# Export of Medium and High-Tech Products in Europe

LEOGRANDE, ANGELO

LUM University Giuseppe Degennaro

3 April 2022

**Angelo Leogrande**[1]

# Export of Medium and High-Tech Products in Europe

*It grew by 19.10% between 2014 and 2021*

The European Innovation Scoreboard-EIS analyzes the value of exports of medium and high-tech products as a percentage of the total value of product exports. In the context of the European Innovation Scoreboard-EIS, the value of the export of medium and high technology products is considered as a function of the employment of human capital. That is, the companies that export more in terms of medium and high technology products are also companies that have a more qualified human capital and whose employability is more resistant to economic crises and recessions.

*Ranking of European countries by export value of medium and high technology products in 2021.* Hungary is in first place for export of medium and high technology products with an amount equal to 143.53, followed by Slovakia with an amount equal to 142.19 and from the Czech Republic with an amount equal to 139.35. In the middle of the table are Italy with an amount equal to 93.54 units, followed by Holland with an amount equal to 92.68 and Belgium with a value equal to 92.05 units. Montenegro closes the ranking with a value of 3.99 units, followed by Iceland and Norway with a value of 0.

*Ranking of the percentage changes in the export of medium and high technology products between 2014 and 2021.* Greece is in first place in terms of percentage growth in the export of medium and high technology products with a value equal to 1243.09 % equal to 30.58 units, followed by Bosnia with an amount equal to 272.77% equal to 15.63 units and by Bulgaria with a value equal to 92.26% equal to an amount of 24.43 units. In the middle of the table there are the United Kingdom with an amount equal to 18.2% equal to an amount of 15.33 units, followed by Belgium with an amount equal to 16.64% equal to a value of 13.13 units and followed from Croatia with an amount of 14.61% equal to a value of 8.2 units. Malta closes the ranking with an amount equal to -4.82% equal to a value of -5.05 units, followed by Estonia with an amount equal to -5.46% equal to a value of -3.84 units and from Ukraine with a value equal to -47% equal to a value of -23.37 units.

Clustering with the k-Means algorithm. A clustering is proposed below using the k-Means algorithm to verify the presence of groups of countries by value of the export of medium and high technology products. The choice of the number of clusters takes place through the optimization of the Silhouette coefficient. Based on the application of the Silhouette coefficient, two clusters were found, namely:

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

[1] PhD, Assistant Professor of Economics at LUM University Giuseppe Degennaro, Researcher at LUM Enterprise s.r.l. , Casamassima, Bari, Italy, European Union. Email: leogrande.cultore@lum.it

Furthermore, considering the value of the median of the clusters, it appears that the median value of the countries of cluster 1 is equal to a value of 105,835 units while the median value of the countries of cluster 2 is equal to a value of 48.12. Therefore, the following ordering of clusters C1> C2 derives. Furthermore, from the analysis of the clusters, a contrast is evident between Western European countries with high export levels of medium and high technology products and Eastern Europe with significantly lower values.

*Network analysis.* A network analysis mediated across the Manhattan distance is presented below. Specifically, the analysis shows the presence of some particularly dense nodes between the various countries, among which Austria, Poland, Lithuania, United Kingdom, Ireland, Slovenia stand out. Furthermore, the cluster analysis has the following metric values, that is:

- Number of nodes equal to 38;
- Number of edges equal to 151;
- Average of 7,947;
- Density equal to a value of 0.2148;
- Diameter equal to a value of 30.79;
- Radius equal to an amount of 15.91;
- Average length of the shortest route equal to 9.053.

Machine Learning and Predictions. Below is a machine learning analysis for predicting the export value of medium and high-tech goods between the European countries considered. Eight different algorithms were analyzed and compared in terms of performance understood as maximization of the R-square and minimization of statistical errors. 70% of the data was used for training the algorithms while 30% of the data was used for the actual prediction. Therefore, the following ordering of the algorithms derives, namely:

1. Random Forest Regression with a payoff value of 5;
2. Linear Regression with a payoff value of 7;
3. ANN-Artificial Neural Network with a payoff value of 12;
4. Gradient Boosted Tree Regression with a payoff value of 19;
5. Tree Ensemble Regression with a payoff value of 20;
6. Polynomial Regression with a payoff value of 22;
7. PNN-Probabilistic Neural Network with a payoff value of 28;
8. Simple Regression Tree with a payoff value of 31.

Using the Random Forest Regression algorithm, the following predictions are indicated, namely:

- *Switzerland* with a decrease from a value equal to 100.04 units up to a value equal to 92.95% equal to a variation of -7.09 units equal to a value of -7.09%;
- *Germany* with a decrease from a value equal to 138.01 units up to a variation of 130.46 units equal to a variation of -7.55 units or equal to a variation of -5.47%;
- *Ireland* with a decrease from an amount of 119.99 units up to a change of 105.00 units or equal to a change of -14.99 units equal to a change of -12.49%;
- *Iceland* with a variation from 0.00 units up to a variation of 15.04 units;
- Italy with an increase from an amount equal to 93.54 units up to a change of 99.51 units or equal to a value of 5.97 units equal to a variation of 6.38%;
- *Norway* with a variation from 0.00 units up to a value of 15.04 units;
- *Portugal* with a variation from an amount of 69.87 units up to a value of 65.13 units or equal to a variation of -4.74 units equal to a variation of -6.78%;

- *Romania* with an increase from an amount of 110.44 units up to a variation of 109.02 units or equal to a variation of -1.42 units equal to a variation of -1.29%;
- *Serbia* with an increase from an amount of 75.06 units up to a value of 75.40 units or equal to a variation of 0.34 units equal to an amount of 0.45%;
- *Sweden* with a decrease from an amount of 106.37 units up to an amount of 106.34 units or equal to a variation of -0.003 units equal to an amount of -0.03%;
- *Slovakia* with a decrease from a value of 142.19 units up to a value of 129.61 units or equal to a variation of -12.58 units equal to a variation of -8.85%;
- *Ukraine* with an increase from an amount of 26.35 units up to a value of 47.73 units equal to a value of 21.38 units equal to a value of 81.15%.

On average, the export value of medium and high technology products for the countries considered is predicted to grow from an amount of 81.82 units up to a value of 82.60 units or equal to a variation of 0.78 units equal to an amount of 0.95%.

**Conclusions**. The export value of medium and high technology products increased between 2014 and 2021 by an amount equal to a value of 19.10%. The export of medium and high technology products is a significant indicator of the ability of European companies to make significant investments both in human capital and in research and development. However, European policy makers need to create the conditions for a further leading role of European companies in terms of exporting medium and high-tech products, also in the light of Sino-American techwar.

**Reference**:


Laureti L., Costantiello A., Leogrande A., *The Finance-Innovation Nexus in Europe*, IJISET - International Journal of Innovative Science, Engineering & Technology, 2020/12, 7, 12, 11-55.

Costantiello A., Leogrande A., *The Innovation-Employment Nexus in Europe*, American Research Journal of Humanities and Social Sciences, 2020, 166-187.

Leogrande, A., Costantiello, A., *Human Resources in Europe. Estimation, Clusterization, Machine Learning and Prediction,* American Journal of Humanities and Social Sciences Research (AJHSSR) e-ISSN :2378-703X, Volume-5, Issue-9, pp-240-259.

Leogrande, A., Costantiello, A., Laureti, L., *The Impact of Venture Capital Expenditures on Innovation in Europe,* American Journal of Humanities and Social Sciences Research (AJHSSR) e-ISSN :2378-703X, Volume-5, Issue-10, pp-85-102.

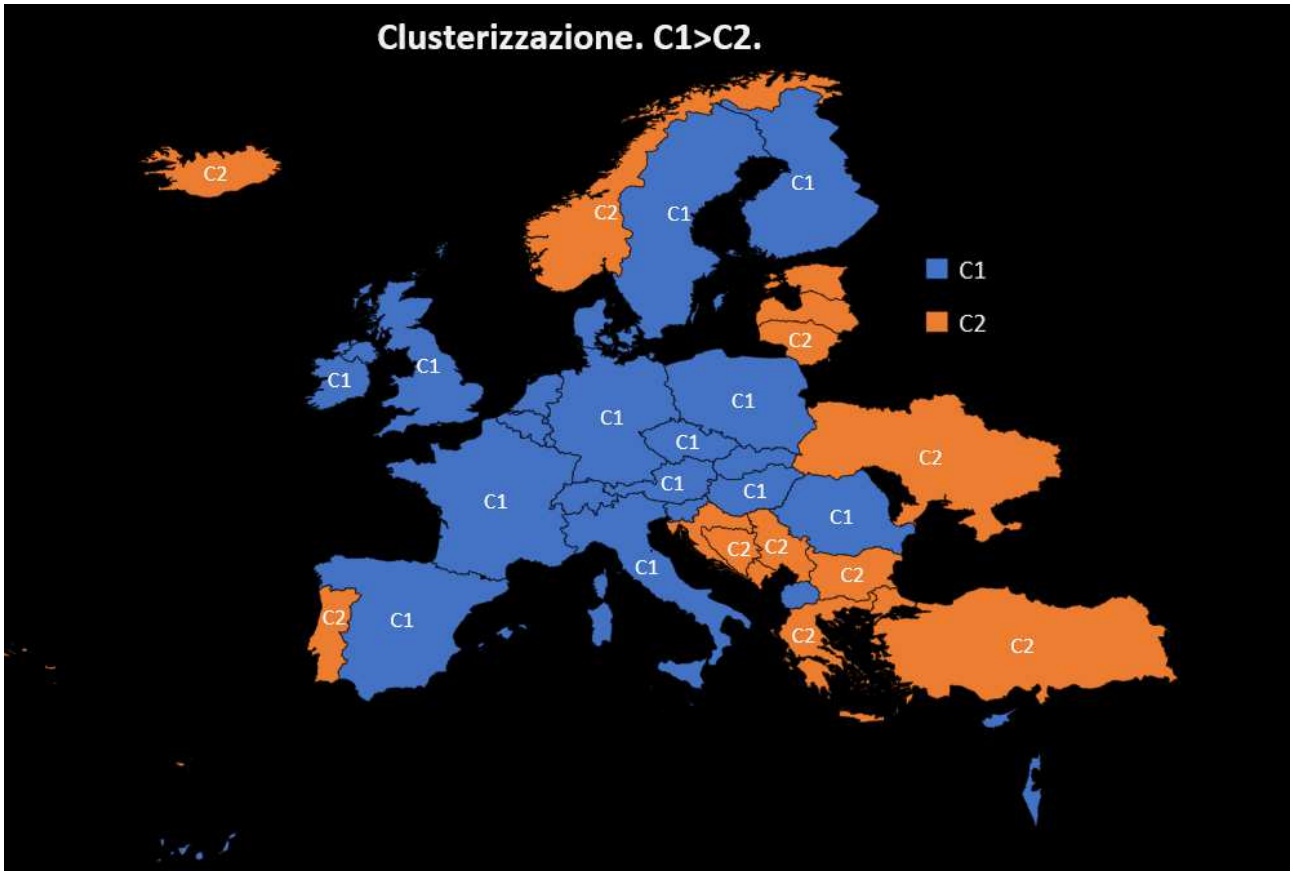
Leogrande, A., Costantiello, A., Laureti, L., The Broadband Penetration in Europe, *Journal of Applied Economic Sciences* 3(73):324– 349.

Leogrande A, Costantiello, A, Laureti, L., Leogrande, D. *The Determinants of Design Application in Europe* (November, 05, 2021)

Laureti, L., Costantiello, A., Matarrese, M., Leogrande, A., *The Employment in Innovative Enterprises in Europe* (January 1, 2022). Available at SSRN: https://ssrn.com/abstract=

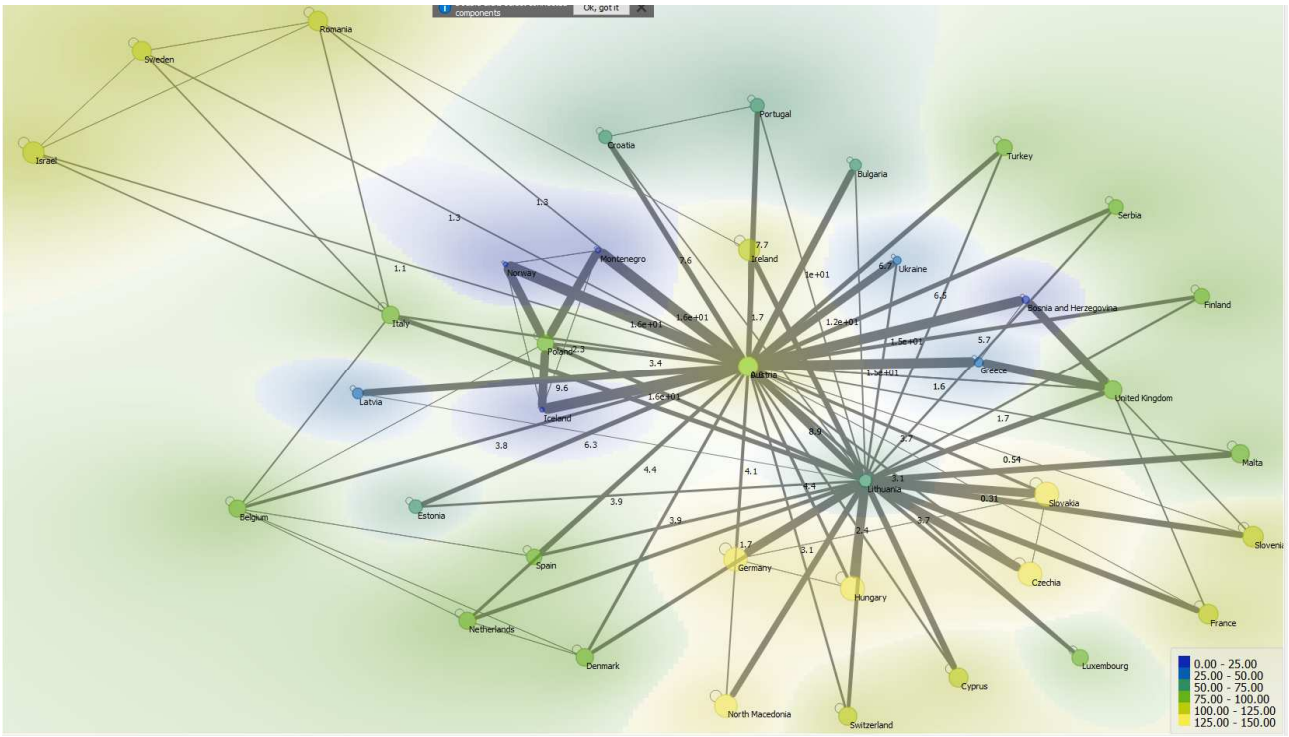
Laureti, Lucio and Costantiello, Alberto and Matarrese, Marco and Leogrande, Angelo, *Enterprises Providing ICT Training in Europe* (January 29, 2022). Available at SSRN: https://ssrn.com/abstract=

Laureti, Lucio and Costantiello, Alberto and Matarrese, Marco and Leogrande, Angelo, *Foreign Doctorate Students in Europe* (February 11, 2022). Available at SSRN: https://ssrn.com/abstract=


Clusterizzazione. C1>C2.
C1
C2
C2
C1
C1
C2
C1
C1
C1
C1
C1
C1
C2
C1
C1
C2
C2
C2
C1
C2
C1
C2
C2

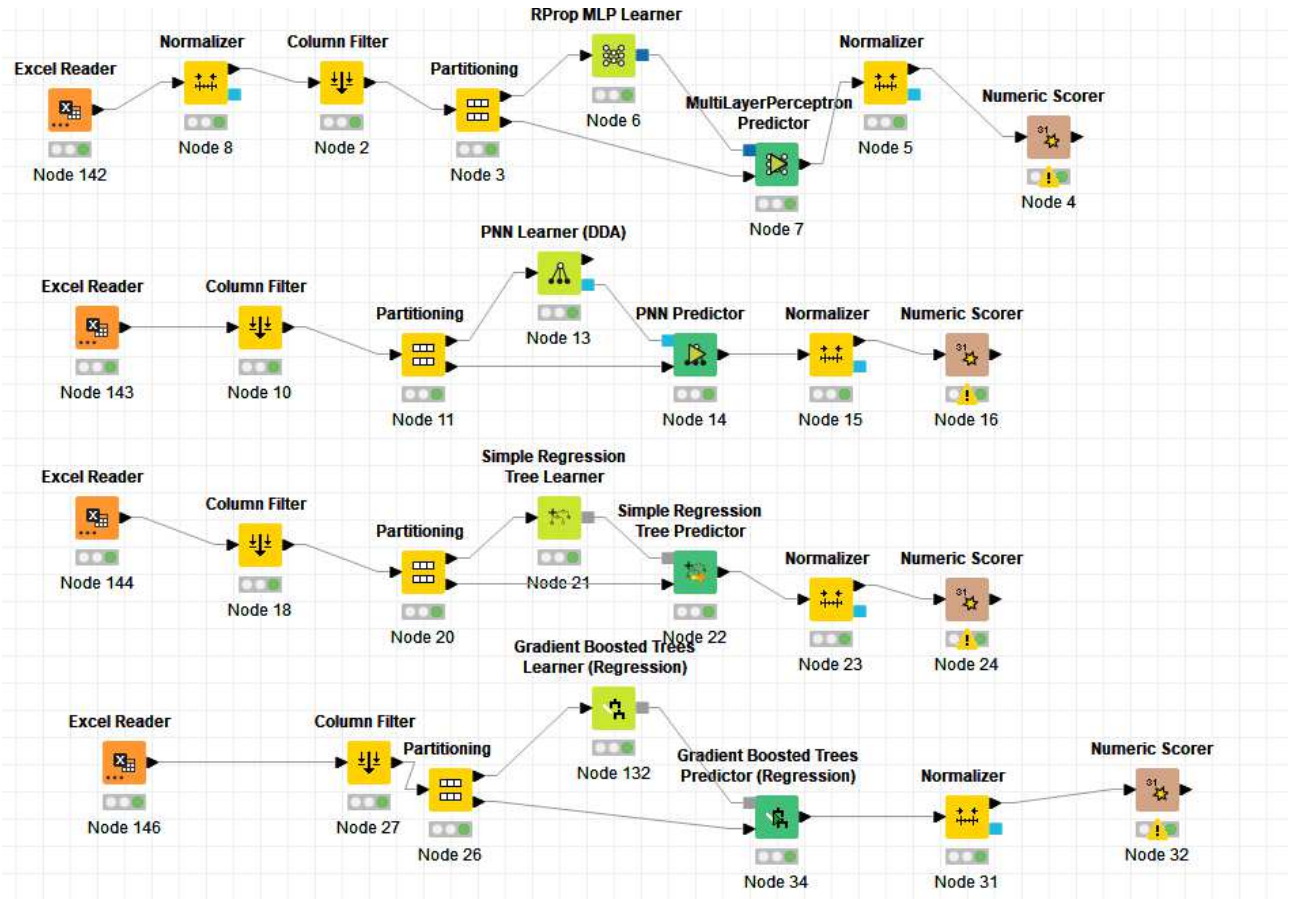
| Export di prodotti di media e alta tecnologia-Variazione Percentual 2014-2021 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Rank** | **Country** | **Var Ass** | **Var Perc** | **Rank** | **Country** | **Var Ass** | **Var Perc** |
| 1 | *Greece* | 30,58 | 1243,09 | 19 | *Croatia* | 8,2 | 14,61 |
| 2 | *Bosnia and Herzegovina* | 15,63 | 272,77 | 20 | *Serbia* | 9,34 | 14,21 |
| 3 | *Bulgaria* | 24,43 | 92,26 | 21 | *Slovenia* | 13,86 | 13,51 |
| 4 | *North Macedonia* | 52,72 | 67,56 | 22 | *Czechia* | 14,93 | 12 |
| 5 | *Lithuania* | 25,08 | 65,3 | 23 | *Slovakia* | 14,81 | 11,63 |
| 6 | *Turkey* | 30,6 | 57,02 | 24 | *Sweden* | 9,65 | 9,98 |
| 7 | *Switzerland* | 33,77 | 50,96 | 25 | *Hungary* | 8,72 | 6,47 |
| 8 | *Cyprus* | 33,82 | 47,31 | 26 | *Austria* | 4,52 | 4,18 |
| 9 | *Ireland* | 35,1 | 41,35 | 27 | *Germany* | 3,52 | 2,62 |
| 10 | *Portugal* | 20,26 | 40,84 | 28 | *Italy* | 2,25 | 2,46 |
| 11 | *Finland* | 21,55 | 36,45 | 29 | *Poland* | 2,02 | 2,34 |
| 12 | *Netherlands* | 24,22 | 35,38 | 30 | *Spain* | 0,66 | 0,83 |
| 13 | *Denmark* | 22,41 | 30,95 | 31 | *France* | -0,05 | -0,05 |
| 14 | *Israel* | 27,87 | 28,91 | 32 | *Luxembourg* | -3,3 | -3,73 |
| 15 | *Latvia* | 9,15 | 25,29 | 33 | *Malta* | -5,05 | -4,82 |
| 16 | *Romania* | 18,34 | 19,91 | 34 | *Estonia* | -3,84 | -5,46 |
| 17 | *United Kingdom* | 15,33 | 18,2 | 35 | *Ukraine* | -23,37 | -47 |
| 18 | *Belgium* | 13,13 | 16,64 | | | | |

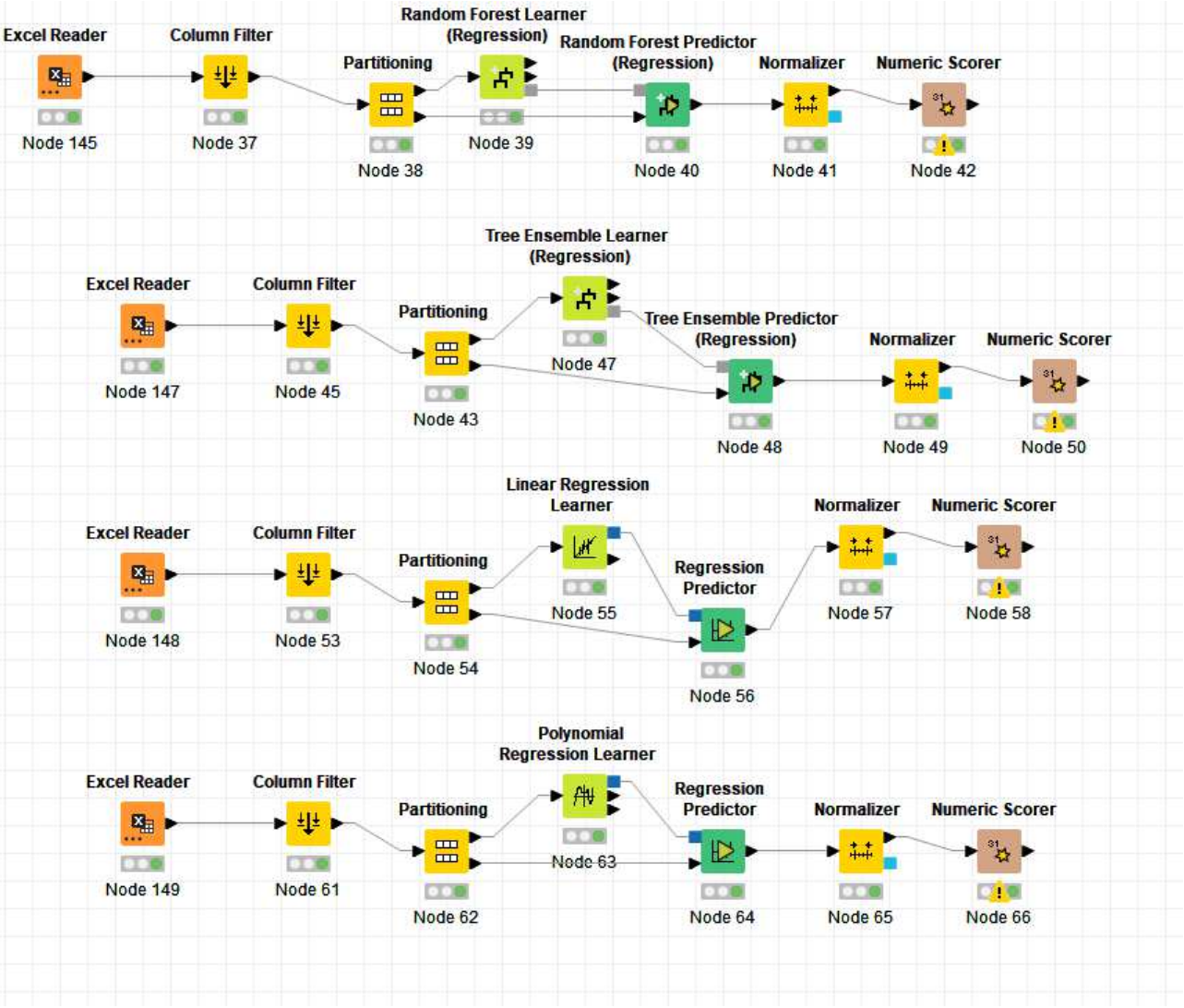
| Export di prodotti di media e alta tecnologia | | | | | |
|---|---|---|---|---|---|
| **Rank** | ***Countries*** | **2021** | **Rank** | ***Countries*** | **2021** |
| 1 | *Hungary* | 143,53 | 20 | *Belgium* | 92,05 |
| 2 | *Slovakia* | 142,19 | 21 | *Poland* | 88,49 |
| 3 | *Czechia* | 139,35 | 22 | *Luxembourg* | 85,28 |
| 4 | *Germany* | 138,01 | 23 | *Turkey* | 84,27 |
| 5 | *North Macedonia* | 130,76 | 24 | *Finland* | 80,67 |
| 6 | *Israel* | 124,26 | 25 | *Spain* | 79,72 |
| 7 | *Ireland* | 119,99 | 26 | *Serbia* | 75,06 |
| 8 | *Slovenia* | 116,46 | 27 | *Portugal* | 69,87 |
| 9 | *Austria* | 112,69 | 28 | *Estonia* | 66,44 |
| 10 | *Romania* | 110,44 | 29 | *Croatia* | 64,34 |
| 11 | *France* | 109,65 | 30 | *Lithuania* | 63,49 |
| 12 | *Sweden* | 106,37 | 31 | *Bulgaria* | 50,91 |
| 13 | *Cyprus* | 105,3 | 32 | *Latvia* | 45,33 |
| 14 | *Switzerland* | 100,04 | 33 | *Greece* | 33,04 |
| 15 | *Malta* | 99,7 | 34 | *Ukraine* | 26,35 |
| 16 | *United Kingdom* | 99,55 | 35 | *Bosnia and Herzegovina* | 21,36 |
| 17 | *Denmark* | 94,81 | 36 | *Montenegro* | 3,99 |
| 18 | *Italy* | 93,54 | 37 | *Iceland* | 0 |
| 19 | *Netherlands* | 92,68 | 38 | *Norway* | 0 |



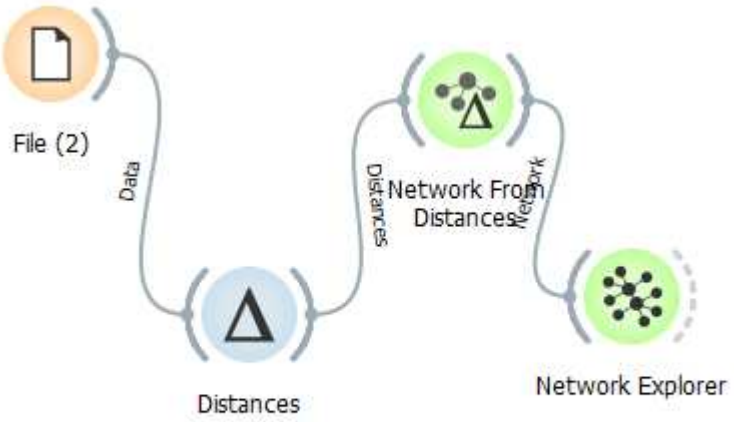

Graph-level indices | Node-level indices

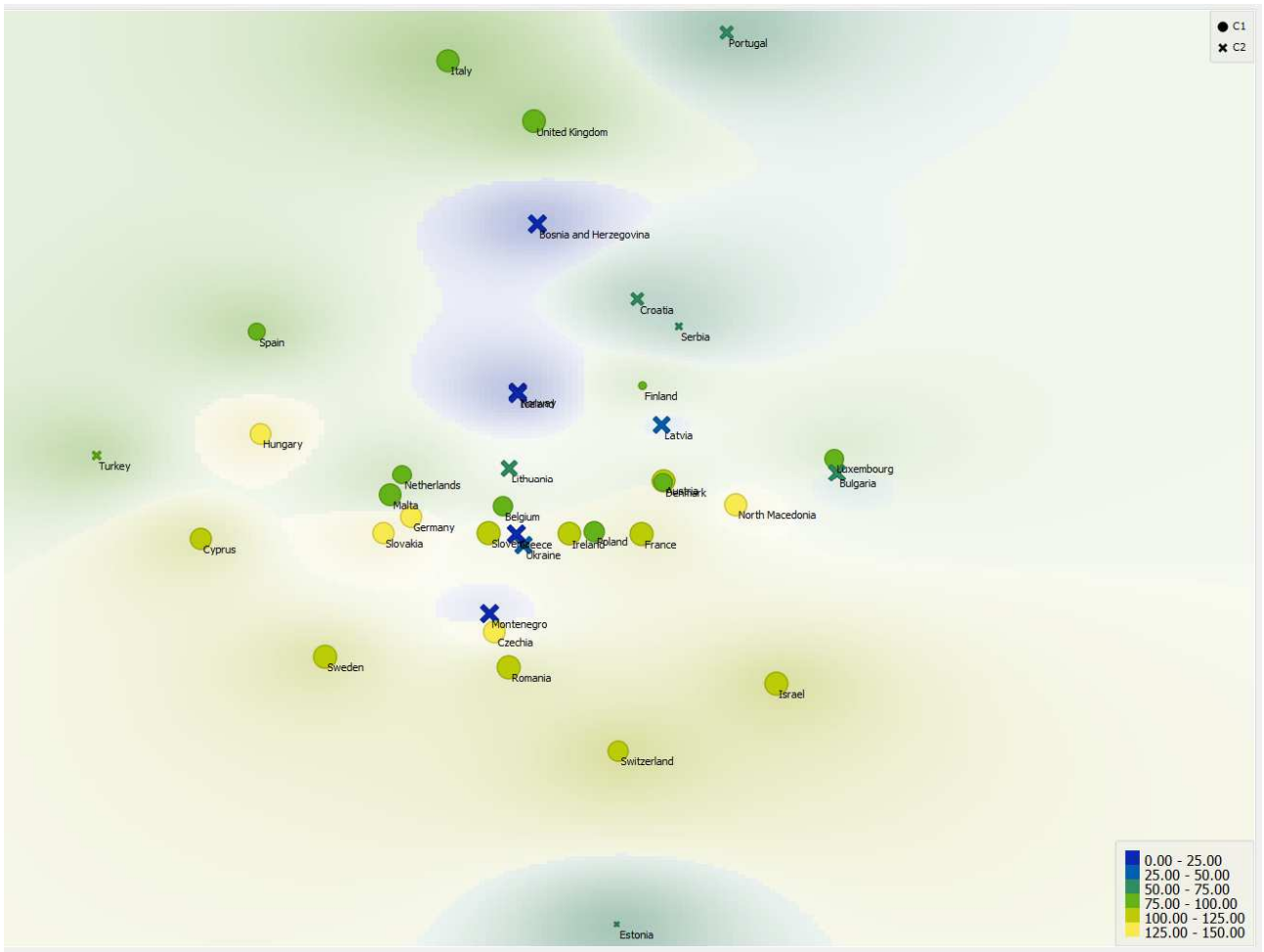
| | |
|---|---|
| ☑ Number of nodes | 38 |
| ☑ Number of edges | 151 |
| ☑ Average degree | 7.947 |
| ☑ Density | 0.2148 |
| ☑ Diameter | 30.79 |
| ☑ Radius | 15.91 |
| ☑ Average shortest path length | 9.053 |

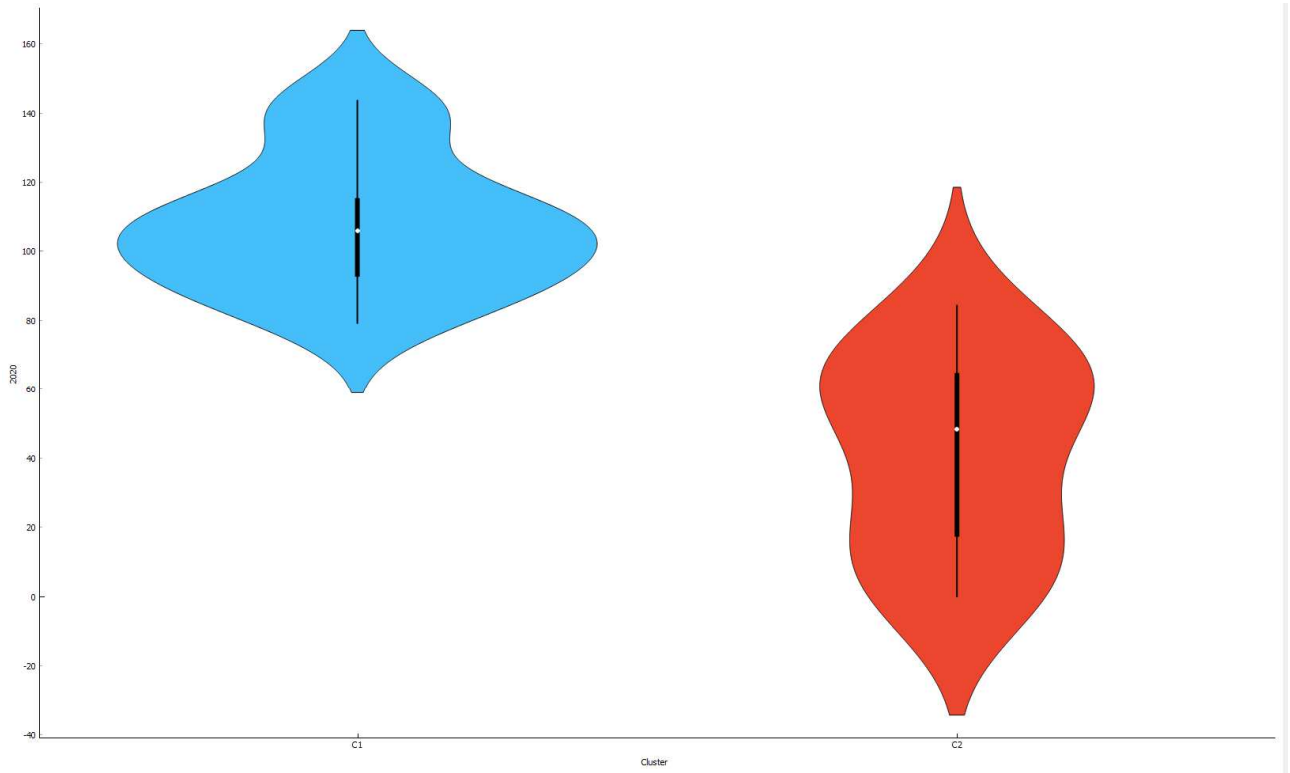

RProp MLP Learner
Excel Reader
Normalizer
Column Filter
Partitioning
Node 142
Node 8
Node 2
Node 3
Node 6
MultiLayerPerceptron Predictor
Normalizer
Numeric Scorer
Node 7
Node 5
Node 4
PNN Learner (DDA)
Excel Reader
Column Filter
Partitioning
PNN Predictor
Normalizer
Numeric Scorer
Node 143
Node 10
Node 11
Node 13
Node 14
Node 15
Node 16
Simple Regression Tree Learner
Excel Reader
Column Filter
Partitioning
Simple Regression Tree Predictor
Normalizer
Numeric Scorer
Node 144
Node 18
Node 20
Node 21
Node 22
Node 23
Node 24
Gradient Boosted Trees Learner (Regression)
Excel Reader
Column Filter
Partitioning
Gradient Boosted Trees Predictor (Regression)
Normalizer
Numeric Scorer
Node 146
Node 27
Node 26
Node 132
Node 34
Node 31
Node 32

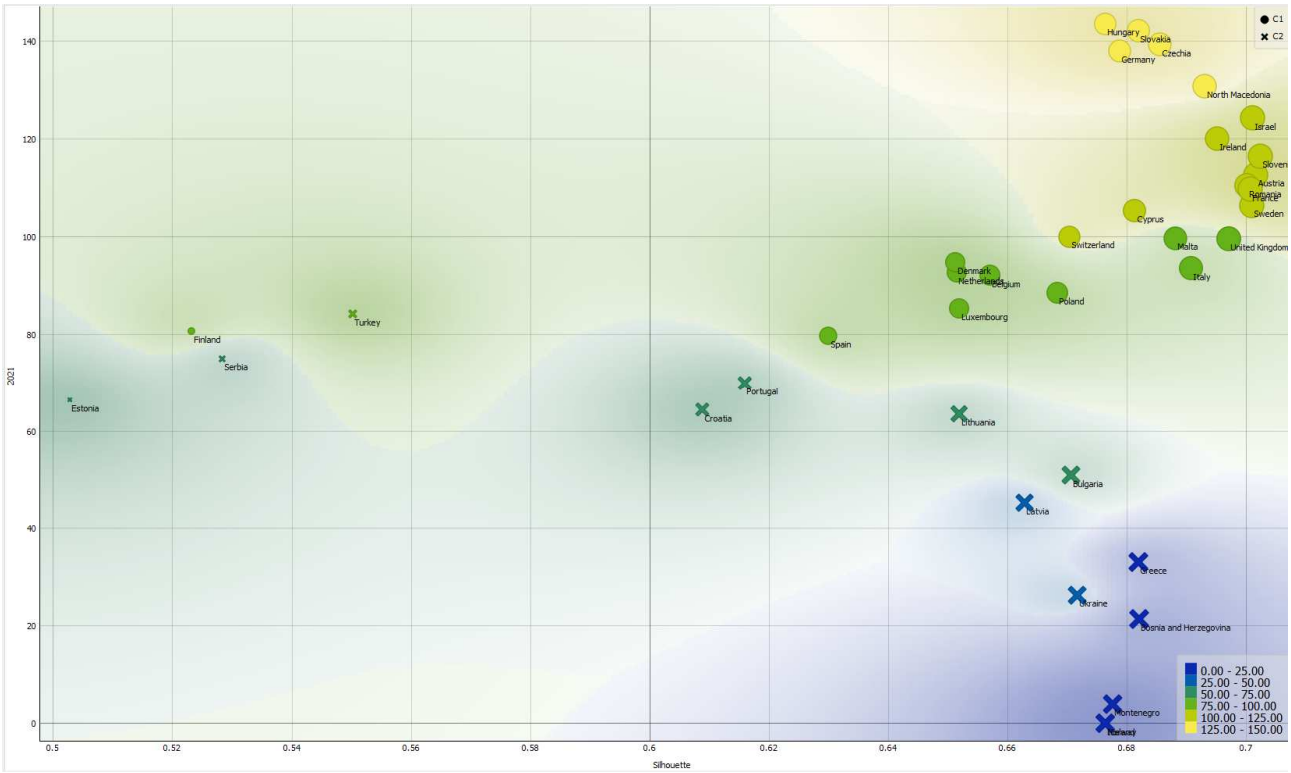

Excel Reader
Column Filter
Random Forest Learner (Regression)
Partitioning
Random Forest Predictor (Regression)
Normalizer
Numeric Scorer
Node 145
Node 37
Node 38
Node 39
Node 40
Node 41
Node 42
Tree Ensemble Learner (Regression)
Excel Reader
Column Filter
Partitioning
Tree Ensemble Predictor (Regression)
Normalizer
Numeric Scorer
Node 147
Node 45
Node 43
Node 47
Node 48
Node 49
Node 50
Linear Regression Learner
Excel Reader
Column Filter
Partitioning
Regression Predictor
Normalizer
Numeric Scorer
Node 148
Node 53
Node 54
Node 55
Node 56
Node 57
Node 58
Polynomial Regression Learner
Excel Reader
Column Filter
Partitioning
Regression Predictor
Normalizer
Numeric Scorer
Node 149
Node 61
Node 62
Node 63
Node 64
Node 65
Node 66

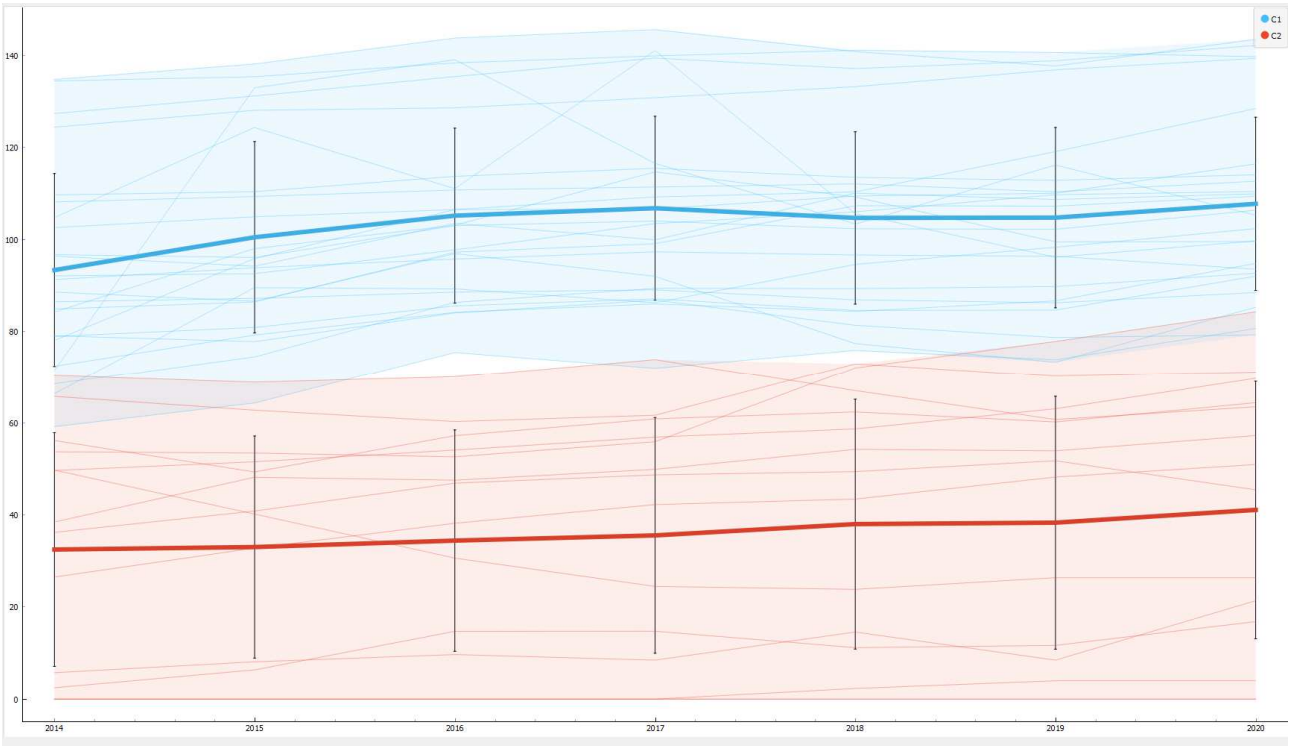
| | 2021 | Country | Cluster | Silhouette |
|---|---|---|---|---|
| 1 | 112.69 | Austria | C1 | 0.701623 |
| 3 | 92.05 | Belgium | C1 | 0.657083 |
| 6 | 105.30 | Cyprus | C1 | 0.681342 |
| 7 | 139.35 | Czechia | C1 | 0.68558 |
| 9 | 94.81 | Denmark | C1 | 0.651306 |
| 13 | 80.67 | Finland | C1 | 0.523248 |
| 14 | 109.65 | France | C1 | 0.700753 |
| 8 | 138.01 | Germany | C1 | 0.678752 |
| 16 | 143.53 | Hungary | C1 | 0.676352 |
| 17 | 119.99 | Ireland | C1 | 0.695197 |
| 18 | 124.26 | Israel | C1 | 0.701032 |
| 20 | 93.54 | Italy | C1 | 0.690723 |
| 22 | 85.28 | Luxembourg | C1 | 0.651954 |
| 26 | 99.70 | Malta | C1 | 0.688111 |
| 27 | 92.68 | Netherlands | C1 | 0.651453 |
| 25 | 130.76 | North Macedonia | C1 | 0.693096 |
| 29 | 88.49 | Poland | C1 | 0.66835 |
| 31 | 110.44 | Romania | C1 | 0.700139 |
| 35 | 142.19 | Slovakia | C1 | 0.681906 |
| 34 | 116.46 | Slovenia | C1 | 0.702435 |
| 12 | 79.72 | Spain | C1 | 0.629982 |
| 33 | 106.37 | Sweden | C1 | 0.701 |
| 5 | 100.04 | Switzerland | C1 | 0.670341 |
| 38 | 99.55 | United Kingdom | C1 | 0.697075 |
| 2 | 21.36 | Bosnia and Her... | C2 | 0.682069 |
| 4 | 50.91 | Bulgaria | C2 | 0.670585 |
| 15 | 64.34 | Croatia | C2 | 0.608865 |
| 10 | 66.44 | Estonia | C2 | 0.502826 |
| 11 | 33.04 | Greece | C2 | 0.681924 |
| 19 | 0.00 | Iceland | C2 | 0.676373 |
| 23 | 45.33 | Latvia | C2 | 0.662838 |
| 21 | 63.49 | Lithuania | C2 | 0.651909 |
| 24 | 3.99 | Montenegro | C2 | 0.677634 |
| 28 | 0.00 | Norway | C2 | 0.676373 |
| 30 | 69.87 | Portugal | C2 | 0.615947 |
| 32 | 75.06 | Serbia | C2 | 0.528365 |
| 36 | 84.27 | Turkey | C2 | 0.550189 |
| 37 | 26.35 | Ukraine | C2 | 0.671718 |

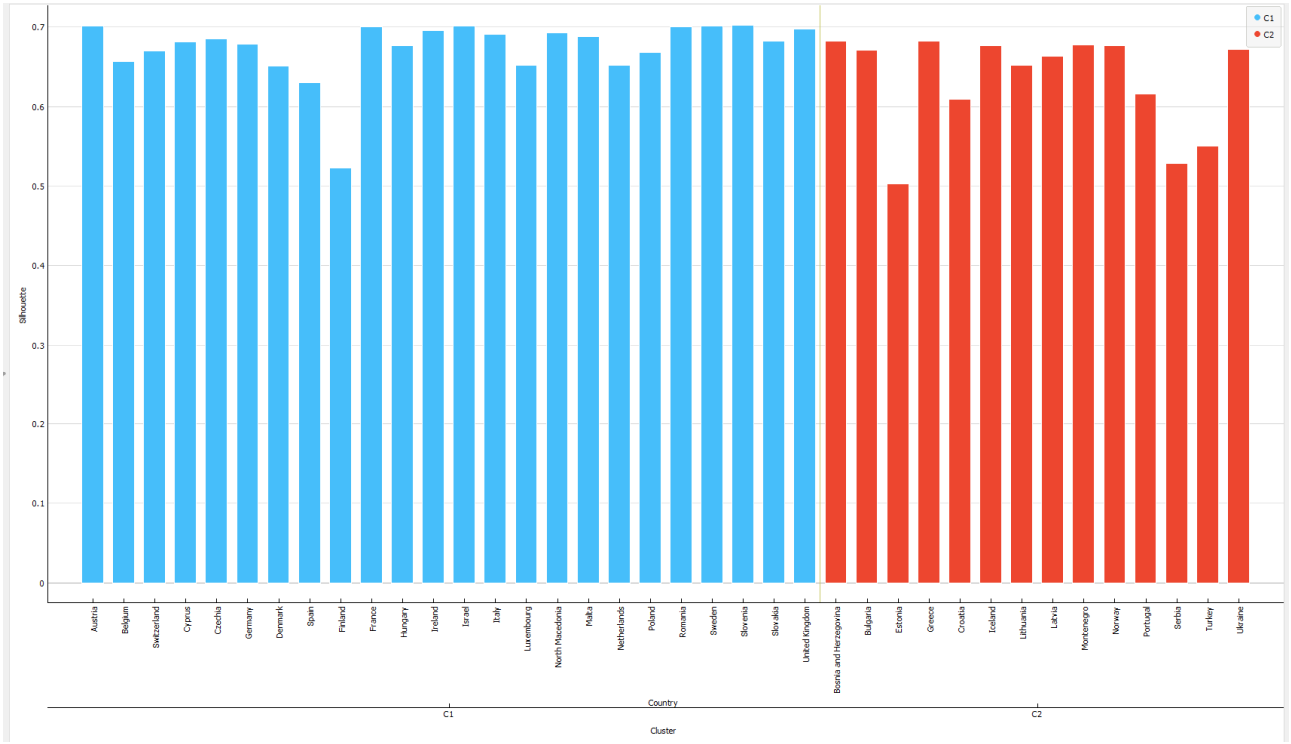

File (2)
Data
Distances
Network From Distances
Network
Network Explorer

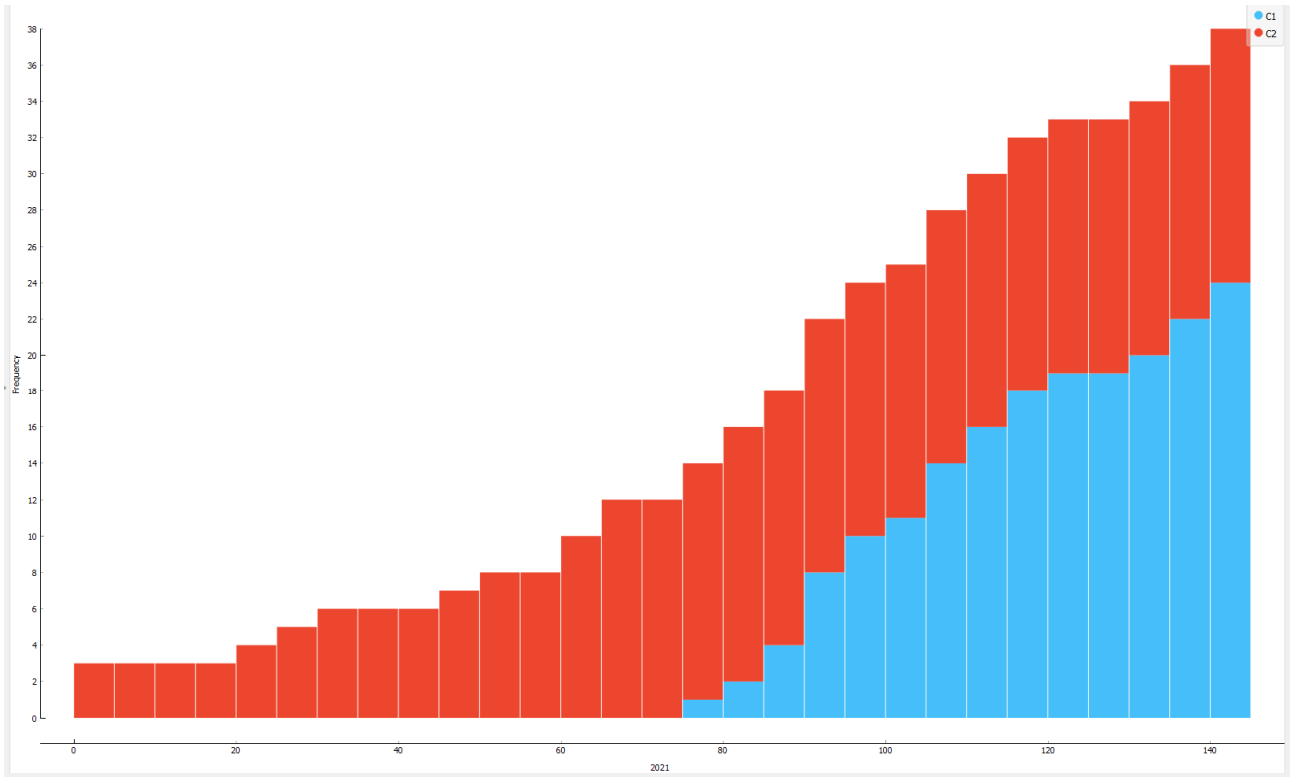

C1
C2
Portugal
Italy
United Kingdom
Bosnia and Herzegovina
Croatia
Serbia
Spain
Finland
Latvia
Hungary
Turkey
Netherlands
Lithuania
Luxembourg
Bulgaria
Malta
Belgium
North Macedonia
Germany
Slovakia
Ireland
Poland
France
Cyprus
Ukraine
Montenegro
Czechia
Sweden
Romania
Israel
Switzerland
Estonia
0.00 - 25.00
25.00 - 50.00
50.00 - 75.00
75.00 - 100.00
100.00 - 125.00
125.00 - 150.00


160
140
120
100
80
60
40
20
0
-20
-40
2020
C1
C2
Cluster


C1
C2
Hungary
Slovakia
Czechia
Germany
North Macedonia
Israel
Ireland
Austria
Cyprus
Sweden
Switzerland
Malta
United Kingdom
Italy
Poland
Luxembourg
Spain
Turkey
Finland
Serbia
Estonia
Portugal
Croatia
Lithuania
Bulgaria
Latvia
Greece
Ukraine
Bosnia and Herzegovina
Montenegro
0.00 - 25.00
25.00 - 50.00
50.00 - 75.00
75.00 - 100.00
100.00 - 125.00
125.00 - 150.00
2021
Silhouette


C1
C2
140
120
100
80
60
40
20
0
2014
2015
2016
2017
2018
2019
2020


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


C1
C2
Frequency
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
0
20
40
60
80
100
120
140
2021