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LEOGRANDE, ANGELO

LUM University Giuseppe Degennaro

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Angelo Leogrande¹

The Export of High Knowledge Intensity Services of European Countries

On average, 77% of service exports are knowledge-intensive services

The European Innovation Scoreboard-EIS calculates the export value of knowledge-intensive services produced in Europe. By knowledge-intensive services we mean a set of activities ranging from sea and air transport to financial services, the use of intellectual property, telecommunications, and audiovisual services. The value is considered as a percentage ratio with respect to the complex value of the exports of services.

Keywords: Innovation, and Invention: Processes and Incentives; Management of Technological Innovation and R&D; Diffusion Processes; Open Innovation.

JEL Classification: O30; O31, O32; O33; O36

Ranking of countries by value of the level of exports of knowledge-intensive services. Ireland ranks first for the value of exports of knowledge-intensive services in 2021 with a value of 161.06, followed by Luxembourg with an amount of 157.43 and the United Kingdom with an amount of 135.16. In the middle of the table there are Hungary with an amount equal to 72.02 units, followed by Greece with a value of 71.90 and Serbia with an amount of 71.79 units. Lithuania closes the ranking with an amount equal to 4.63, followed by Montenegro with an amount equal to 2.96 and Bosnia with a value equal to 1.72. On average in 2021, the average value of exports of knowledge-intensive services was 77.21%.

Ranking of countries by percentage change in exports of knowledge-intensive services. Lithuania ranks first in terms of the percentage change in exports of knowledge-intensive services between 2014 and 2021 with a value of 6398.2%, followed by Malta with a value of 212.2% equivalent to a value of 21.7, and from Turkey with a value of 85.8% equal to a value of 20.3 units. In the middle of the table there are Belgium with a value equal to 11.4% equal to a value of 11.8 units, followed by Hungary with a value equal to 9.3% equal to a value of 6.1 units, followed by from Latvia with an amount equal to 8.45% equal to a value of 5.82 units. Greece closes the ranking with a value equal to -13.87% equal to a value of -11.58 units, followed by Iceland with a value equal to -18.57% equal to an amount of -16.53 units and from Portugal with a value equal to -24.49% equal to an amount of -12.85 units. The average percentage changes in the value of exports of knowledge-intensive services grew by 195.8% between 2014 and 2021 for the countries considered.

Clustering with the use of the k-Means algorithm. The k-Means algorithm is used below for clustering analysis. The Silhouette coefficient was used to choose the optimal number of clusters. In particular, the optimal number of clusters is chosen in connection with the higher Silhouette coefficient considering that this indicator can vary from -1 to 1. Specifically, the greater Silhouette

¹ PhD, Assistant Professor of Economics at Lum University Giuseppe Degennaro, Researcher at LUM Enterprise s.r.l. email: leogrande.culture@lum.it

coefficient was found with reference to the Silhouette coefficient corresponding to two clusters. The three clusters are made up as follows:

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

With reference to the median value of the estimated variable, it results that the value of Cluster 1-C1 is equal to 73, while the value of Cluster 2-C2 is equal to 65. It therefore follows that $C1 > C2$. It follows that looking at the clustering map there is a contrast between North-Western Europe - which has low levels of export of services with a high value of knowledge - and South-Eastern Europe which has higher values. This result may appear to be counterfactual. However, it can be better understood considering that many of the countries of Eastern Europe and Southern Europe have been the subject of productive relocations of the countries of Central and Northern Europe.

Network Analysis. Subsequently, a network analysis was carried out to verify the presence of nations that are particularly connected in terms of exporting services with a high level of knowledge. Among the most connected nations are Holland and Luxembourg, Hungary and Switzerland, the United Kingdom and Germany, Poland and Estonia. The network analysis was carried out through the use of the Cosine distance. Therefore, the following results result:

- Number of nodes: 37;
- Number of edges 51;
- Average degree 0.076;
- Density 0.07658.

Machine Learning and Predictions. An analysis is carried out below through the use of a comparison between eight different machine learning algorithms for predicting the future value of exporting high-level knowledge services produced in Europe. The algorithms were trained with 70% of the available data while the remaining 30% was used for the actual prediction. The algorithms have been classified according to their ability to maximize the R-square value and minimize three statistical errors, namely: "Mean Absolute Error", "Mean Squared Error", "Root Mean Squared Error". Below is the ranking of the algorithms based on predictive efficiency, that is:

1. *Polynomial Regression* with a payoff value of 4;
2. *Tree Ensemble* with a payoff value of 9;
3. *Linear Regression* with a payoff value of 12;
4. *Random Forest* with a payoff value of 17;
5. *ANN-Artificial Neural Network* with a payoff value of 18;
6. *PNN-Probabilistic Neural Network* with a payoff value of 24;
7. *Gradient Boosted Tree* with a payoff value of 28;
8. *Simple Regression Tree* with a payoff value of 32.

Below, based on the application of the best performing algorithm or the Polynomial Regression, it is possible to predict the following variations in the export value of services with a high level of knowledge in the European countries considered:

- *Austria* with a decrease from an amount of 59.51 up to a value of 58.71 or equal to an amount of -0.80 equal to a value of -1.354%;

- *Bosnia* with an increase from an amount of 1.72 up to a value of 2.41 or equal to an amount of 0.688 units equal to a value of 30.90%;
- *Germany* with a decrease from an amount of 121 up to a value of 117.13 or equal to an amount of -3.86 units equal to a value of -3.19%;
- *Greece* with an increase from an amount of 71.9 up to a value of 75.74 or equal to a change of 3.84 units equal to an amount of 5.34%;
- *Israel* with an increase from an amount of 108.95 up to a value of 113.667 units or equal to a change of 4.716 units equal to an amount of 4.3%;
- *Iceland* with an increase from an amount of 72.46 units up to a value of 72.91 units or equal to a variation of 0.45 units equal to a value of 0.62%;
- *Luxembourg* with an increase from an amount of 157.42 units up to a value of 157.8 units or equal to a change of 0.3 units equal to a value of 0.23%;
- *Malta* with an increase from an amount of 31.8 units up to a value of 35.5 units or equal to a change of 3.6 units equal to an amount of 11.36%;
- *Poland* with a decrease from an amount of 57.04 units up to a value of 55.97 units or equal to a variation of -1.07 units equal to a value of -1.883%;
- *Slovakia* with an increase from an amount equal to 44.1 up to a value of 44.93 units or equal to a change of 0.79 units equal to a value of 1.80%;
- *Turkey* with an increase from an amount of 43.9 units up to a value of 50.37 units or equal to a variation of 6.4 units equal to an amount of 14.75%;
- *Ukraine* with an increase from an amount of 69.89 units up to a value of 76.16 units or equal to a variation of 6.2 units equal to an amount of 8.9%.

On average, the value of exports of high-level knowledge services for the countries considered is expected to grow from an amount of 69.9 units up to a value of 71.7 or equal to a growth of 1.7 units equal to a value of 2.55%.

Conclusions. The value of exports of high-level knowledge services grew on average in European countries between 2014 and 2021 by 7.8%. It is mainly the countries of Southern and Eastern Europe that export because of de-localizations. However, in first place there is Ireland which exports a very high level of services thanks to the presence of many IT companies that have chosen Ireland for tax reasons. The percentage of exports of high-level knowledge services should increase in Europe even though there is a high probability that the European economy will not be able to compete with either the US or China and will therefore be crushed by the Sino-American conflict.

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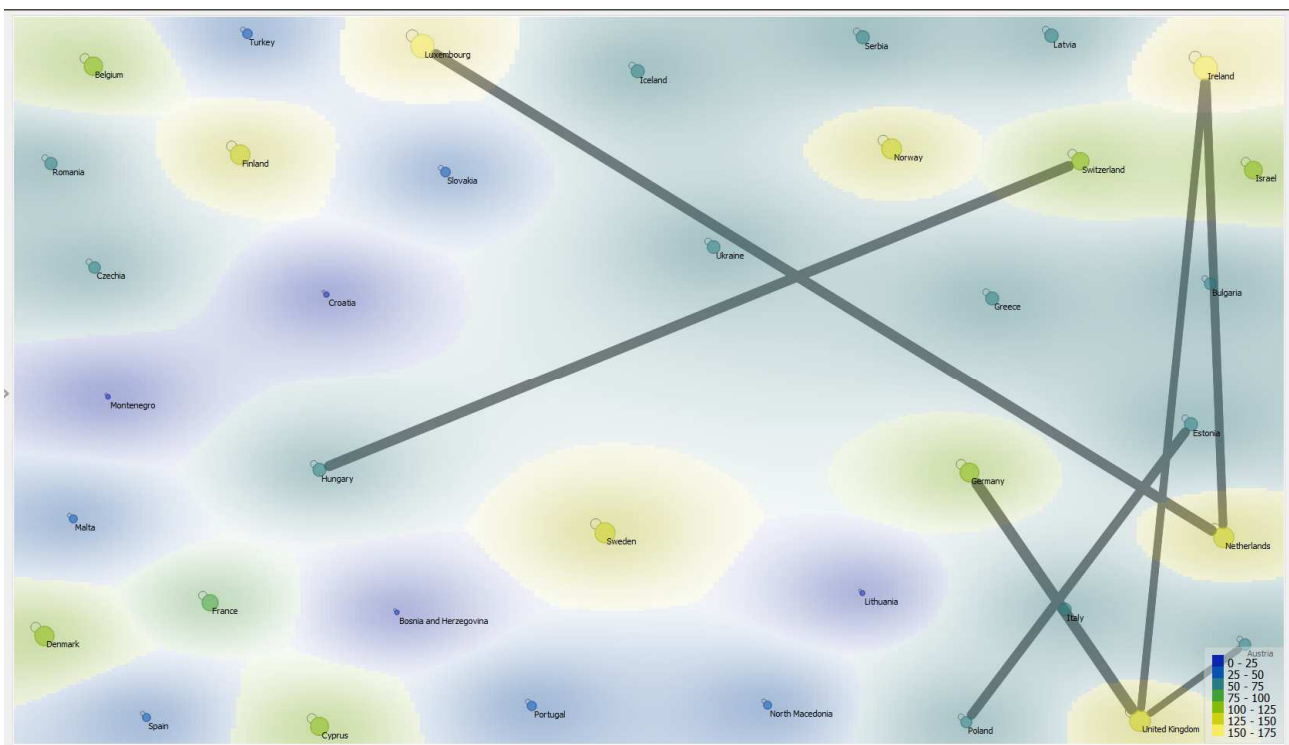
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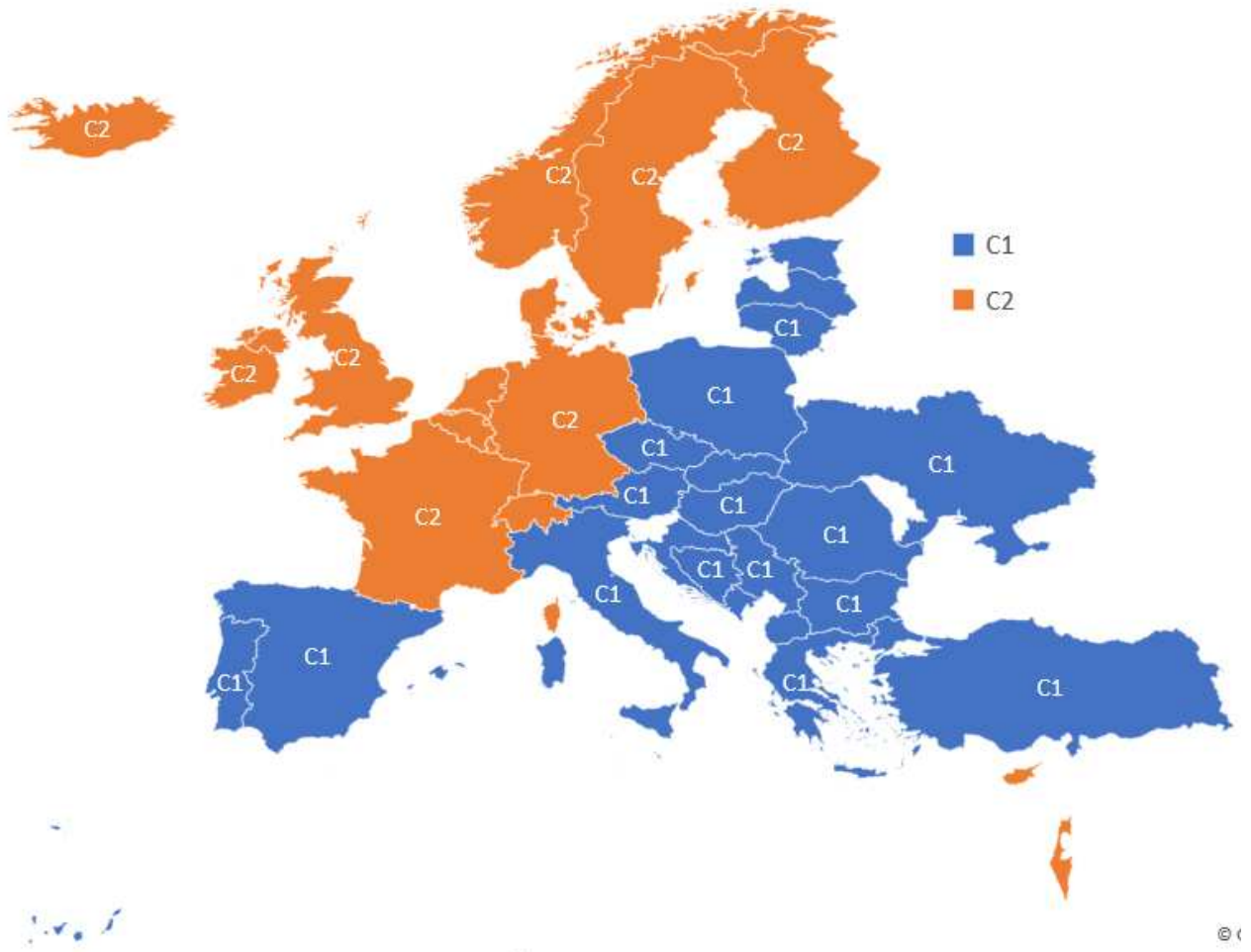
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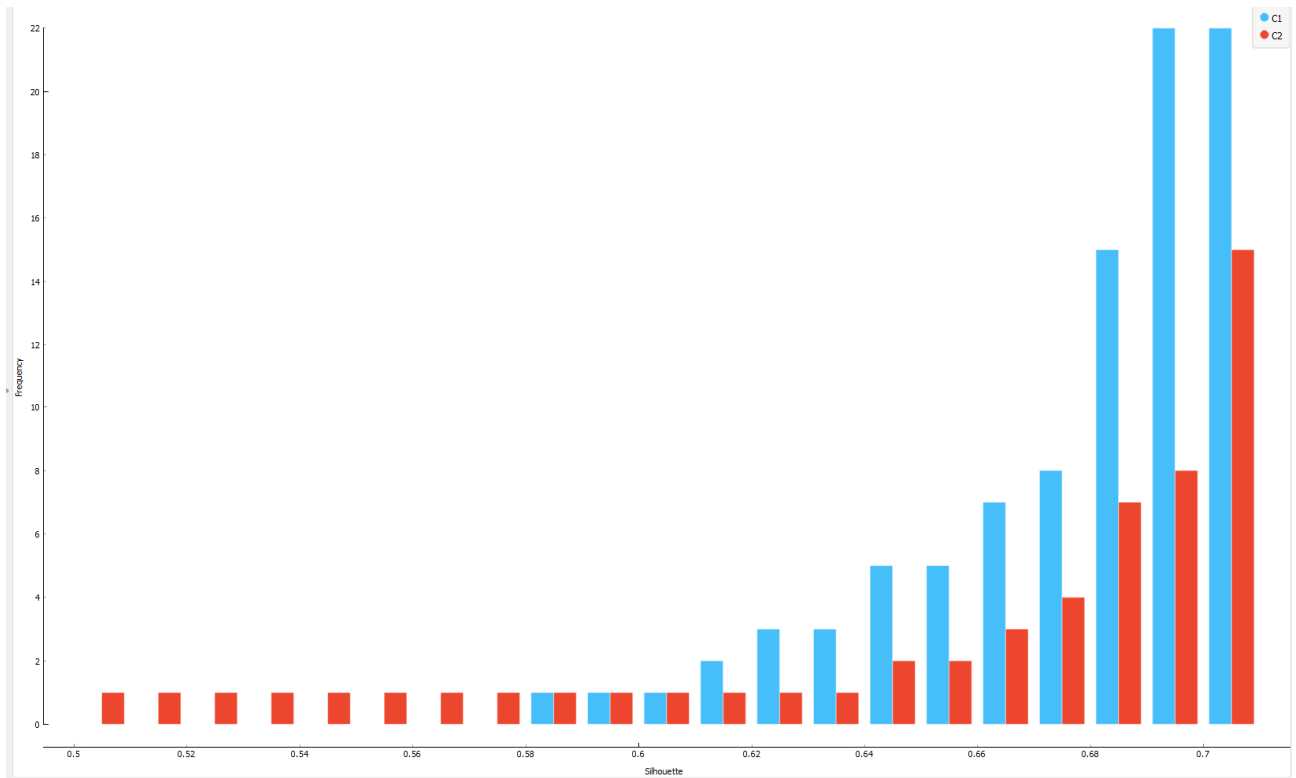
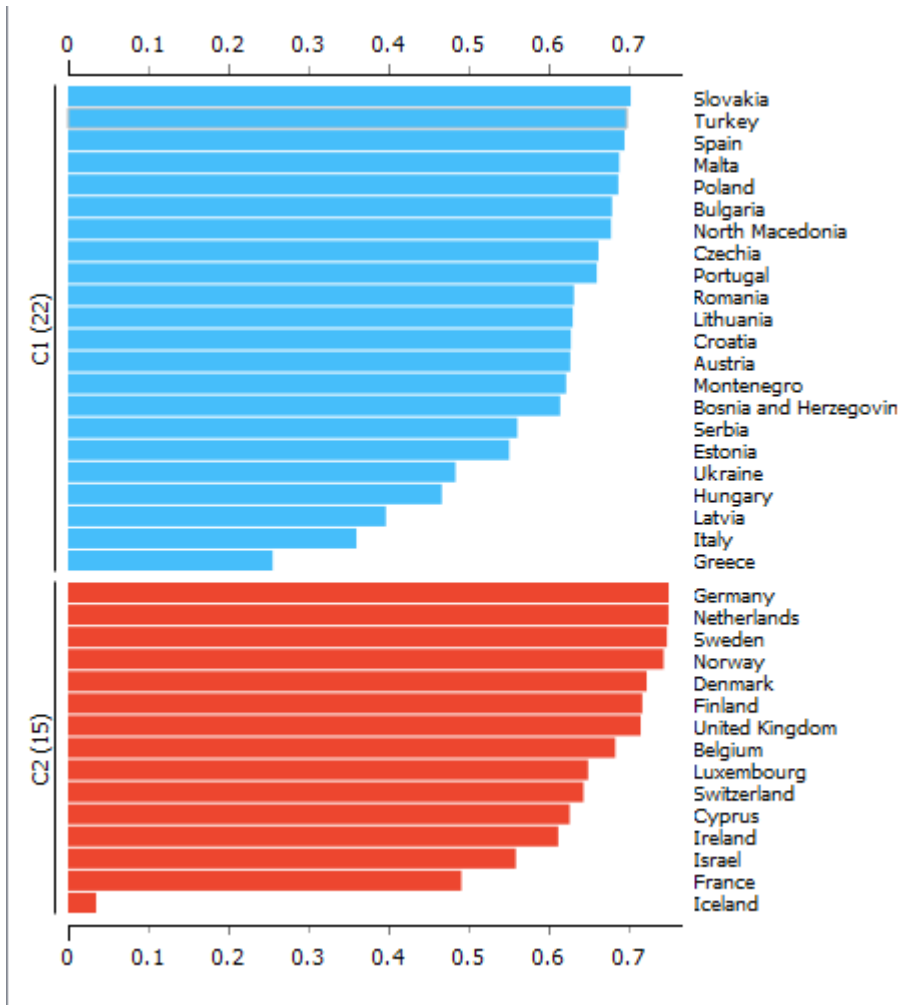
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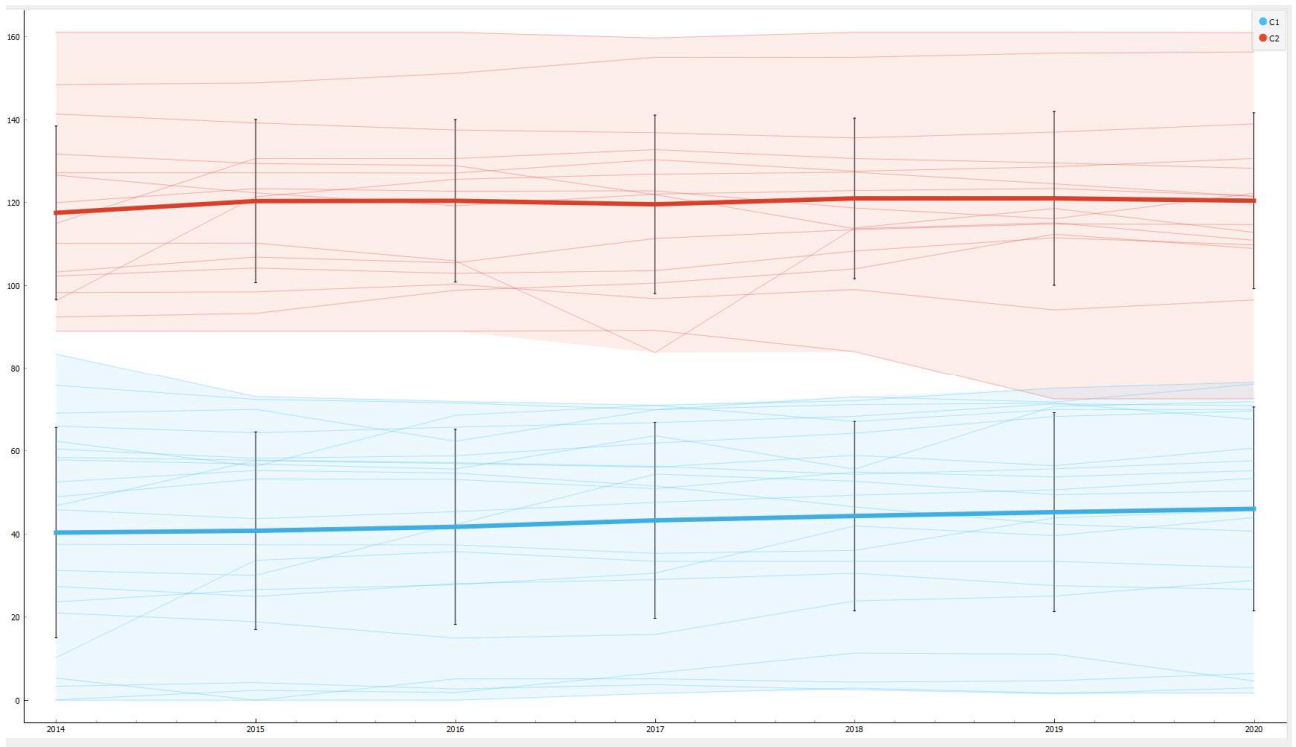
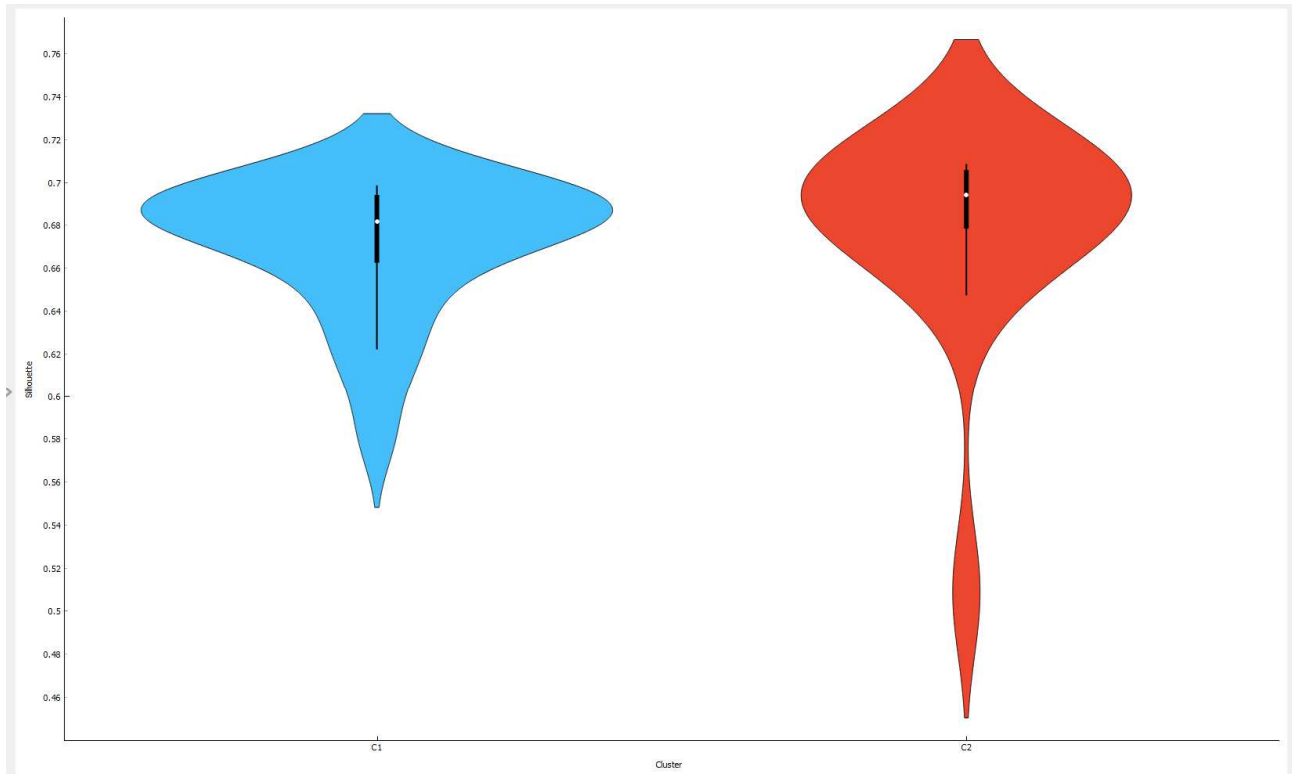
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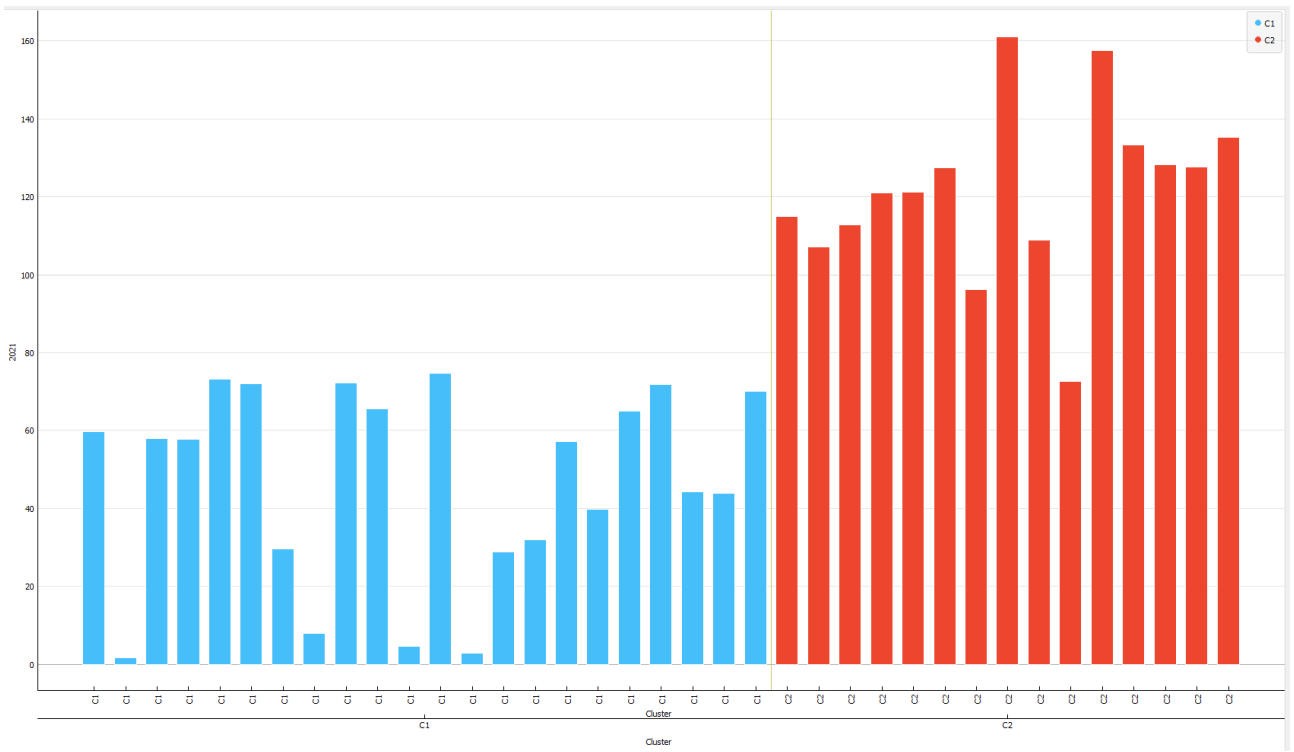
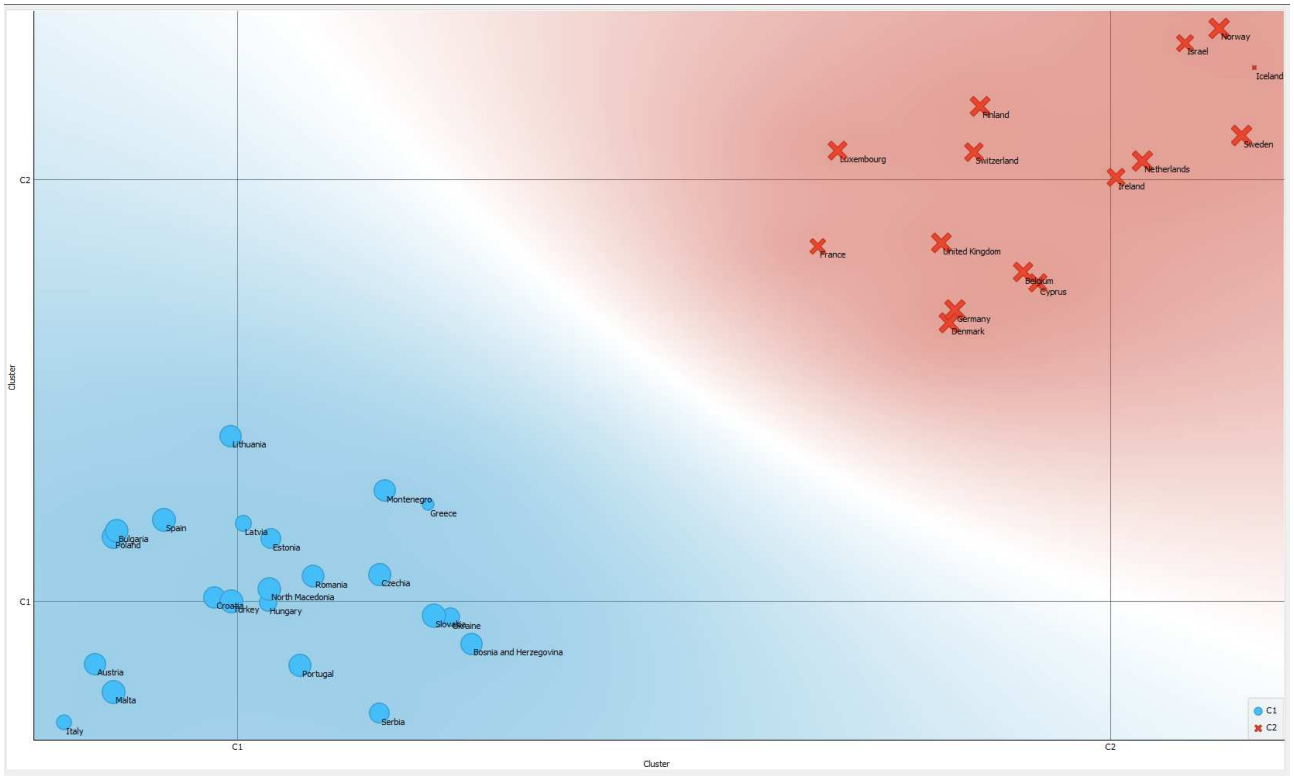


Clusterization. C1>C2









Predizioni con l'utilizzo dell' algoritmo Polynomial Regression				
Countries	2021	Prediction	Variazione Assoluta	Variazione Percentuale
<i>Austria</i>	★ 59,516	★ 58,710	★ -0,806	★ -1,354
<i>Bosnia</i>	★ 1,724	★ 2,412	★ 0,688	★ 39,907
<i>Germania</i>	★ 121,006	★ 117,137	★ -3,869	★ -3,197
<i>Grecia</i>	★ 71,905	★ 75,749	★ 3,844	★ 5,346
<i>Israele</i>	★ 108,951	★ 113,667	★ 4,716	★ 4,329
<i>Islanda</i>	★ 72,462	★ 72,915	★ 0,453	★ 0,625
<i>Lussemburgo</i>	★ 157,427	★ 157,800	★ 0,373	★ 0,237
<i>Malta</i>	☆ 31,895	☆ 35,520	★ 3,625	☆ 11,365
<i>Polonia</i>	★ 57,046	★ 55,972	★ -1,074	★ -1,883
<i>Slovacchia</i>	☆ 44,141	☆ 44,936	★ 0,795	★ 1,801
<i>Turchia</i>	☆ 43,902	★ 50,379	★ 6,477	☆ 14,753
<i>Ucraina</i>	★ 69,898	★ 76,164	★ 6,266	★ 8,964
<i>Media</i>	★ 69,989	★ 71,780	★ 1,791	★ 2,558