Workers in the Knowledge Economy in Europe

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They grew by 11% between 2014 and 2021

The European Innovation Scoreboard-EIS calculates the value of employees in knowledge-intensive activities in Europe.

Ranking of European countries by value of employment in the knowledge economy in 2021. Israel is in first place by value of employment in the knowledge economy with an amount equal to 250.67 units, tied with Luxembourg. In second place is Norway with an amount equal to 216.00 units followed by Ireland with an amount equal to 194.67 units. In the middle of the table there are Slovenia with a value equal to 118.67 units, followed by Italy with an amount equal to 114.67 units and Estonia with an amount equal to 113.33 units. Romania closes the ranking with an amount equal to 25.33 units, followed by North Macedonia with an amount equal to 17.33 and by Turkey with an amount equal to 10.67 units.

Ranking of European countries by value of the percentage change in employment in the knowledge sectors between 2014 and 2021. Romania ranks first in terms of the percentage change in employment between 2014 and 2021 with a value of 137.5% equal to an amount of 14.67 units, Bulgaria is in second place with a value equal to 68.97% equal to an amount of 26.67 units, followed by Norway with a variation equal to an amount of 68.75% equal to an amount of 88 units. In the middle of the table there are Italy with an amount equal to 13.16% equal to a value of 13.33 units, followed by France with a value equal to 12.05% equal to an amount of 13.33 units, and from Luxembourg with a value of 9.3% equal to an amount of 21.33 units. Hungary closes the ranking with a value equal to -4.41% equal to a value of -4 units, followed by Switzerland with a variation of -6.25% equal to an amount of -12.00 units, followed by 'Iceland with a variation of -16.95% equal to an amount of -26.67 units.

Clustering with the k-Means algorithm. A clustering model is created below through the use of the k-Means algorithm. However, since the k-Means algorithm is unsupervised, it is necessary to choose an optimization tool. The Silhouette coefficient is used for this. 2 clusters with a Silhouette coefficient value of 0.535, 3 clusters with a value of 0.506, 4 clusters with a value of 0.462, 5 clusters with a value of 0.504, 6 clusters with a value of 0.530, 7 clusters with a value of 0.534, 8 clusters with a value of 0.512. Therefore, a 2-clusters model is chosen as follows:

- *Cluster 1*: Sweden, United Kingdom, Iceland, Malta, Ireland, Switzerland, Holland, Cyprus, Luxembourg, Israel, Finland, Norway, Belgium, Denmark, Germany, Austria;
- *Cluster 2*: Poland, Slovakia, Portugal, Bulgaria, Lithuania, Serbia, Montenegro, Latvia, Croatia, Romania, Greece, Hungary, Spain, North Macedonia, Turkey, Estonia, Czech Republic, Ukraine, Italy, Slovenia, France.

By calculating the value of the median of the value of employed in the knowledge economy, it appears that the countries of cluster 1 have a value of 120.67 units, while the value of cluster 2 is equal to an

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amount of 113.33 units. From the cluster analysis highlights the presence of a contrast between Northern Europe which has higher levels of the value of employed in the knowledge economy, as opposed to Southern Europe which instead has lower values.

Optimization of predictive algorithms through machine learning. A prediction model was then created by comparing 7 different algorithms. The data was trained with 80% of the data and classified based on performance in terms of R-Quadro, MAE, MSE, RMSE. Based on the analysis carried out, the following order is found, namely:

1. Linear Regression with a value of 4;
2. AdaBoost with a value of 8;
3. Gradient Boosting with a value of 12;
4. Random Forest with a value of 16;
5. Tree with a value of 21;
6. kNN with a value equal to 23;
7. Neural Network with an amount equal to 28.

A Linear Regression model is applied below and shows the countries for which a higher and lower value of the variation is expected. Among the fastest growing countries there are the following five paresis, namely:

- Serbia with a value of 35.29%;
- Romania with a value of 22.18%;
- Latvia with a variation of 15.36%;
- Spain with a value of 13.46%;
- Slovenia with a change of 10.65%.

Among the countries that have the largest negative percentage change are:

- Lithuania with an amount of -17.02%;
- Norway with a change of -22.73%;
- North Macedonia with a change equal to -24.14%;
- Slovakia with a change of -27.44%;
- Turkey with a change of -46.375%.

Conclusions. Between 2014 and 2021 the value of employees in the knowledge economy in Europe grew by an amount equal to 11.33%. However, it is necessary to consider, as manifested by clustering, that there is a contrast between Northern Europe, with high levels, and Southern Europe, which has lower levels. Finally, using machine learning, a comparison was made between 7 different algorithms in terms of MAE, MSE, RMSE and R2. The best predictor algorithm is then chosen, i.e. the Linear Regression algorithm by applying which the countries that best performers and worst performers have been identified. In summary, economic policies should intervene to reduce the gap between Northern Europe and Southern Europe in terms of employment in the knowledge economy.

Reference

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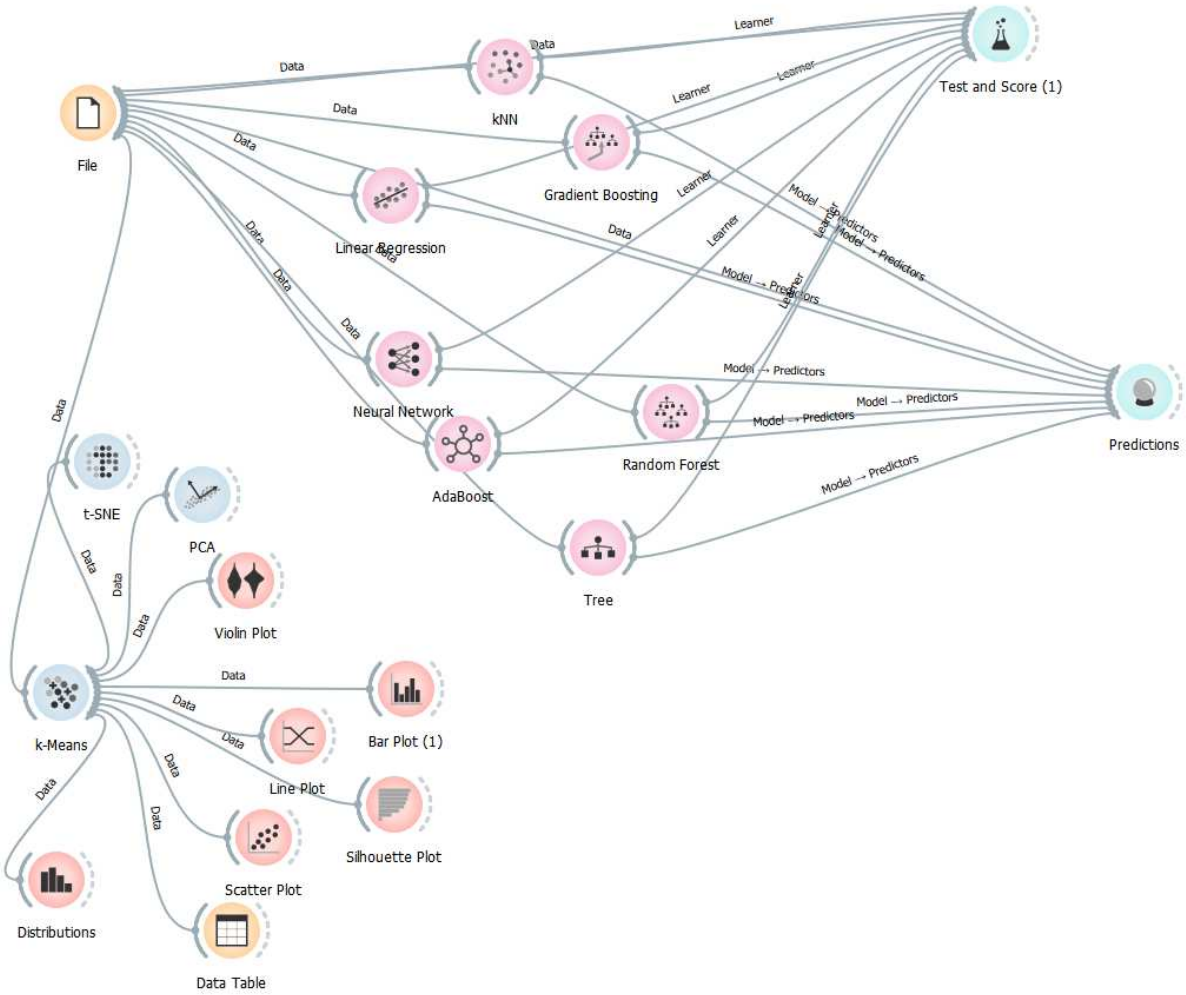

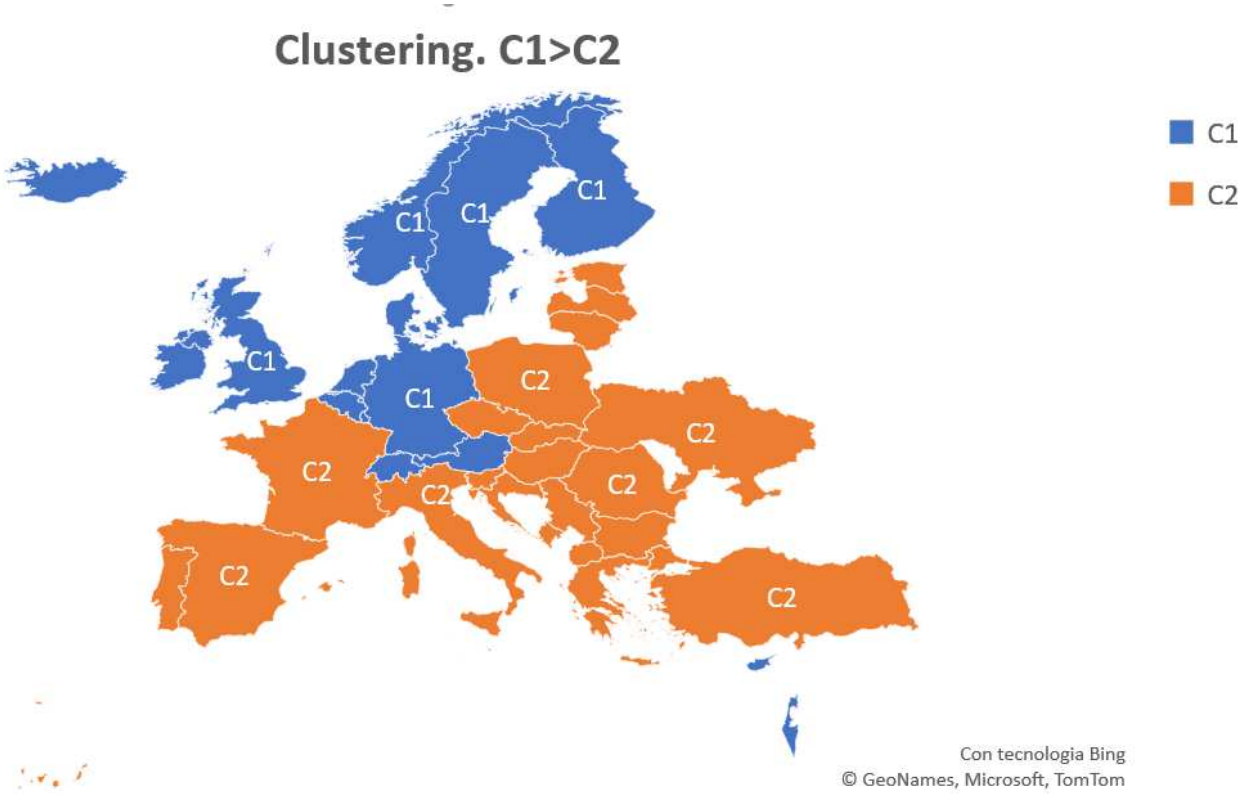
Clustering. C1>C2
C1
C2
C1
C1
C1
C1
C1
C2
C2
C2
C2
C2
C2
C2
Con tecnologia Bing
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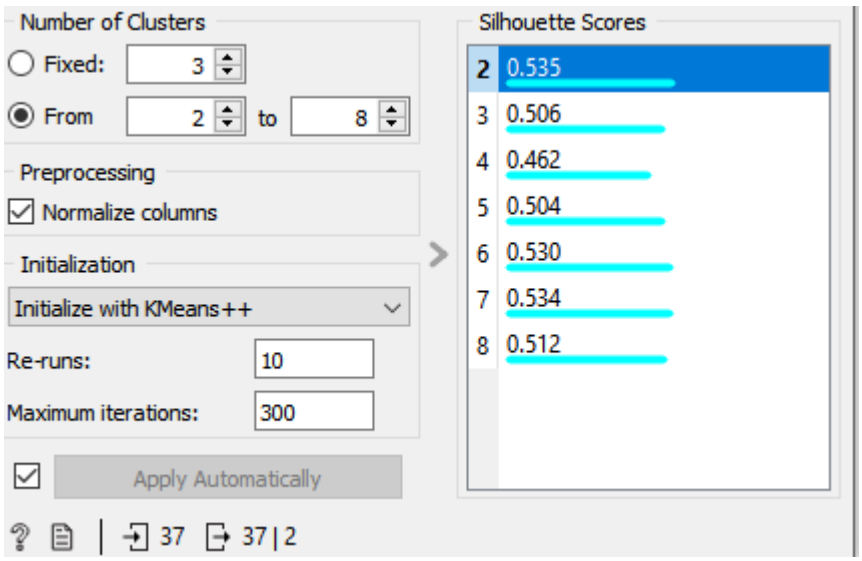
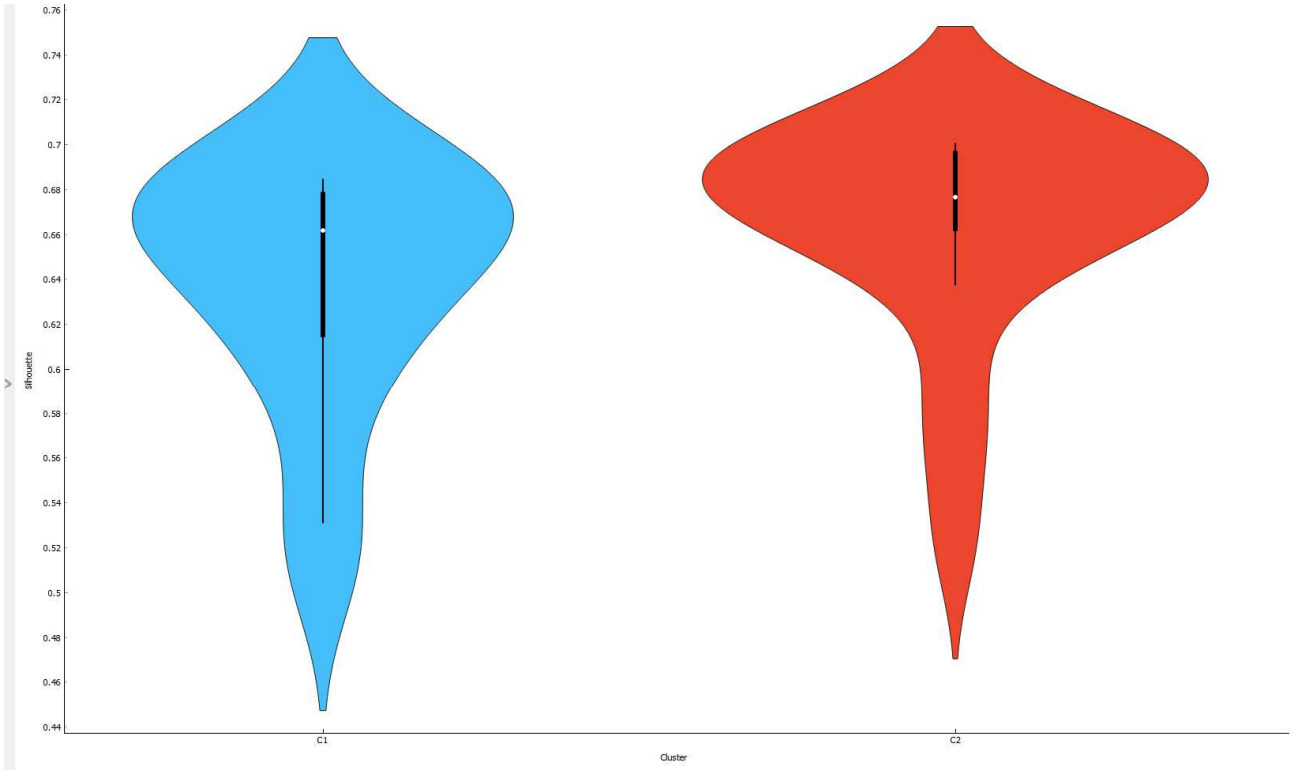
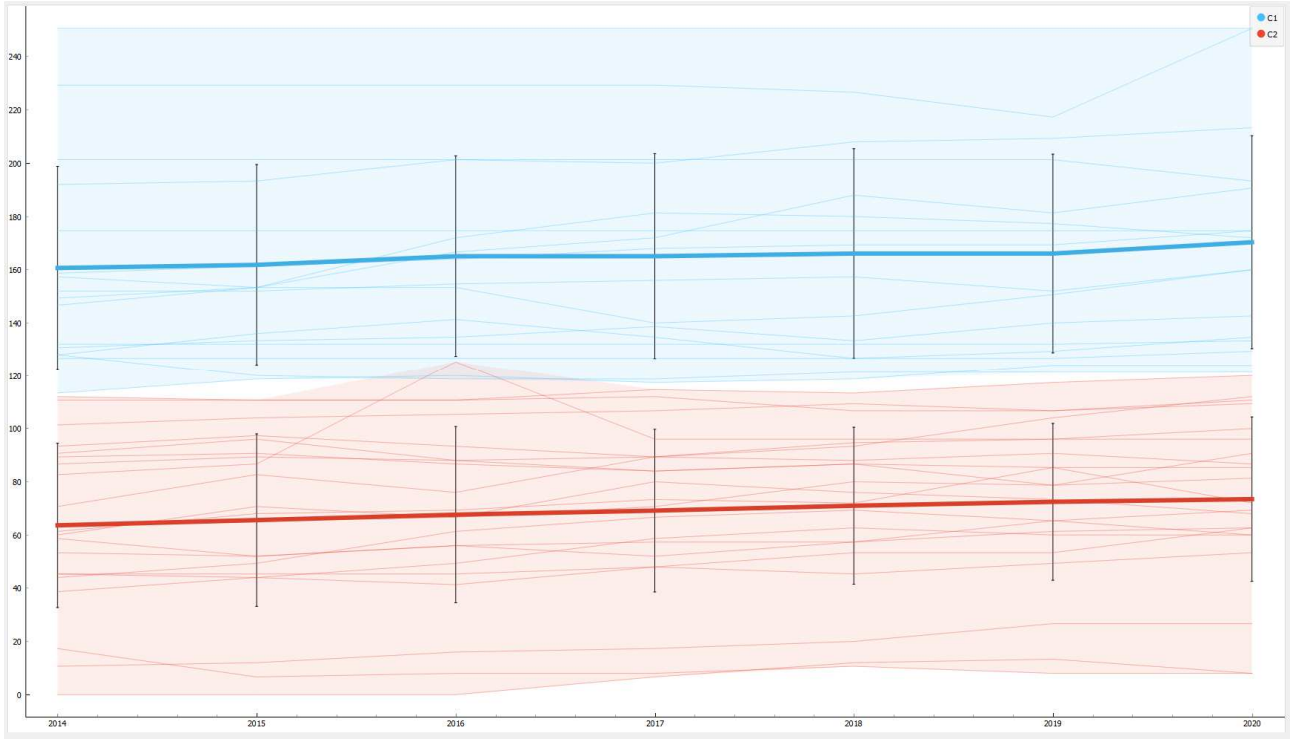
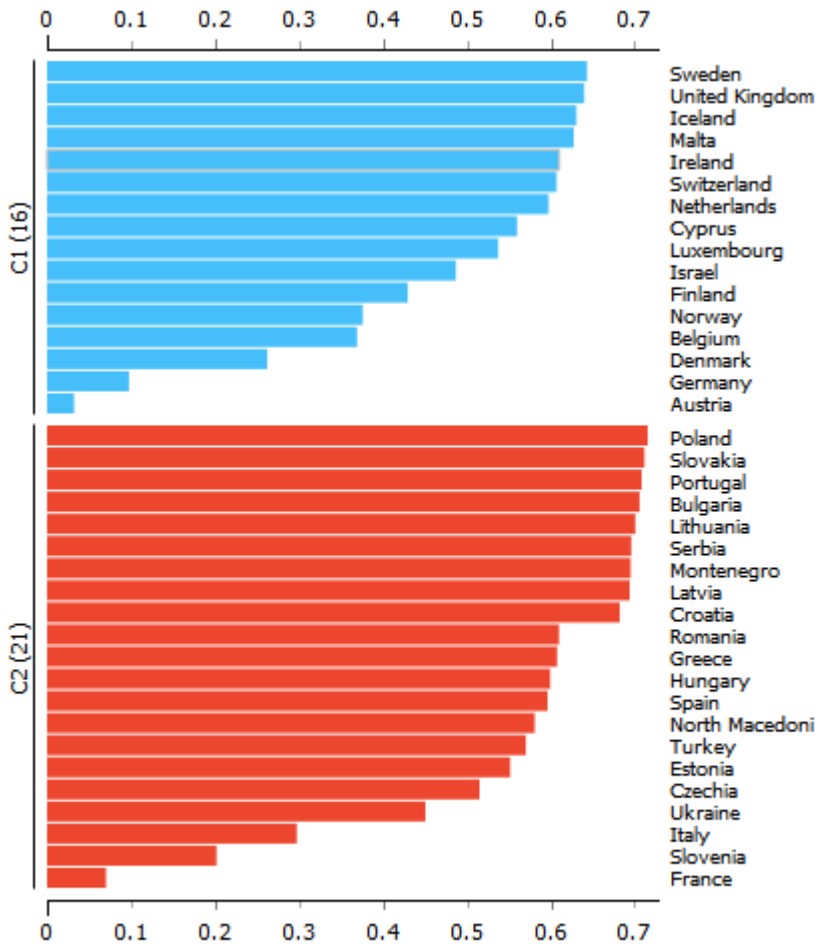
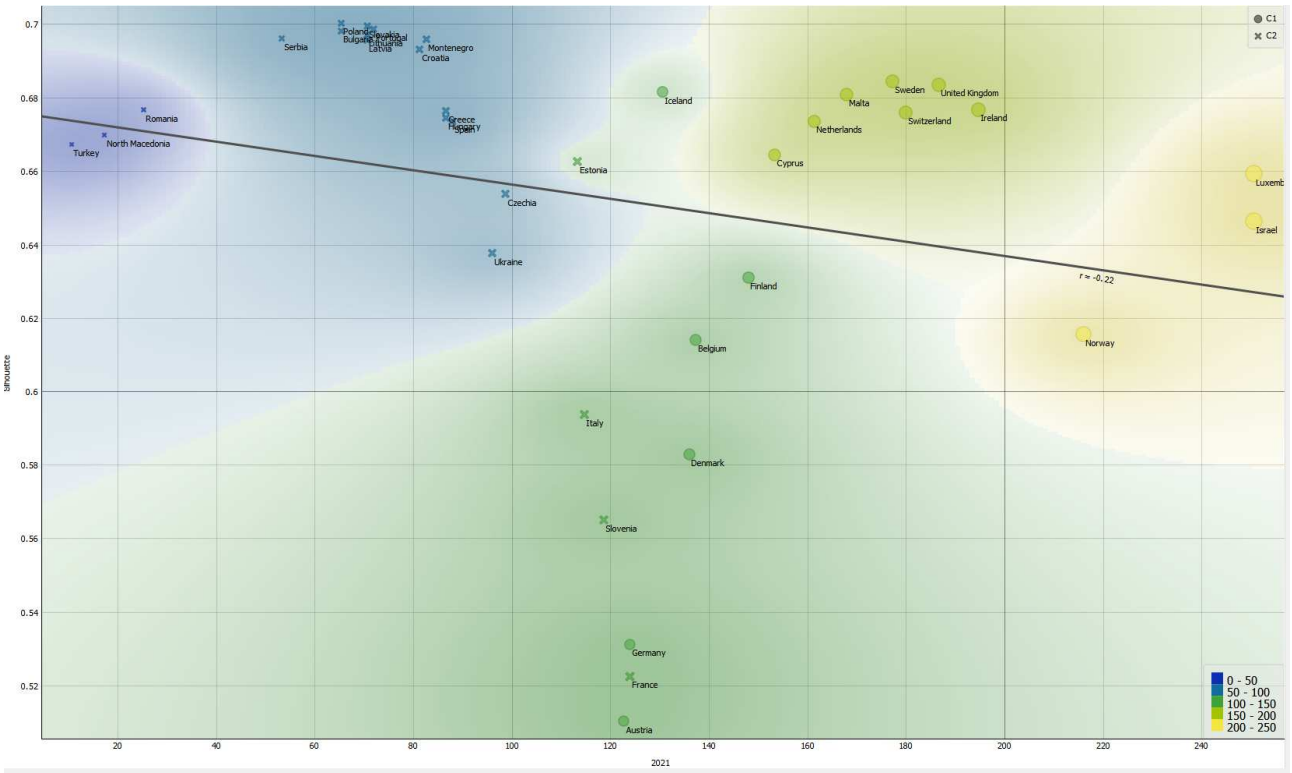

Number of Clusters
Fixed: 3
From 2 to 8
Preprocessing
Normalize columns
Initialization
Initialize with KMeans++
Re-runs: 10
Maximum iterations: 300
Apply Automatically
37
37 | 2
Silhouette Scores
2 0.535
3 0.506
4 0.462
5 0.504
6 0.530
7 0.534
8 0.512

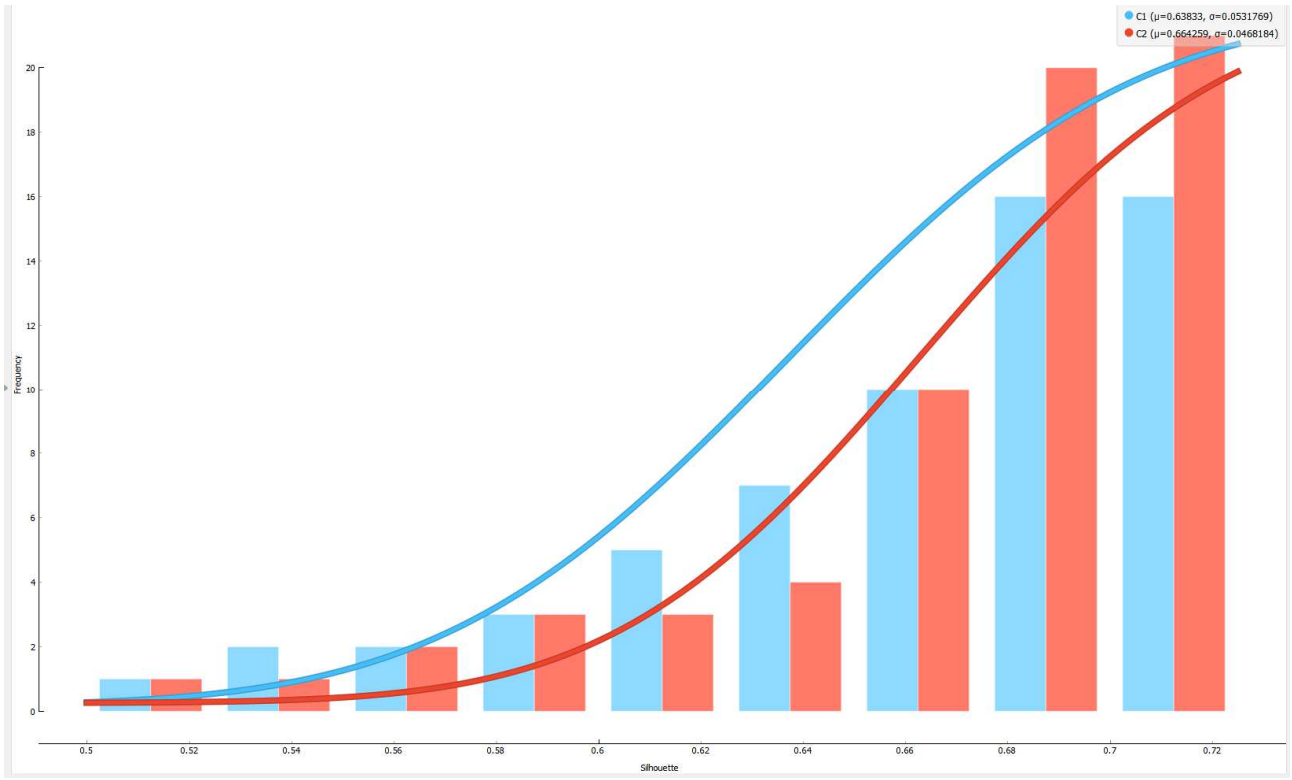
	2021	Feature 1	Cluster	Silhouette
1	122.667	Austria	C1	0.51046
7	124	Germany	C1	0.531328
8	136	Denmark	C1	0.582776
2	137.333	Belgium	C1	0.614242
27	216	Norway	C1	0.615773
12	148	Finland	C1	0.631147
17	250.667	Israel	C1	0.646428
21	250.667	Luxembourg	C1	0.65936
5	153.333	Cyprus	C1	0.664593
26	161.333	Netherlands	C1	0.673717
4	180	Switzerland	C1	0.67605
16	194.667	Ireland	C1	0.676864
25	168	Malta	C1	0.680868
18	130.667	Iceland	C1	0.681581
37	186.667	United Kingdom	C1	0.683654
32	177.333	Sweden	C1	0.684433
13	124	France	C2	0.522645
33	118.667	Slovenia	C2	0.565118
19	114.667	Italy	C2	0.593725
36	96	Ukraine	C2	0.637725
6	98.6667	Czechia	C2	0.653894
9	113.333	Estonia	C2	0.662618
35	10.6667	Turkey	C2	0.667424
24	17.3333	North Macedonia	C2	0.669873
11	88	Spain	C2	0.673659
15	86.6667	Hungary	C2	0.674571
10	86.6667	Greece	C2	0.676422
30	25.3333	Romania	C2	0.676783
14	81.3333	Croatia	C2	0.693216
22	70.6667	Latvia	C2	0.695642
23	82.6667	Montenegro	C2	0.695967
31	53.3333	Serbia	C2	0.696098
20	70.6667	Lithuania	C2	0.697173
3	65.3333	Bulgaria	C2	0.698276
29	72	Portugal	C2	0.698802
34	70.6667	Slovakia	C2	0.699485
28	65.3333	Poland	C2	0.70032


0.76
0.74
0.72
0.7
0.68
0.66
0.64
0.62
0.6
0.58
0.56
0.54
0.52
0.5
0.48
0.46
0.44
Silhouette
C1
C2
Cluster


C1
C2
240
220
200
180
160
140
120
100
80
60
40
20
0
2014
2015
2016
2017
2018
2019
2020


0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
C1 (16)
Sweden
United Kingdom
Iceland
Malta
Ireland
Switzerland
Netherlands
Cyprus
Luxembourg
Israel
Finland
Norway
Belgium
Denmark
Germany
Austria
C2 (21)
Poland
Slovakia
Portugal
Bulgaria
Lithuania
Serbia
Montenegro
Latvia
Croatia
Romania
Greece
Hungary
Spain
North Macedoni
Turkey
Estonia
Czechia
Ukraine
Italy
Slovenia
France


C1
C2
Serbia
Montenegro
Croatia
Romania
Turkey
North Macedonia
Iceland
Sweden
United Kingdom
Malta
Switzerland
Ireland
Netherlands
Cyprus
Estonia
Czechia
Ukraine
Finland
Belgium
Norway
Italy
Denmark
Slovenia
Germany
France
Austria
Israel
r = -0.22
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250
2021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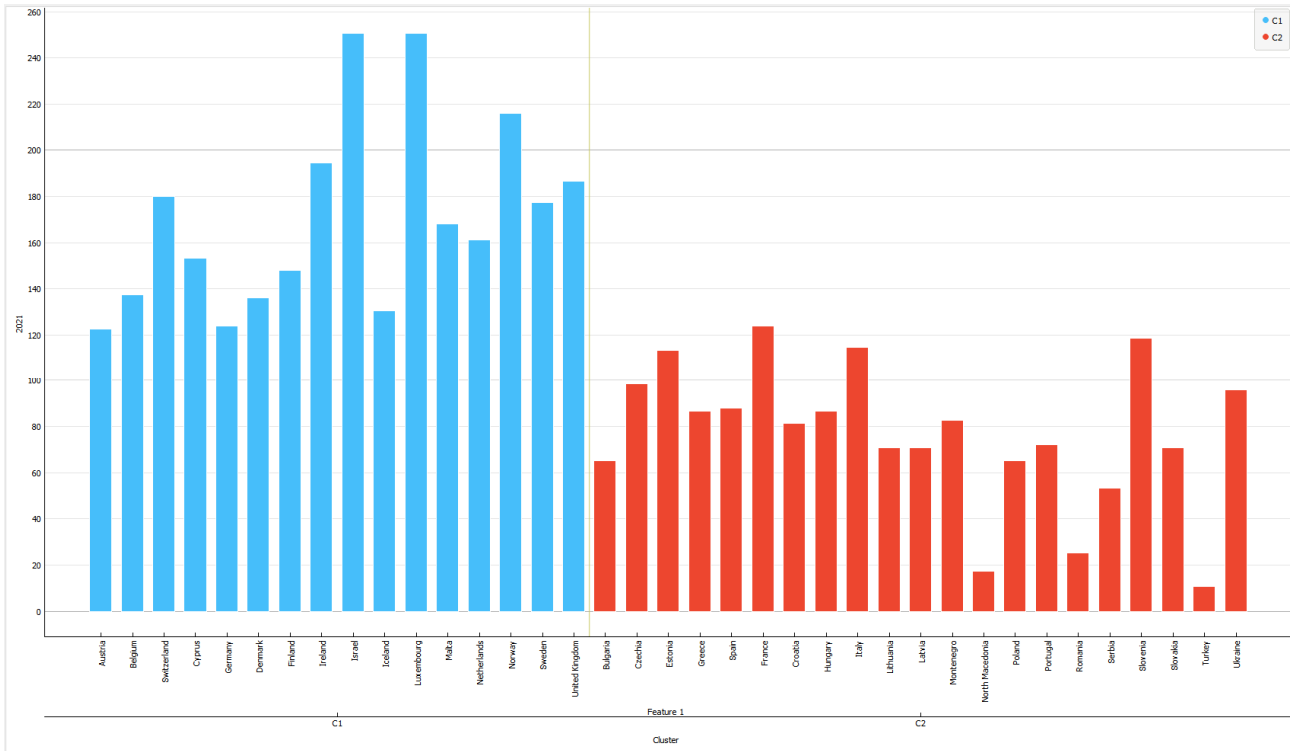
C2 (μ=0.664259, σ=0.0468184)
Frequency
Silhouette


C1
C2
2021
Austria
Belgium
Switzerland
Cyprus
Germany
Denmark
Finland
Ireland
Israel
Iceland
Luxembourg
Malta
Netherlands
Norway
Sweden
United Kingdom
Bulgaria
Czechia
Estonia
Greece
Spain
France
Croatia
Hungary
Italy
Lithuania
Latvia
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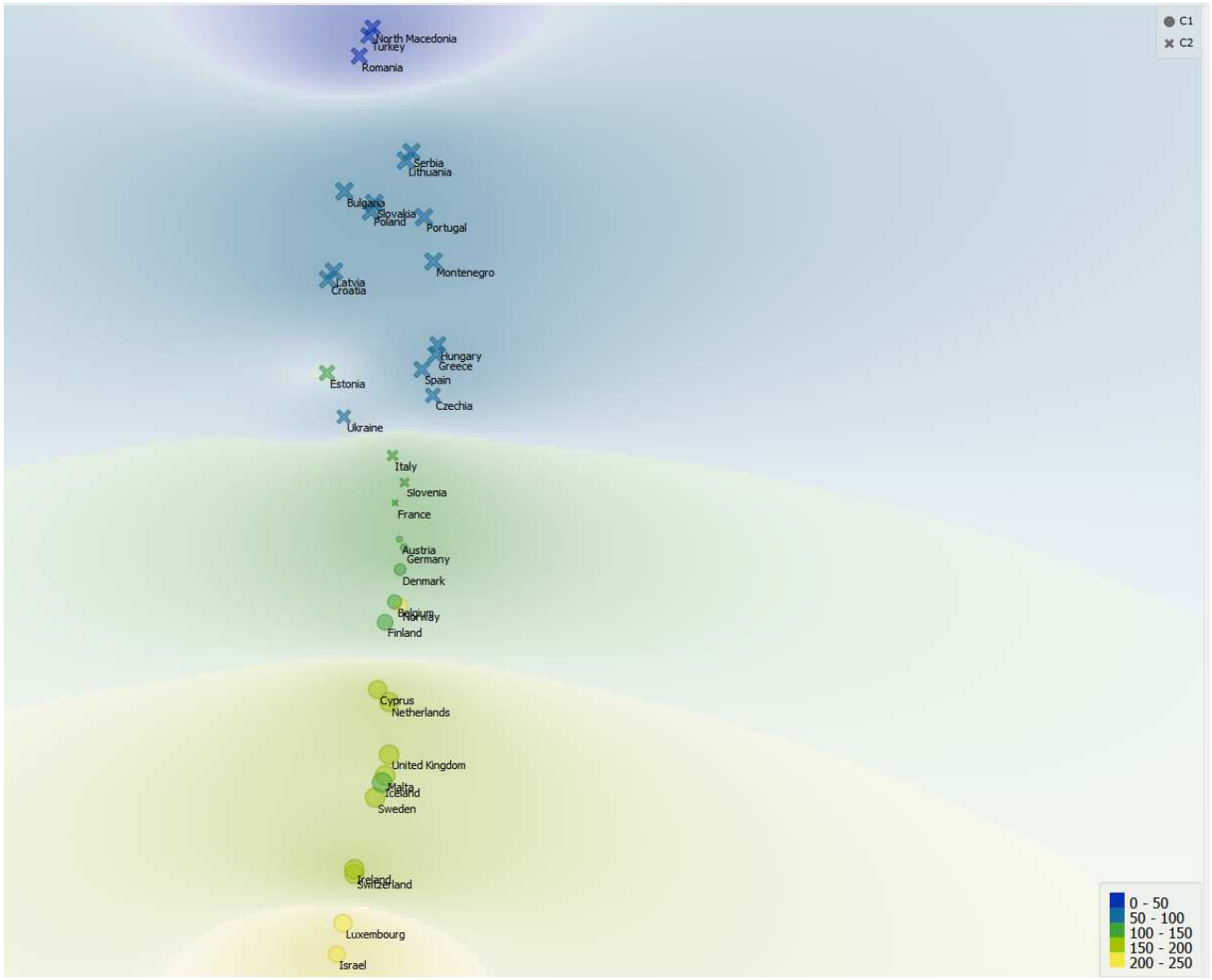
Slovakia
Turkey
Ukraine
Feature 1
C1
C2
Cluster


C1
C2
North Macedonia
Turkey
Romania
Serbia
Lithuania
Bulgaria
Slovakia
Poland
Portugal
Montenegro
Latvia
Croatia
Hungary
Greece
Spain
Estonia
Czechia
Ukraine
Italy
Slovenia
France
Austria
Germany
Denmark
Belgium
Norway
Finland
Cyprus
Netherlands
United Kingdom
Malta
Iceland
Sweden
Ireland
Switzerland
Luxembourg
Israel
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250

Rank	Country	2021	Rank	Country	2021
1	*Israel*	250,67	18	*Estonia*	113,33
1	*Luxembourg*	250,67	19	*Czechia*	98,67
2	*Norway*	216,00	20	*Ukraine*	96,00
3	*Ireland*	194,67	21	*Spain*	88,00
4	*United Kingdom*	186,67	22	*Greece*	86,67
5	*Switzerland*	180,00	22	*Hungary*	86,67
6	*Sweden*	177,33	23	*Montenegro*	82,67
7	*Malta*	168,00	24	*Croatia*	81,33
8	*Netherlands*	161,33	25	*Portugal*	72,00
9	*Cyprus*	153,33	26	*Lithuania*	70,67
10	*Finland*	148,00	26	*Latvia*	70,67
11	*Belgium*	137,33	26	*Slovakia*	70,67
12	*Denmark*	136,00	27	*Bulgaria*	65,33
13	*Iceland*	130,67	27	*Poland*	65,33
14	*Germany*	124,00	28	*Serbia*	53,33
14	*France*	124,00	29	*Romania*	25,33
15	*Austria*	122,67	30	*North Macedonia*	17,33
16	*Slovenia*	118,67	31	*Turkey*	10,67
17	*Italy*	114,67			

Occupati nell'economia della conoscenza tra il 2014 ed il 2021							
Rank	**Country**	**Var Ass**	**Var Per**	**Rank**	**Country**	**Var Ass**	**Var Per**
1	*Romania*	14,67	137,5	19	*Luxembourg*	21,33	9,3
2	*Bulgaria*	26,67	68,97	20	*Austria*	9,33	8,24
3	*Norway*	88	68,75	21	*Denmark*	9,33	7,37
4	*Portugal*	28	63,64	22	*Netherlands*	9,33	6,14
5	*Estonia*	42,67	60,38	23	*Slovenia*	6,67	5,95
6	*Lithuania*	25,33	55,88	24	*Czechia*	5,33	5,71
7	*Montenegro*	22,67	37,78	25	*Belgium*	5,33	4,04
8	*Croatia*	17,33	27,08	26	*Cyprus*	4	2,68
9	*Poland*	12	22,5	27	*Spain*	1,33	1,54
10	*Slovakia*	12	20,45	28	*Sweden*	2,67	1,53
11	*Serbia*	8	17,65	29	*Israel*	0	0
12	*United Kingdom*	28	17,65	30	*North Macedonia*	0	0
13	*Ukraine*	13,33	16,13	31	*Greece*	-2,67	-2,99
14	*Latvia*	9,33	15,22	32	*Germany*	-4	-3,13
15	*Malta*	21,33	14,55	33	*Ireland*	-6,67	-3,31
16	*Finland*	17,33	13,27	34	*Hungary*	-4	-4,41
17	*Italy*	13,33	13,16	35	*Switzerland*	-12	-6,25
18	*France*	13,33	12,05	36	*Iceland*	-26,67	-16,95