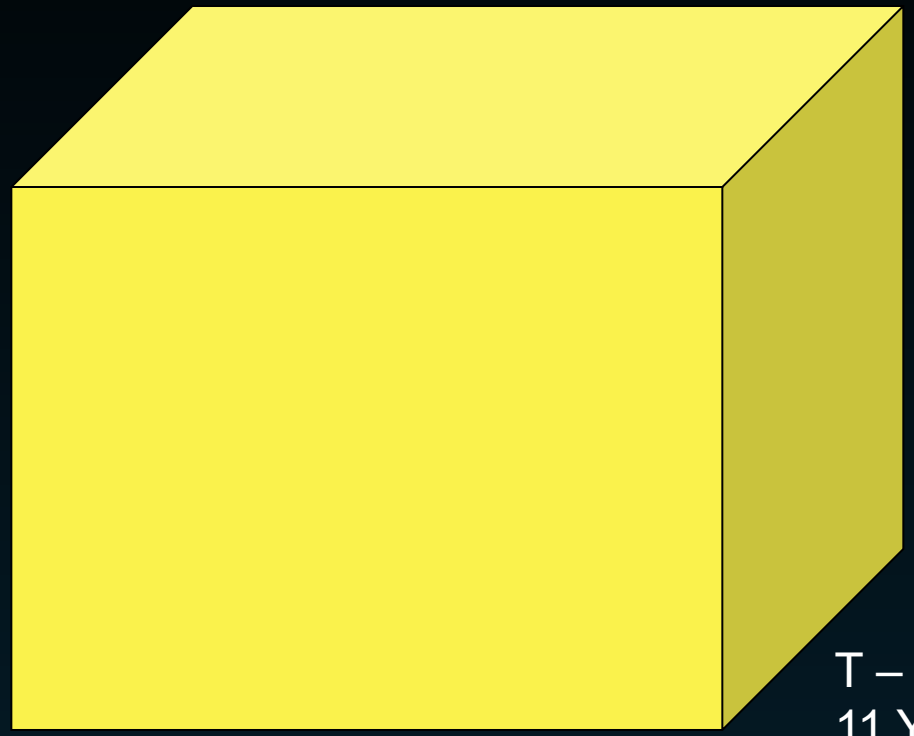
Data Cube



Y - objects
27 EU countries

T – Time units
11 Years: 2014-2024

Z – variables
5 variables

Multivariate Spatio-Temporal Data

Multidimensional Scaling (MDS)

Multidimensional scaling (MDS) is a popular and well established procedure in multivariate analysis. It allows for optimal graphical representation of multidimensional objects configuration in low-dimensional space, usually on the two-dimensional plane. Distance matrix in original space is an input data for the procedure which is looking for such configuration of objects which produce the distance matrix in output space minimizing similarity measure for original and output distances (such as stress - [7]). Details can be found in textbook on MDS, like [1, 2, 3, 4, 5, 8, 9].

Walesiak M., Dehnel G., Dudek A., Visualisation of linear ordering results using multidimensional scaling – problems and an overview of studies, *Argumenta Oeconomica*, 2025, Vol. 54, No 1, 187-203

International Conference on Information Complexity and Statistical Modeling in High Dimensions with Applications (IC-SMHD-2016)

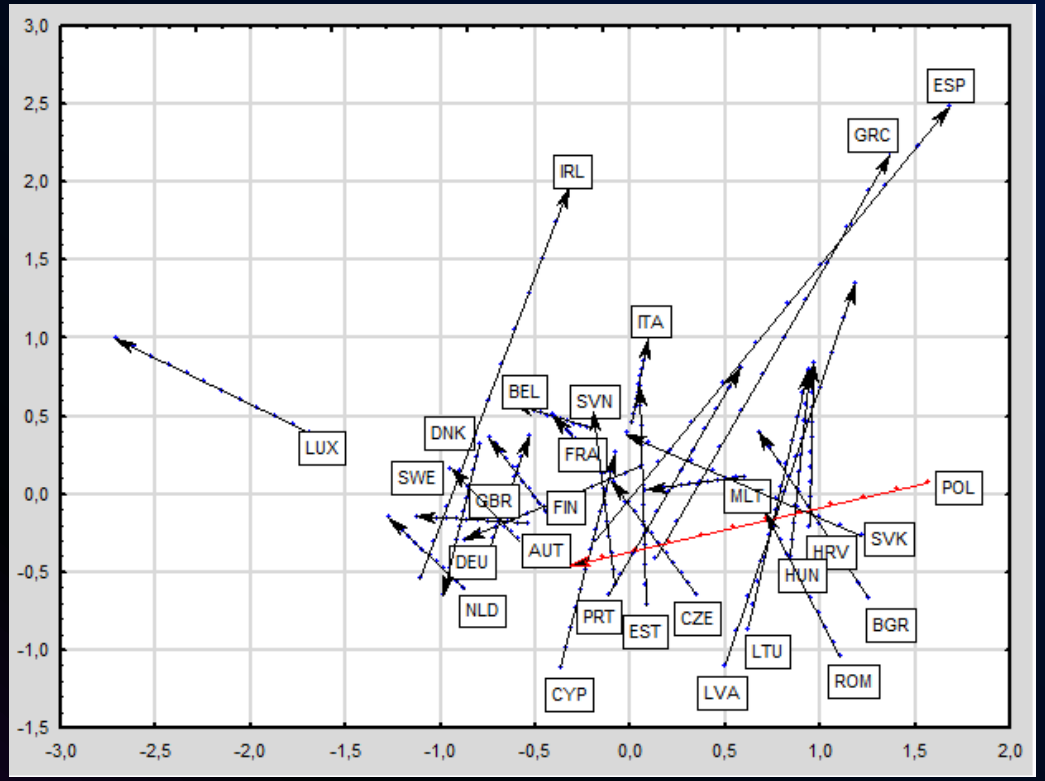
May 18-21, 2016, Nevsehir, Turkey

Predictive Multidimensional Scaling. The Analysis of EU and Turkey Economic Development

Andrzej Sokołowski and Małgorzata Markowska and Agnieszka Rygiel

APPROACH 1

- Global standardization – using mean and standard deviation, calculated for the whole period
- MDS separately for each year
- Linear trends for two coordinates
- Clustering trends



Conference of Classification and Data Analysis Section of the Polish Statistical Society (SKAD)

October 23-25, 2017, Kraków, Poland

NIELINIOWE DYNAMICZNE SKALOWANIE WIELOWYMIAROWE

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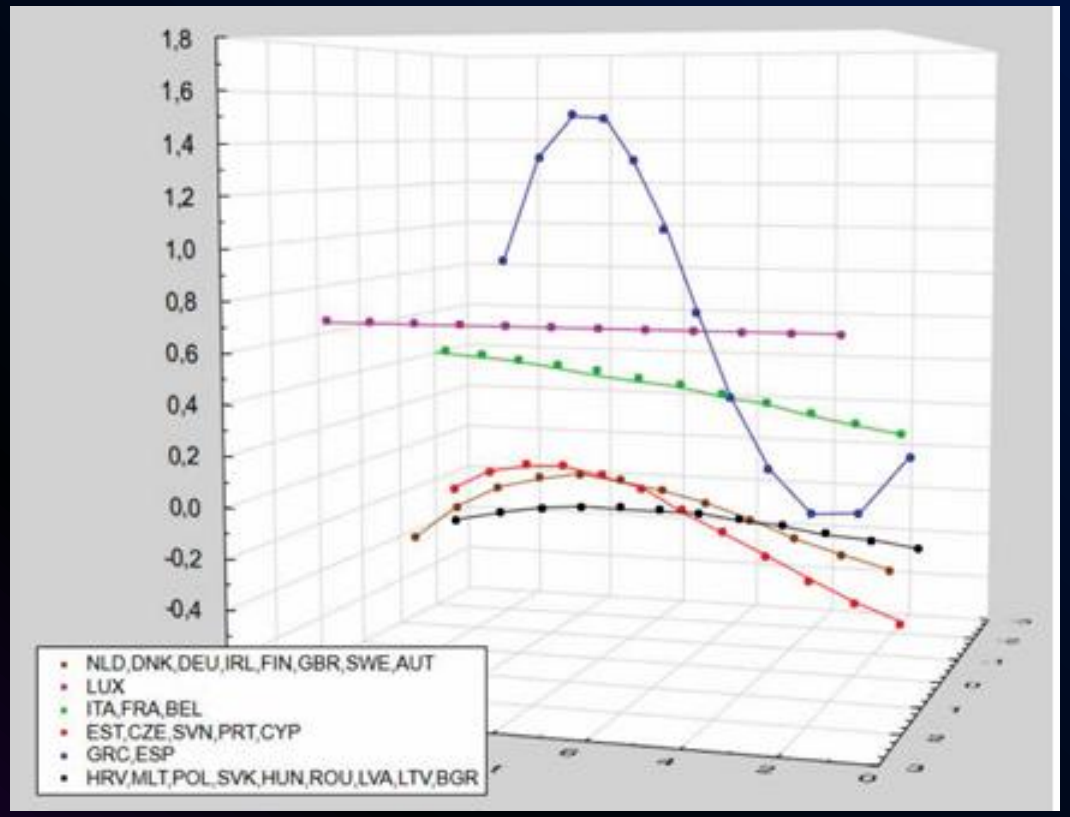
APROKSYMACJA WYNIKÓW DYNAMICZNEGO SKALOWANIA WIELOWYMIAROWEGO TRENDAMI NIELINIOWYMI

NONLINEAR TREND APPROXIMATION OF THE RESULTS OF DYNAMIC MULTIDIMENSIONAL SCALING

DOI: 10.15611/pn.2018.507.16
JEL Classification: C14, C23, O11

APPROACH 2

- Global standardization – using mean and standard deviation, calculated for the whole period
- MDS separately for each year
- Non-linear trends for two coordinates
- Clustering trends



APPROACH 3 (NEW)

- Local standardization – using mean and standard deviation, calculated for each period
- MDS separately for each year
- Chain rotation
- Non-linear and linear trends for two coordinates

$$x_1^* = x_1 \cos\alpha - x_2 \sin\alpha$$

$$x_2^* = x_1 \sin\alpha + x_2 \cos\alpha$$

$$D = \sum_{i=1}^{n} d(y_{i,t-1}; y_{i,t})$$

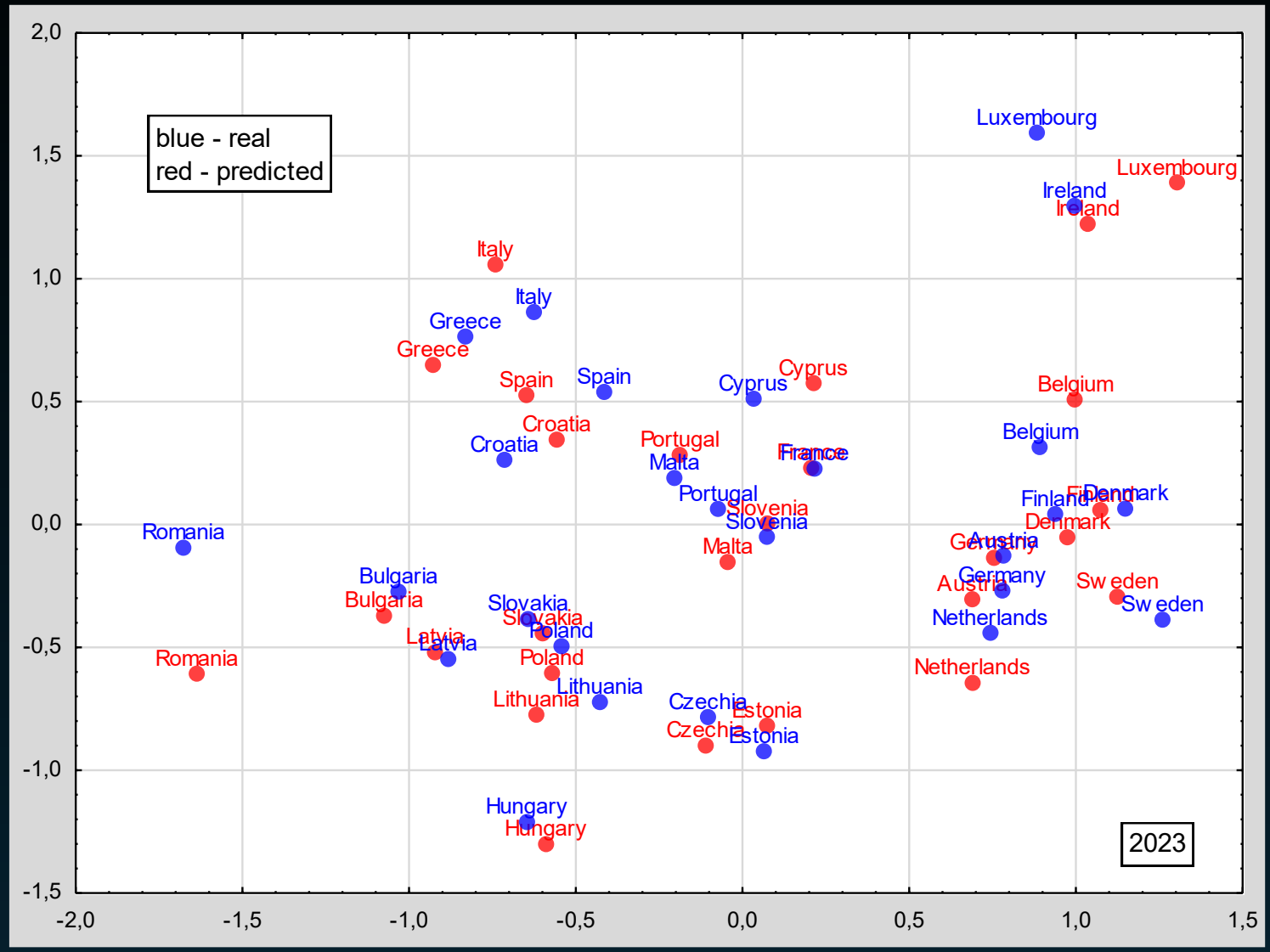
VARIABLES

- Gross domestic expenditure on R & D (GERD) – percentage of GDP, all sectors
- Gross domestic product (GDP) at current market prices – Purchasing power standard (PPS), per inhabitant
- Total employment – from 20 to 64 years: percentage of total population
- SII – Summary Innovation Index (average of 32 indicators)
- Harmonised Index of Consumer Prices (HICP) – annual average, all-items HICP

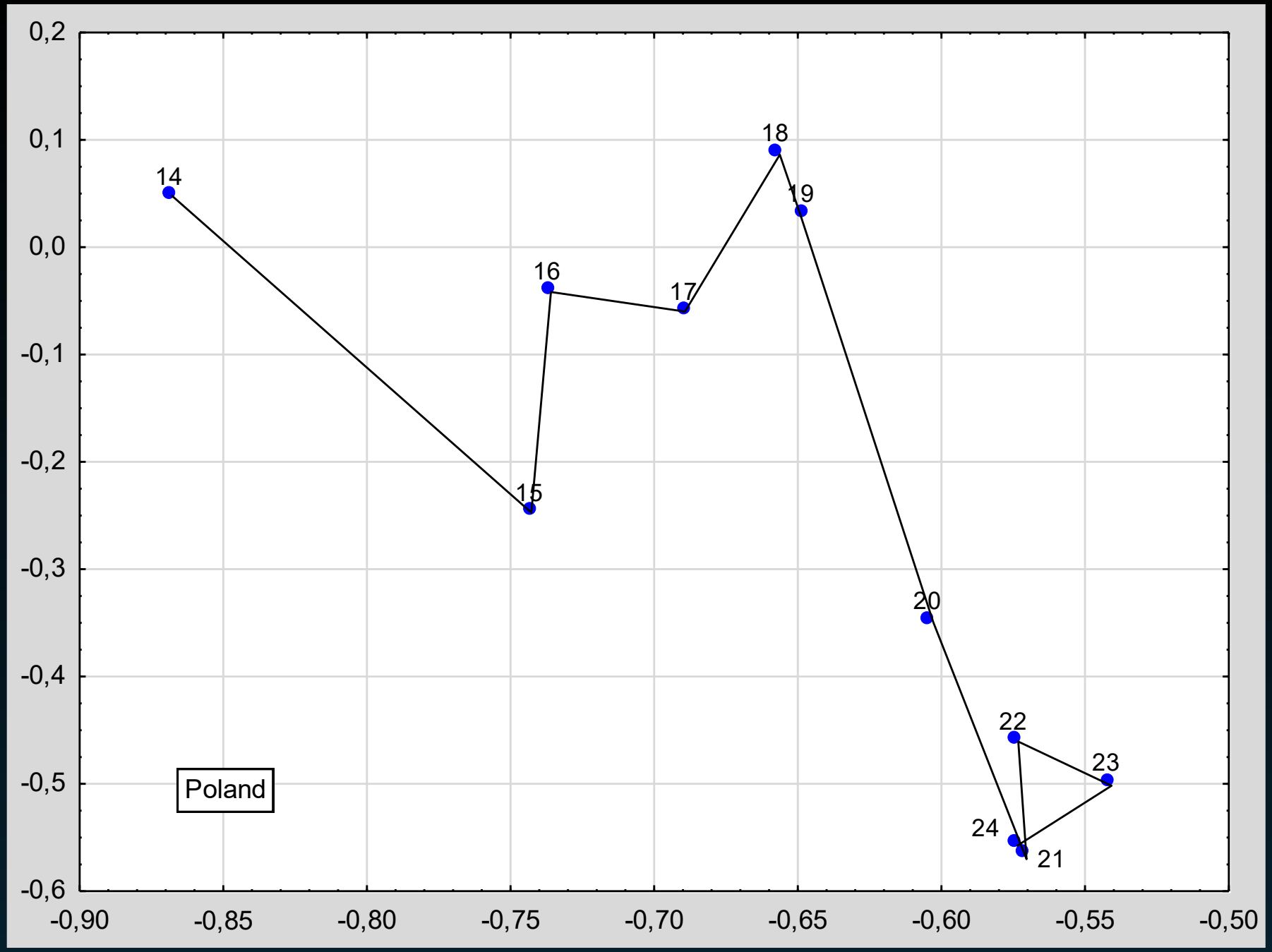
ROTATIONS

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Angle (degrees)	3	-6	-3	2	8	12	12	24	25	27
$d(C_t,C_{t-1})$	3,380	2,566	1,158	0,780	0,773	0,867	0,579	1,357	0,523	0,393

Prediction vs Actual - for 2023 – Approach 3

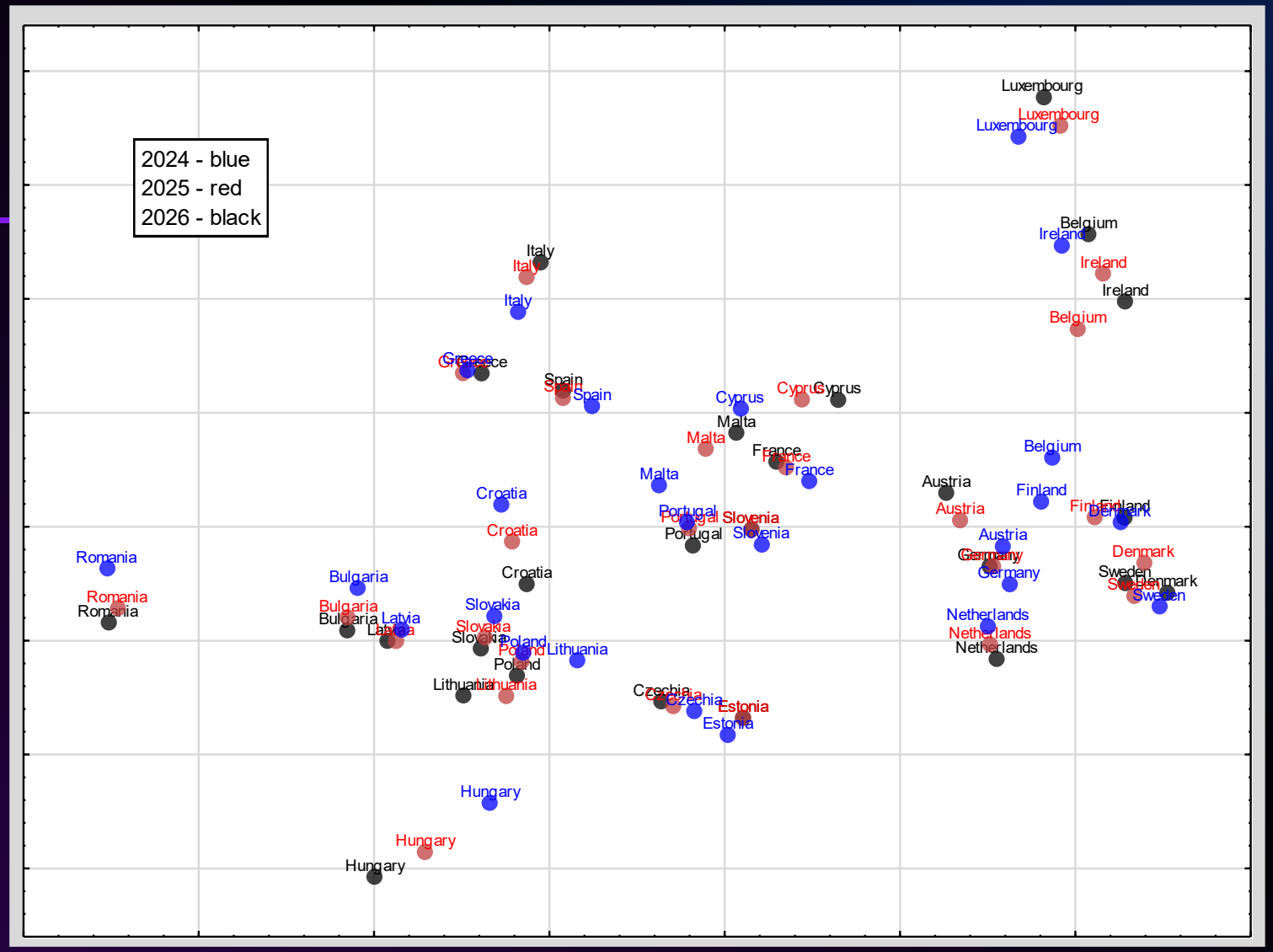


Average error: 0.046


0,2
0,1
0,0
-0,1
-0,2
-0,3
-0,4
-0,5
-0,6
-0,90
-0,85
-0,80
-0,75
-0,70
-0,65
-0,60
-0,55
-0,50
14
15
16
17
18
19
20
21
22
23
24
Poland

FORECASTS APPROACH 3

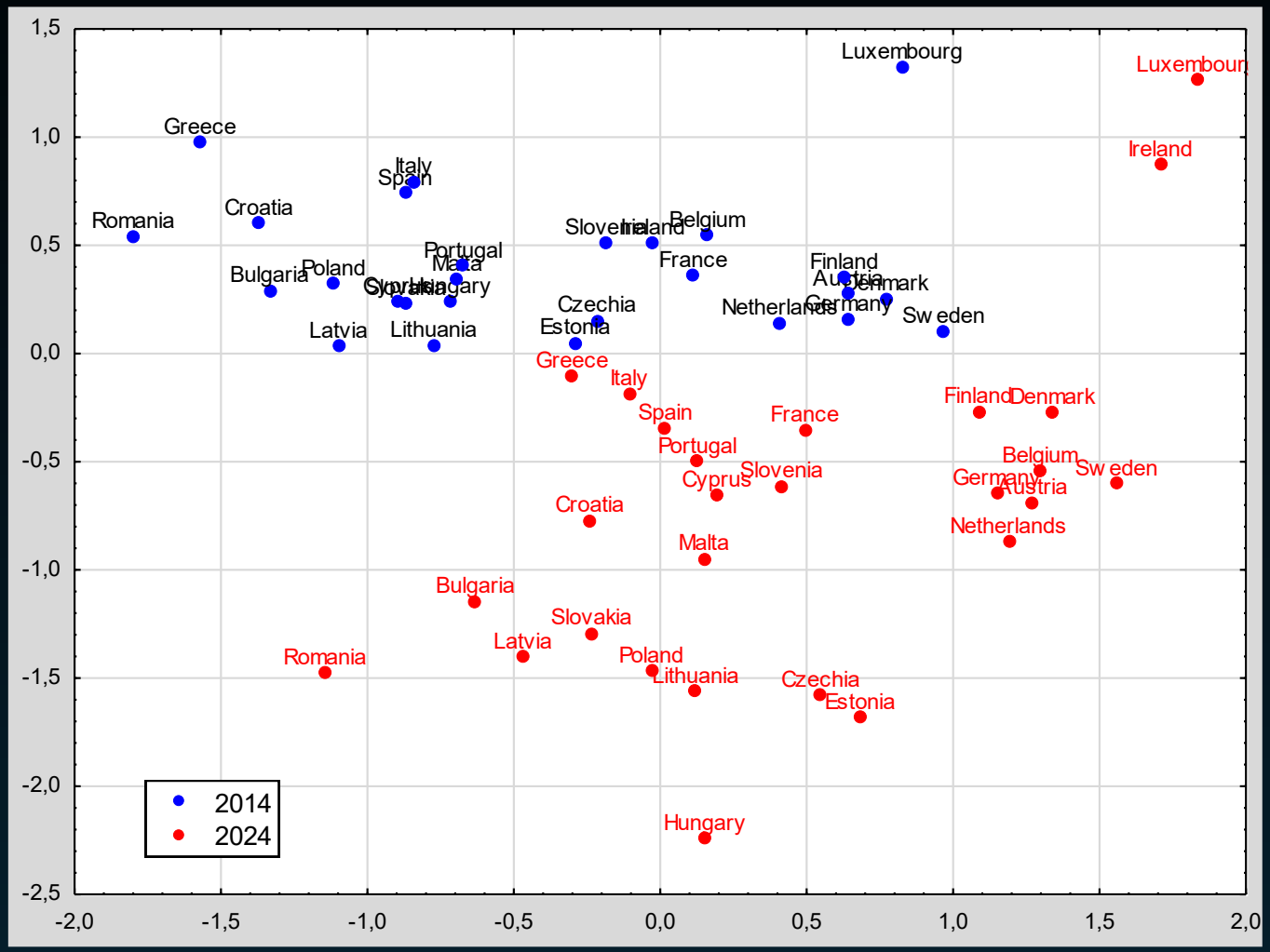
Year	2024	2025	2026
Angle	27	-1	-1
Distance	0,393	0,924	0,637



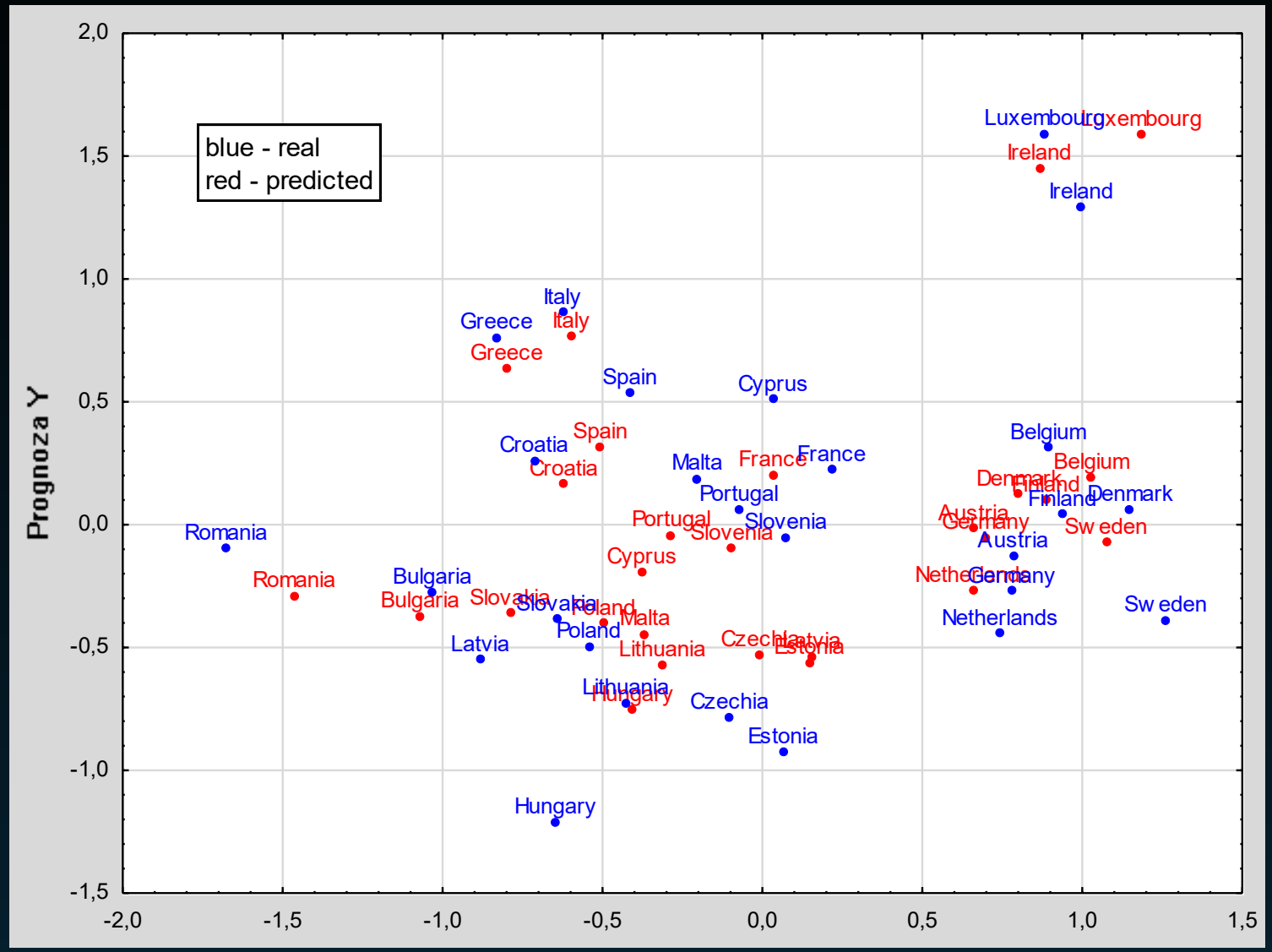
APPROACH 4 (NEW)

- Global standardization – using mean and standard deviation, calculated for the whole period
- MDS globally for the whole period
- Non-linear trends for two coordinates
- Standardization for each year

Approach 4


1,5
1,0
0,5
0,0
-0,5
-1,0
-1,5
-2,0
-2,5
-2,0
-1,5
-1,0
-0,5
0,0
0,5
1,0
1,5
2,0
Luxembourg
Luxembourg
Greece
Ireland
Italy
Spain
Croatia
Romania
Slovenia
Belgium
France
Portugal
Malta
Bulgaria
Poland
Finland
Czechia
Netherlands
Sweden
Latvia
Lithuania
Estonia
Greece
Italy
Finland
Denmark
Spain
France
Portugal
Belgium
Cyprus
Slovenia
Sweden
Germany
Austria
Croatia
Netherlands
Malta
Bulgaria
Slovakia
Latvia
Romania
Poland
Lithuania
Czechia
Estonia
Hungary
2014
2024

Prediction vs Actual - for 2023 – Approach 4



Average error: 0.133

SUMMARY

Approach	1	2	3	4
Standardization	global	global	local	global
MDS	local	local	local	global
Tranformation	none	none	rotation	none
Trends	linear	non-linear	BE	BE
Transformation of results	trend clustering	trend clustering	none	local standardization
Advantage			forecasting	movement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