Healthy Life Expectancy at Birth in the Italian Regions

Leogrande, Angelo

LUM University Giuseppe Degennaro; Lum Enterprise S.r.l.

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Angelo Leogrande[1]

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It has grown in all regions with the exception of Basilicata

Istat-BES calculates the value of life expectancy in good health. Healthy life expectancy at birth "*expresses the average number of years that a child born in a given calendar year can expect to live in good health, using the prevalence of individuals who respond positively (" well " or "very well") to the question about perceived health*". This indicator therefore reflects a set of elements that refer to both environmental, food and wine and individual aspects that can have a significant impact in determining the degree of health of the population. In addition, there is a specific economic interest in healthy life expectancy at birth. In fact, a healthier population costs less in terms of the health system and therefore appears to be more sustainable in the long term for the state and the community.

Ranking of the Italian regions by value of healthy life expectancy at birth in 2019. Trentino-Alto Adige is in first place for value of healthy life expectancy with an amount equal to 65.8 years, followed by Friuli-Venezia Giulia with an amount equal to 61.8 years, followed by Valle d'Aosta with an amount of 60.7 years. In the middle of the table there are Liguria with an amount equal to 58.9 years, followed by Piedmont with an amount equal to 58.9 years and the Marche with an amount equal to 58.8 years. Sardinia closes the ranking with an amount equal to 54.4 years, followed by Basilicata with an amount equal to 54.3 years and Calabria with an amount equal to 49.7 years. On average in the Italian regions, life expectancy in good health at birth was equal to a value of 58.32 years.

Ranking of Italian regions by percentage change in life expectancy at birth between 2009 and 2019. Umbria ranks first in terms of the percentage change in healthy life expectancy between 2009 and 2019 with an amount of 8.11% equal to 4.50 years, followed by Valle d'Aosta with an amount equal to 7.05% equal to an amount of 4.00 years, and by Emilia Romagna with an amount of 6.05% equal to an amount of 3.40 years. In the middle of the table there are Veneto with an amount equal to 4.15% equal to an amount of 2.40 years, followed by Lazio with a value of 3.90% equal to an amount of 2.20 years, and Piedmont with a variation of 3.88% equal to an amount of 2.20 years. Liguria closes the ranking with an amount equal to 0.51% equal to an amount of 0.30 years, Molise with a percentage change equal to 0.00% and Basilicata with a change equal to -0.37% equal to to an amount of -0.20 years. On average between 2009 and 2019, the value of the percentage change in life expectancy at birth in the Italian regions increased by an amount equal to 3.57% equal to an amount of 2.02 years.

Italian macro-regions. The healthy life expectancy at birth in the North has grown from an amount of 57.4 years in 2009 to 60.1 years in 2019 or a change equal to an amount of 2.70 years equal to an amount of 4 , 70%. Between 2015 and 2019, the value of life expectancy in good health at birth in the North grew by 0.50 years, equal to an amount of 0.84%. Between 2009 and 2019, life expectancy in good health at birth grew by an amount equal to 0.27 years per year, while between 2005 and 2019 this value grew by 0.14 years per year. In Central Italy, the value of life expectancy in good health at birth increased from an amount of 56.9 years in 2009 to a value of 59.1 years in 2019 or equal to an amount of 2.20 years, equal to at 3.87% and an average growth of 0.22 years. Between 2015 and 2019 the value of life expectancy in good health at birth increased from an amount of 58.8 years to a value

[1] PhD, Assistant Professor of Economics at Lum University Giuseppe Degennaro, researcher at LUM Enterprise s.r.l. Email: leogrande.cultore@lum.it

of 59.1 years or equal to a variation of 0.30 years equal to a value of 0.51%. However, between 2015 and 2019 the value of the average absolute changes in life expectancy in good health at birth decreased by an amount equal to -0.04 units. In the South of Italy between 2009 and 2019 the value of life expectancy in good health at birth increased from 54.5 years to a value of 56.2 years or a variation of 1.70 years equal to an amount of 3, 12%. Between 2015 and 2019, the value of life expectancy at birth in good health increased from an amount of 56 years to a value of 56.2 years or equal to a variation of 0.20 years equal to a value of 0.36%. On average in Italy between 2009 and 2019 the value of life expectancy in good health at birth increased from an amount of 56.4 years up to a value of 58.6 years in 2019 or a variation of 2.20 years equal to an amount of 3.90%. Between 2015 and 2019, the value of life expectancy in good health at birth increased from an amount of 58.3 years to a value of 58.6 years in 2019 or a variation of 0.30 years equal to a variation of 0.51%. There are therefore two phenomena to consider in the Italian macro-regions: on the one hand there is a growth in life expectancy in good health at birth in all Italian geographic areas, on the other hand there is a growing gap between the North and Center-South. In fact, considering the difference between the healthy life expectancy at birth in the North and in the South, it appears that: in 2009 the southerners had a healthy life expectancy at birth of 2.9 years lower than in the North, a value which worsened to 3.6 years in 2015 and to 3.9 years in 2019. It therefore follows that the healthy life expectancy of the southerners improved in historical series even if it worsened in comparison with Northern Italy.

Clusterization. An analysis of clustering is proposed below using the k-Means algorithm used to identify the presence of groups among the Italian regions. Since the k-Means algorithm is an unsupervised algorithm, it is necessary to identify a criterion to choose the optimal number of clusters. In the specific case, the Silhouette coefficient was used. The Silhouette coefficient ranges from -1 to 1. The optimal number of clusters corresponds to the highest Silhouette coefficient. In the case analyzed, the higher Silhouette coefficient occurred in the presence of several clusters equal to 3. The following clustering therefore derives:

- *Cluster 1*: Aosta Valley, Lombardy, Veneto, Friuli-Venezia Giulia, Tuscany, Emilia-Romagna, Liguria, Piedmont, Marche, Umbria, Lazio, Abruzzo, Molise;
- *Cluster 2*: Trentino-Alto Adige;
- *Cluster 3*: Sardinia, Basilicata, Calabria, Sicily, Puglia.

In terms of the median value of the clusters it is therefore possible to identify the following order, i.e. C2 with a median value of life expectancy in good health at birth equal to an amount of 65.8, followed by C1 with a value of 59.6 and from cluster 3 with an amount of 55.15 units. Therefore, the following ordering derives from it, namely C2> C1> C3. Analyzing the geographical map of clustering, the central-northern regions have a significantly better value of life expectancy in good health at birth than the southern regions. Among all the regions, Trentino-Alto Adige stands out as it has healthy life expectancy levels at birth that far exceed those of the southern regions. It therefore follows that the levels of human and social capital probably also have a significant impact in determining the quality-of-life levels of the population from the health point of view. In fact, Trentino-Alto Adige is not only one of the regions with the highest per capita income in Italy but also one of the regions with the greatest culture of cooperation and social cohesion.

Network Analysis. A network analysis was carried out below. The analysis is carried out through the use of the Manhattan distance. The following elements are detected:

- Number of nodes equal to 20;
- Number of edges 24;

- Average degree 2.4;
- Density 0.1263.

Specifically, there are two significant links within the analysis carried out, namely:

- Piedmont-Veneto with a value of 2.9;
- Campania-Sicily with a value of 1.6.

These links indicate a significant correlation between the indicated regions. These relationships may indicate a convergence within the economic, social, institutional and behavioral dynamics that have an impact in determining healthy life expectancy at birth.

Machine Learning and Predictions. Below eight different machine learning algorithms are used to predict the future value of healthy life expectancy at birth in the Italian regions. The algorithms were trained with 70% of the available dataset while the remaining 30% of the dataset was used for prediction. The performance analysis was carried out considering the algorithms' ability to maximize the R-square and minimize the main statistical errors, namely "Mean Absolute Error", "Mean Squared Error", "Root Mean Squared Error". The following ordering of the algorithms is therefore derived, that is:

- *Random Forest Regression* with a payoff value of 4;
- *Tree Ensemble Regression* with a payoff value of 9;
- *Artificial Neural Network-ANN* with a payoff value of 14;
- *PNN-Probabilistic Neural Network* with a payoff value of 15;
- *Simple Regression Tree* with a payoff value of 18;
- *Linear Regression* with a payoff value of 26;
- *Gradient Boosted Tree* with a payoff value of 26;
- *Polynomial Regression* with a payoff value of 32.

Therefore, using the best performer algorithm or the Random Forest Regression it was possible to make the following predictions, namely:

- *Liguria* with an increase from an amount of 59.20 units up to a value of 50.43 units or equal to a variation of 1.23 units equal to 2.08%;
- *Veneto* with a decrease from an amount of 60.30 units up to a value of 59.57 units or equal to a variation of -0.73 units equal to a variation of -1.21%;
- *Emilia Romagna* with an increase from an amount of 59.60 units up to a value of 60.15 units or equal to a variation of 0.55 units equal to an amount of 0.93%;
- *Abruzzo* with an increase from an amount of 57.30 units up to a value of 57.72 units or equal to a variation of 0.42 units equal to an amount of 0.73%;
- *Calabria* with an increase from an amount of 49.70 units up to a value of 55.16 units or equal to a change of 5.46 units equal to a change of 10.99%;
- *Sicily* with an increase from an amount of 55.90 units up to a value of 57.09 units or equal to a change of 1.19 units equal to a value of 2.12%;

On average, the value of life expectancy in good health at birth is predicted to grow in the regions considered from an average value of 57.00 units up to a value of 58.35 units or equal to a value of 1.35 units equal at a value of 2.37%.

Conclusions. In summary, it is possible to verify that the value of life expectancy in good health at birth increased in the period between 2009 and 2019 in all Italian regions with the exception of

Basilicata. However, it should be borne in mind that the growth rate of life expectancy in good health at birth in the regions of Northern Italy was equal to a value of 4.7% while in central Italy it was equal to an amount of 3.8% and in the South equal to a value of 3.11% between 2009 and 2019. It follows that on average in 2019 a citizen of the North had a healthy life expectancy at birth of about 3 years higher than a citizen of the South. In particular, the most virtuous regions in terms of life expectancy in good health are the regions of the North-East with Trentino Alto Adige in the lead. Since these regions are also the richest in terms of per capita income and human and social capital it follows that inevitably there is a positive connection between the value of healthy life expectancy at birth and the capacity to produce added value and public and social goods. Furthermore, it must be considered that increasing even marginally the life expectancy in good health at birth means saving a lot in terms of regional public spending and therefore also having more sustainable regional health systems from a financial point of view. Economic policies to improve life expectancy at birth are therefore complex and require a series of composite interventions ranging from the growth of added value to the improvement of the production capacity of public and social goods through the appreciation of human capital. Finally, it must be considered that these data are pre-covid. Since Covid has significantly affected Northern Italy, especially Lombardy, it is likely to have led to a significant reduction in life expectancy in good health, especially in the northern regions.

References

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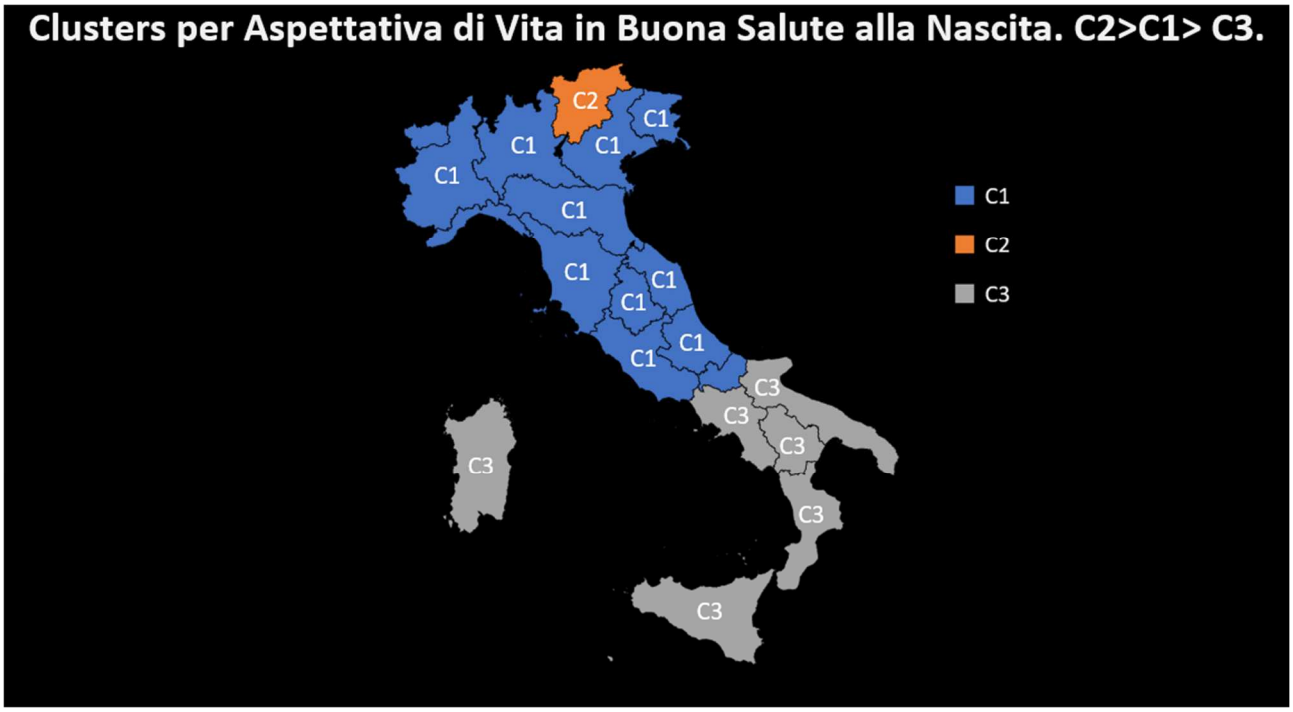
	2019	Prediction	Var Ass	Var Per
Liguria	59,20	60,43	1,23	2,08
Veneto	60,30	59,57	-0,73	-1,21
Emilia-Romagna	59,60	60,15	0,55	0,93
Abruzzo	57,30	57,72	0,42	0,73
Calabria	49,70	55,16	5,46	10,99
Sicilia	55,90	57,09	1,19	2,12
Media	57,00	58,35	1,35	2,37

Risultati ottenuti attraverso il machine learning per la predizione

	R^2	mean absolute error	mean squared error	root mean squared error
Artificial Neural Network	0,614843111	0,159631169	0,042955973	0,207258228
PNN	0,68808268	0,182638889	0,050335327	0,224355358
Simple Regression Tree	0,619959477	0,166400171	0,058627337	0,242130827
Gradient Boosted Tree	-0,305884416	0,274835868	0,117611112	0,342944765
Randoom Forest Regression	0,796869698	0,12194336	0,023224878	0,152397106
Tree Ensemble Regression	0,626578152	0,15361371	0,037026163	0,192421837
Linear Regression	0,067957743	0,265544033	0,119654179	0,345910652
Polynomial Regression	-4	0,698113208	0,592707963	0,76987529

Ranking degli algoritmi per capicità di massimizzare l'R-quadro e minimizzare gli errori statistici

Rank	Algorithm	R^2	mean absolute erro	mean squared erro	root mean squared error	Somma
1	*Random Forest Regression*	1	1	1	1	4
2	*Tree Ensemble Regression*	3	2	2	2	9
3	*Artificial Neural Network*	5	3	3	3	14
4	*PNN*	2	5	4	4	15
5	*Simple Regression Tree*	4	4	5	5	18
6	*Linear Regression*	6	6	7	7	26
7	*Gradient Boosted Tree*	7	7	6	6	26
8	*Polynomial Regression*	8	8	8	8	32


Clusters per Aspettativa di Vita in Buona Salute alla Nascita. C2>C1> C3.
C2
C1
C1
C1
C1
C1
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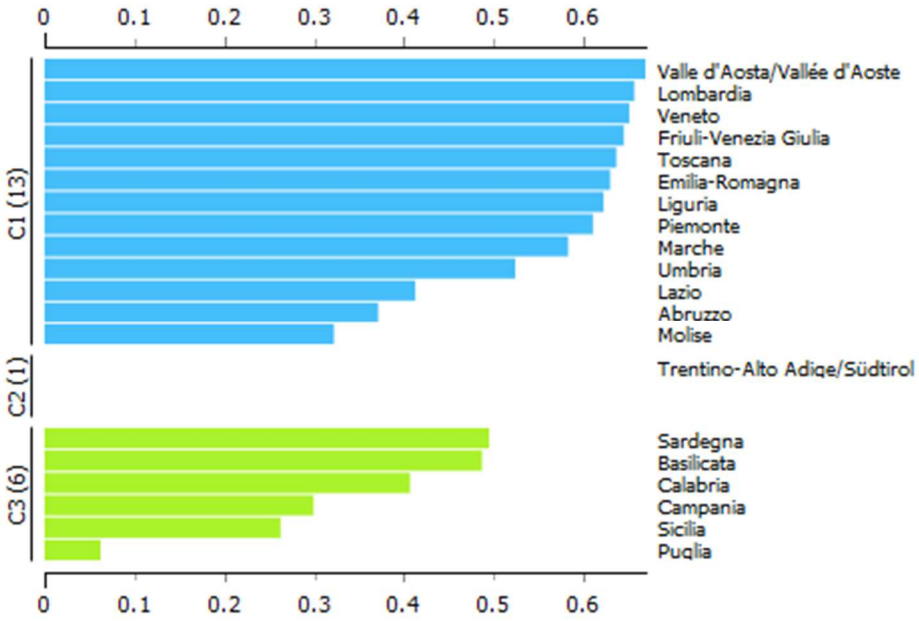
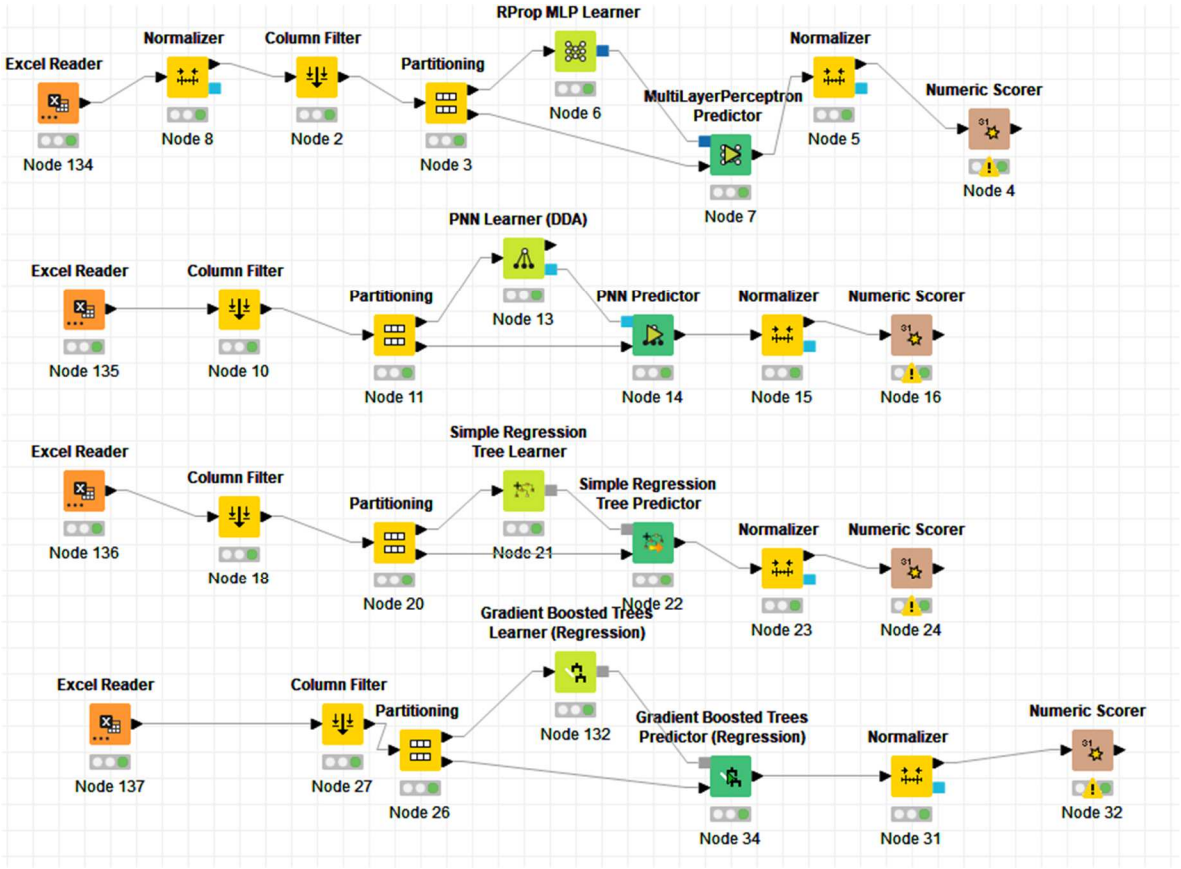
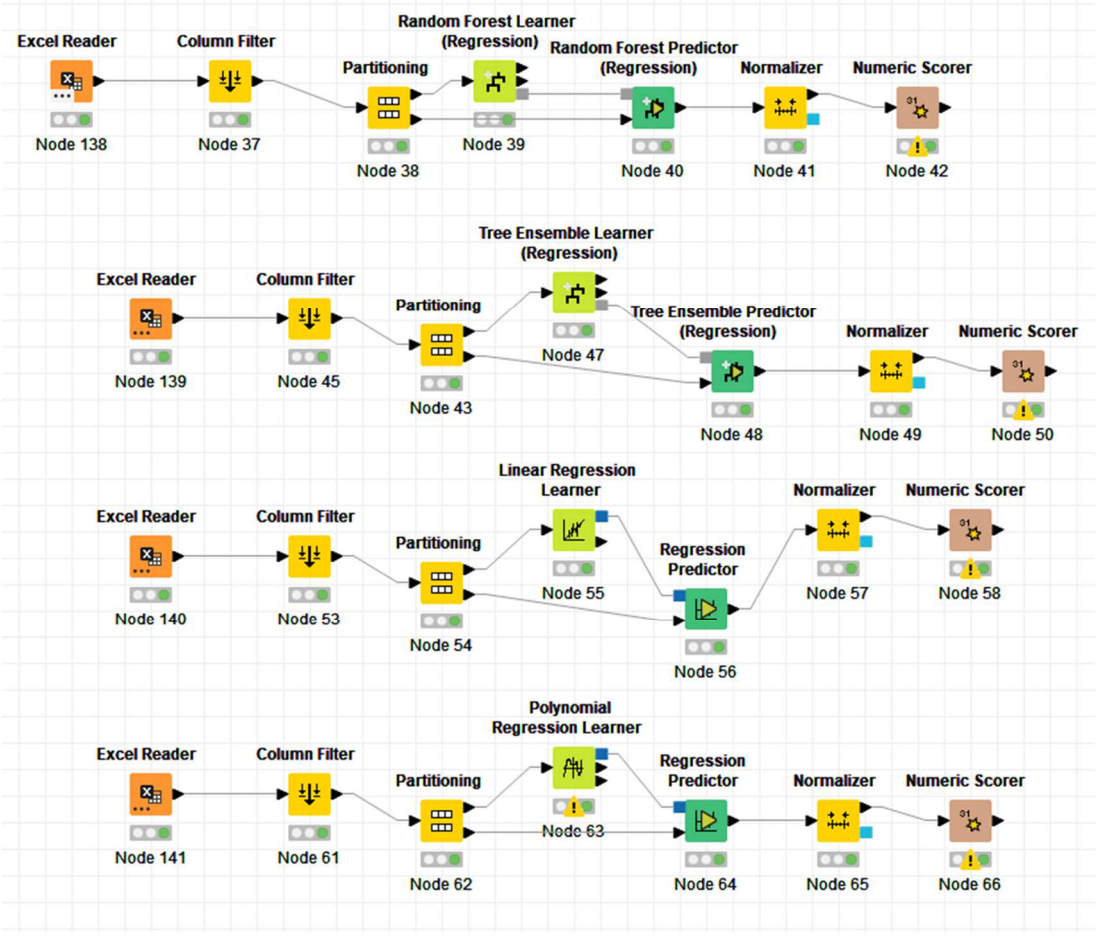
C3
C3
C3
C3
C1
C2
C3


0
0.1
0.2
0.3
0.4
0.5
0.6
C1 (13)
C2 (1)
C3 (6)
Valle d'Aosta/Vallée d'Aoste
Lombardia
Veneto
Friuli-Venezia Giulia
Toscana
Emilia-Romagna
Liguria
Piemonte
Marche
Umbria
Lazio
Abruzzo
Molise
Trentino-Alto Adige/Südtirol
Sardegna
Basilicata
Calabria
Campania
Sicilia
Puglia


RProp MLP Learner
Normalizer
Column Filter
Excel Reader
Partitioning
Node 6
MultiLayerPerceptron Predictor
Normalizer
Numeric Scorer
Node 134
Node 8
Node 2
Node 3
Node 5
Node 4
Node 7
PNN Learner (DDA)
Excel Reader
Column Filter
Partitioning
PNN Predictor
Normalizer
Numeric Scorer
Node 13
Node 135
Node 10
Node 11
Node 14
Node 15
Node 16
Simple Regression Tree Learner
Excel Reader
Column Filter
Partitioning
Simple Regression Tree Predictor
Normalizer
Numeric Scorer
Node 136
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 132
Node 137
Node 27
Node 26
Node 34
Node 31
Node 32


Random Forest Learner (Regression)
Excel Reader
Column Filter
Partitioning
Random Forest Predictor (Regression)
Normalizer
Numeric Scorer
Node 138
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 47
Node 139
Node 45
Node 43
Node 48
Node 49
Node 50
Linear Regression Learner
Excel Reader
Column Filter
Partitioning
Regression Predictor
Normalizer
Numeric Scorer
Node 55
Node 140
Node 53
Node 54
Node 56
Node 57
Node 58
Polynomial Regression Learner
Excel Reader
Column Filter
Partitioning
Regression Predictor
Normalizer
Numeric Scorer
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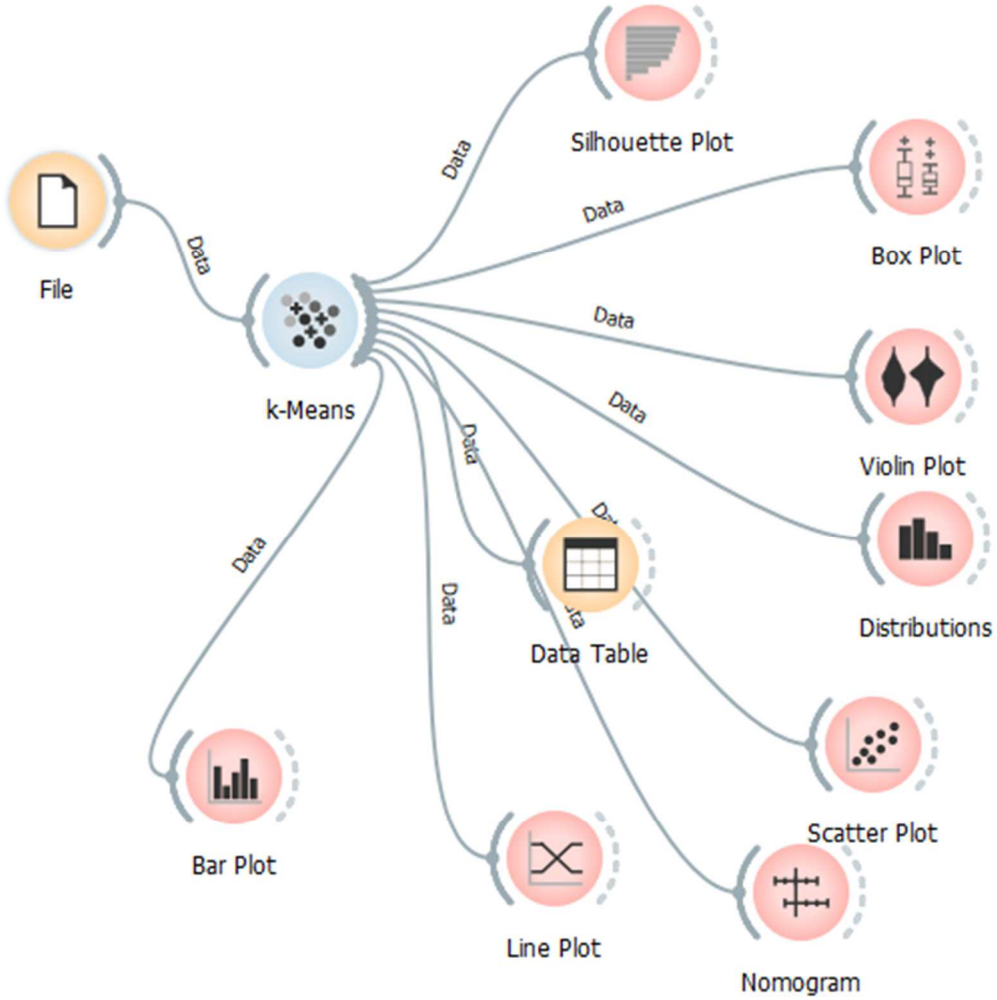
Node 141
Node 61
Node 62
Node 64
Node 65
Node 66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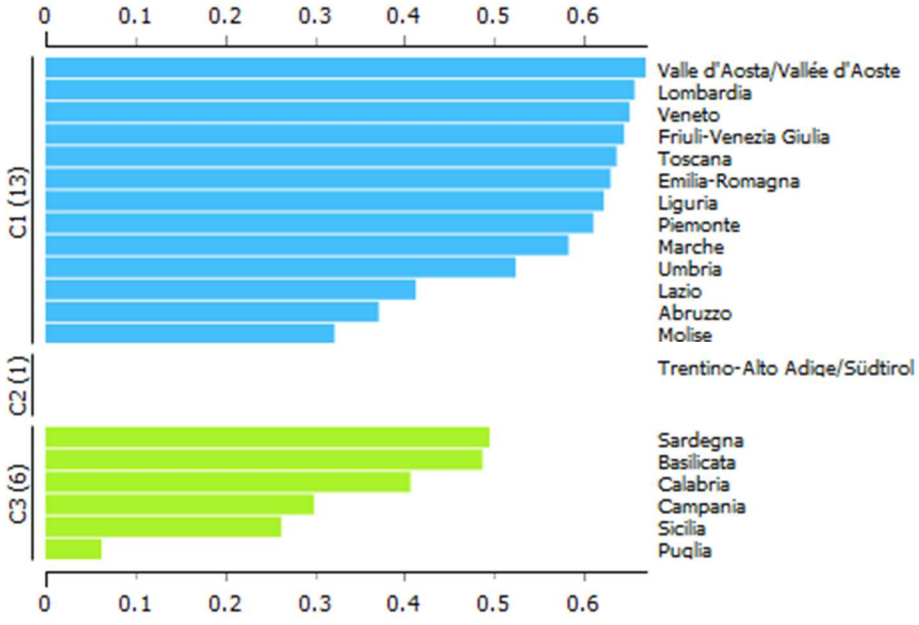
Box Plot
File
k-Means
Violin Plot
Distributions
Data Table
Bar Plot
Scatter Plot
Line Plot
Nomogram
Data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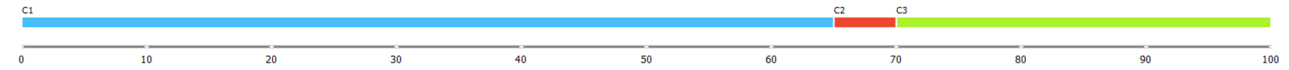
0.6
C1 (13)
C2 (1)
C3 (6)
Valle d'Aosta/Vallée d'Aoste
Lombardia
Veneto
Friuli-Venezia Giulia
Toscana
Emilia-Romagna
Liguria
Piemonte
Marche
Umbria
Lazio
Abruzzo
Molise
Trentino-Alto Adige/Südtirol
Sardegna
Basilicata
Calabria
Campania
Sicilia
Puglia


C1
C2
C3
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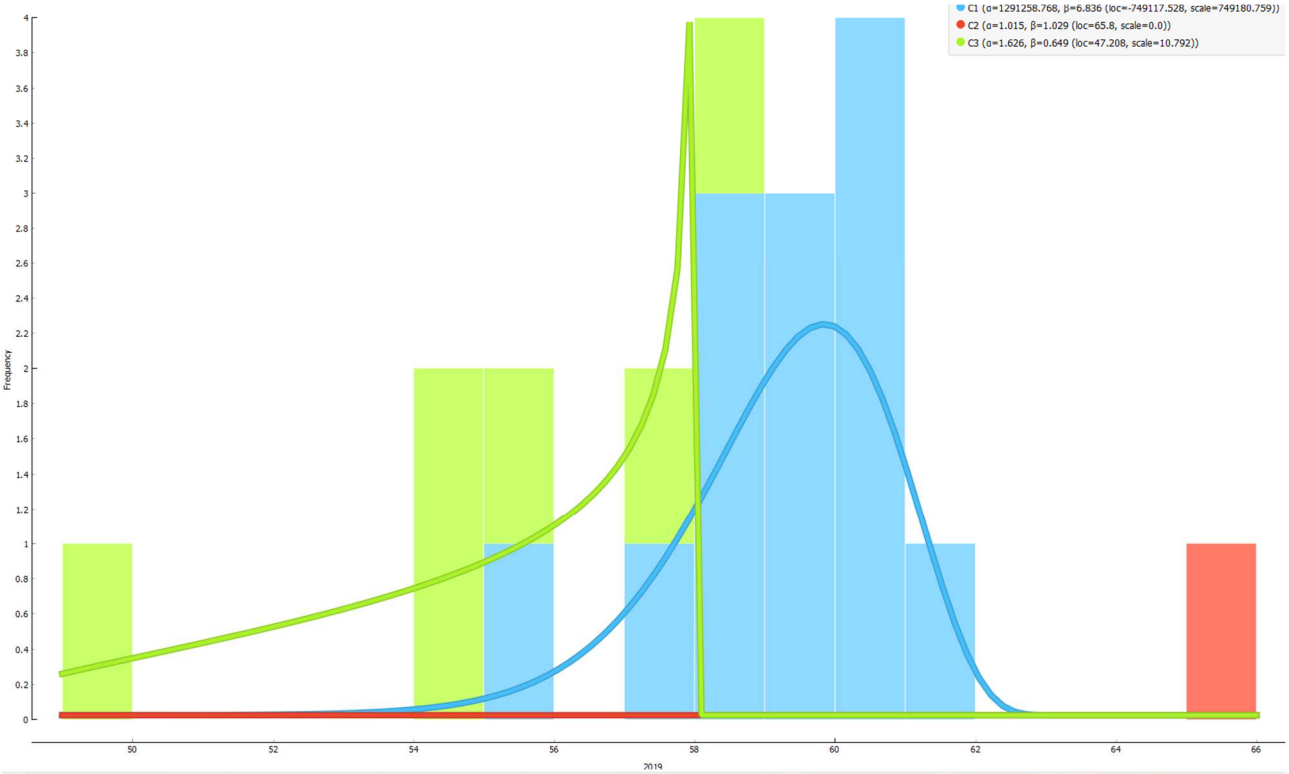
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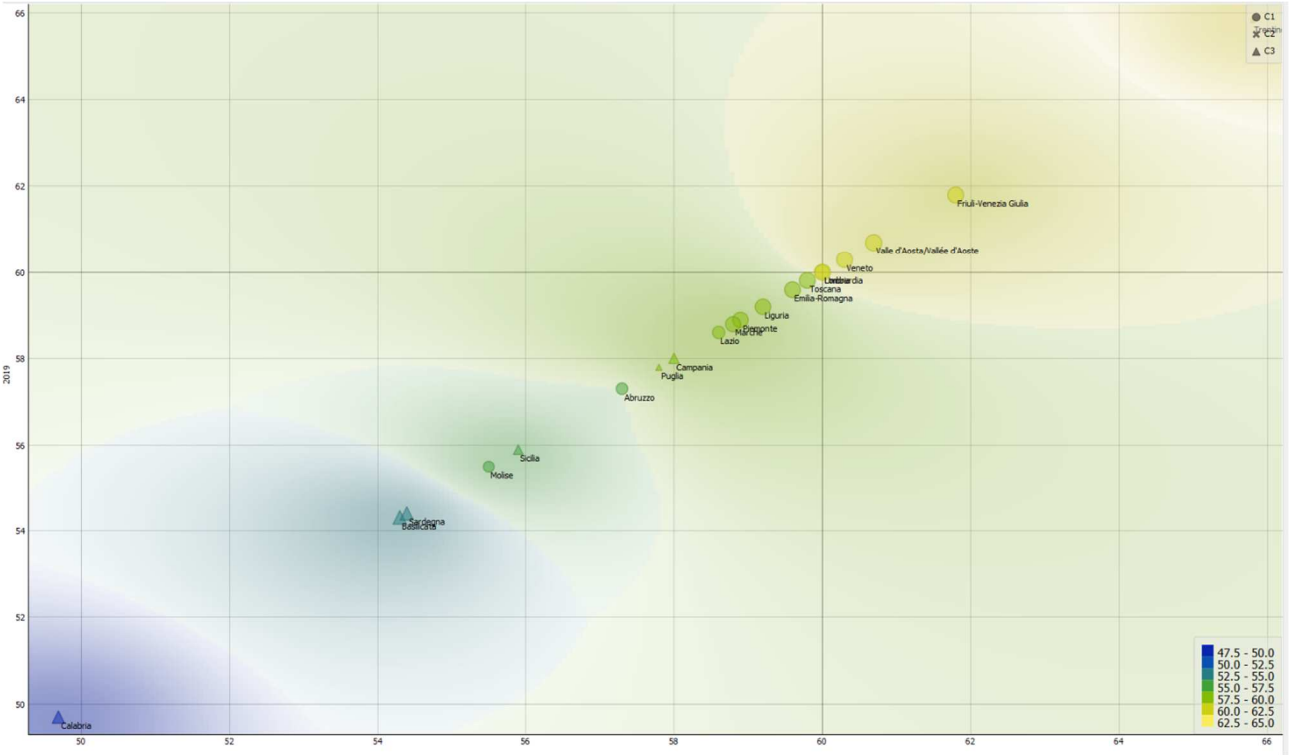
C2 (α=1.015, β=1.029 (loc=65.8, scale=0.0))
C3 (α=1.626, β=0.649 (loc=47.208, scale=10.792))
Frequency
2019


C1
C2
C3
2019
Friuli-Venezia Giulia
Valle d'Aosta/Vallée d'Aoste
Veneto
Toscana
Emilia-Romagna
Liguria
Lazio
Campania
Puglia
Abruzzo
Sicilia
Molise
Calabria
47.5 - 50.0
50.0 - 52.5
52.5 - 55.0
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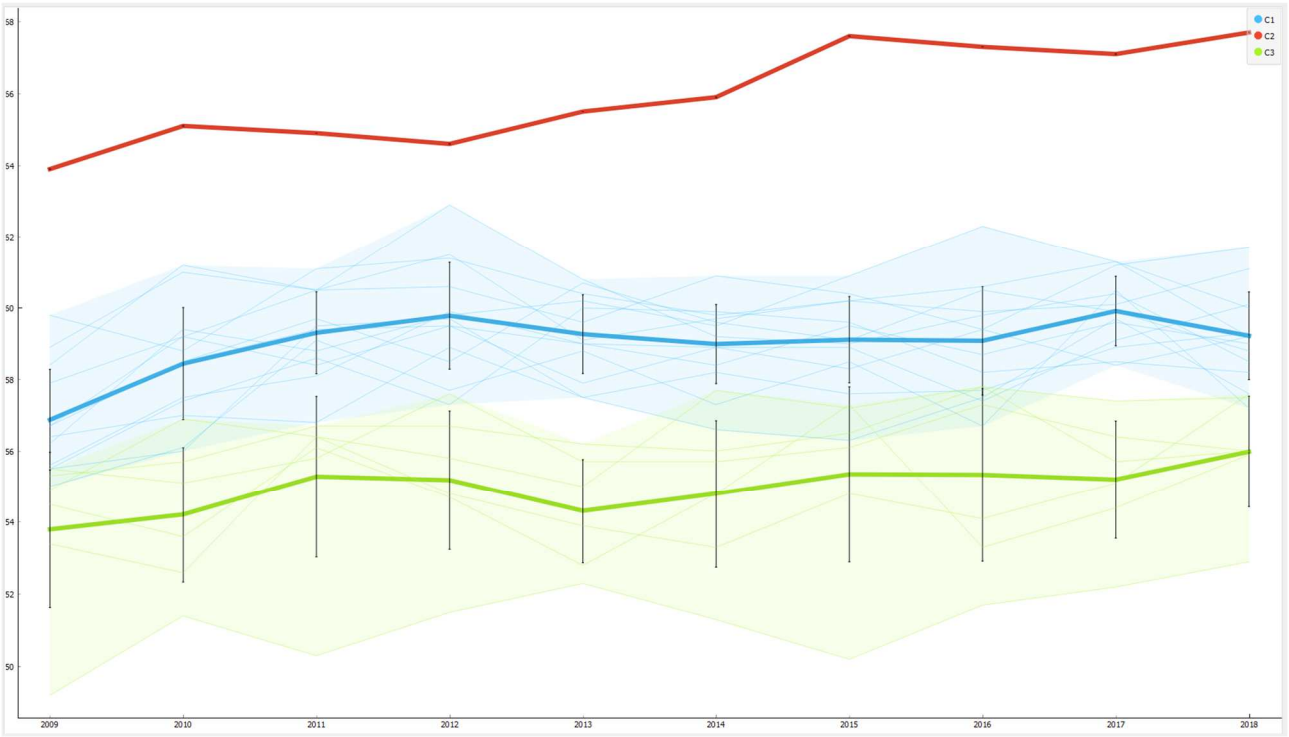
62.5 - 65.0


C1
C2
C3
58
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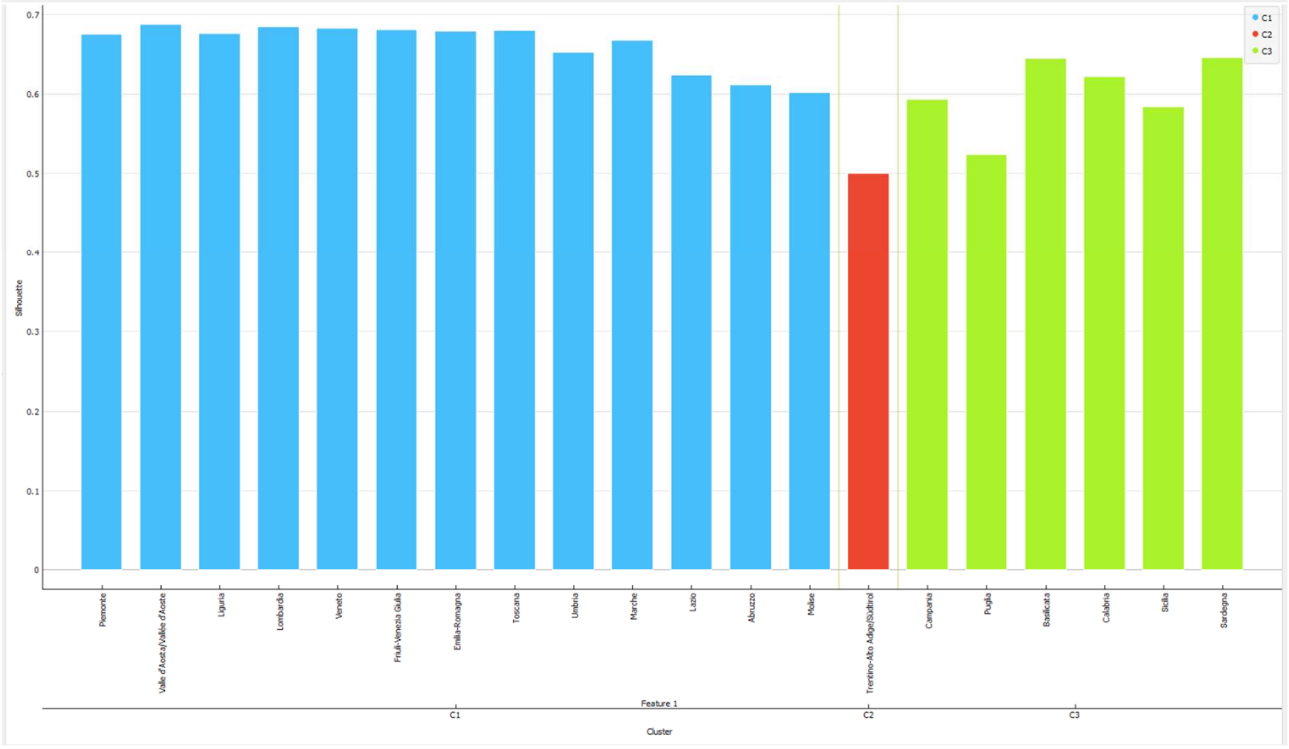
C1
C2
C3
Silhouette
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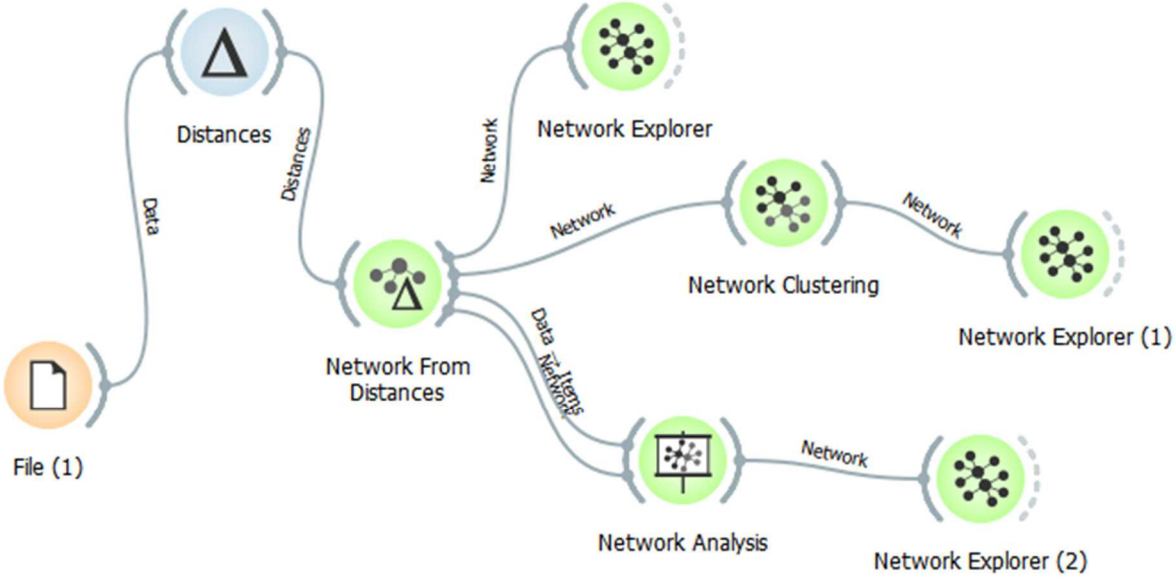
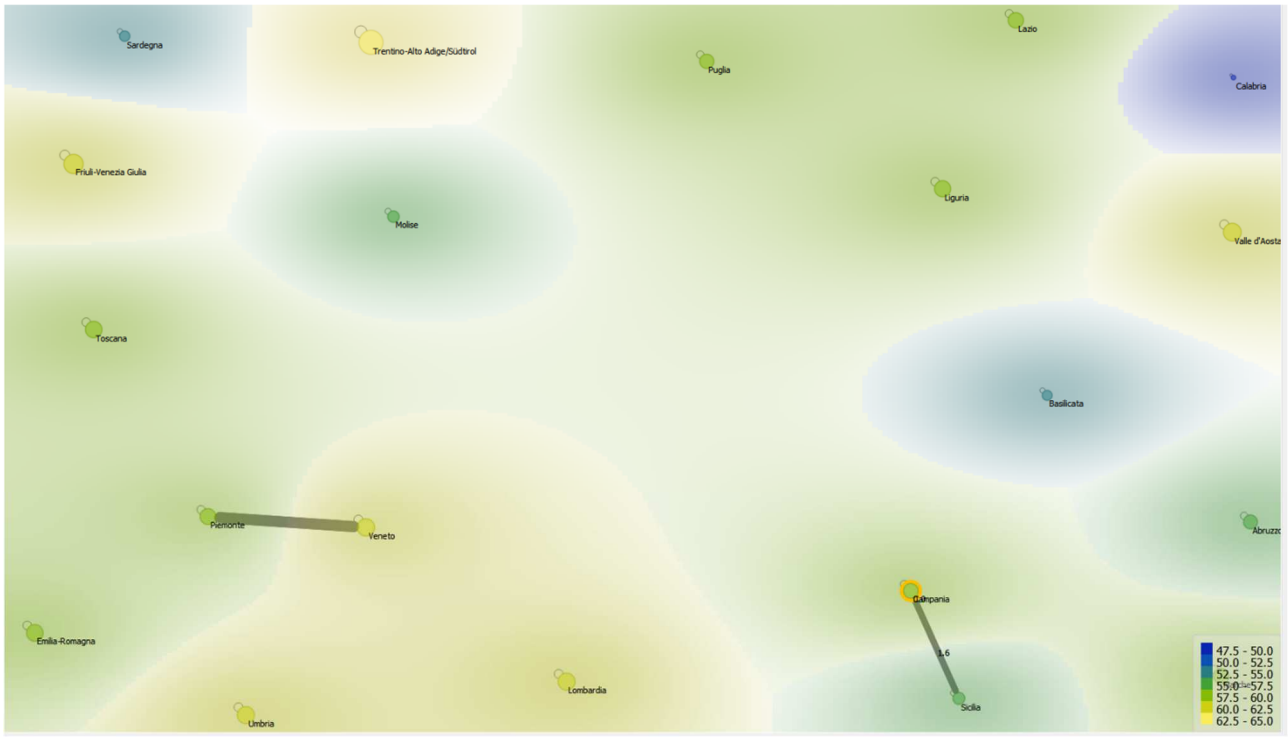
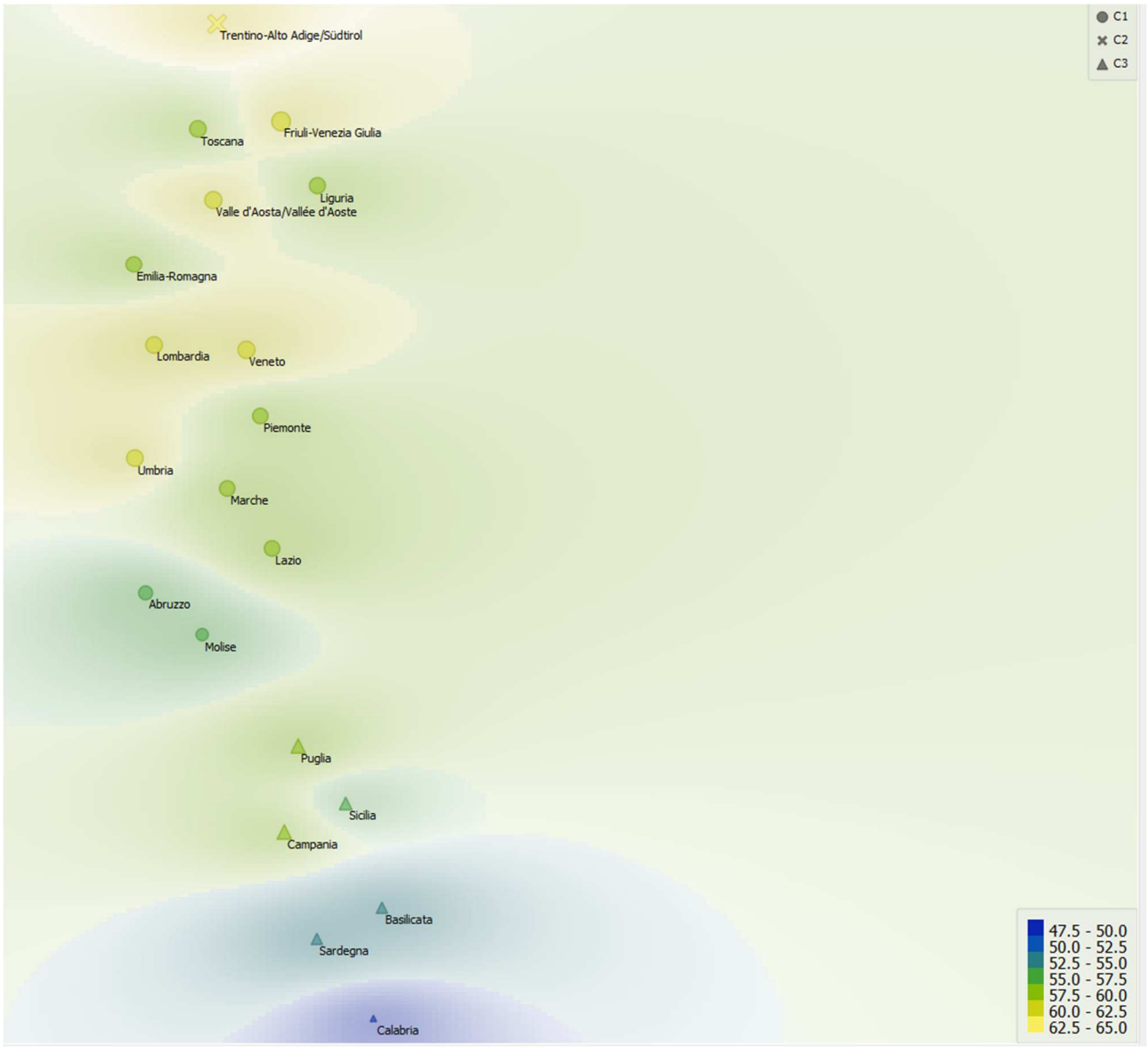
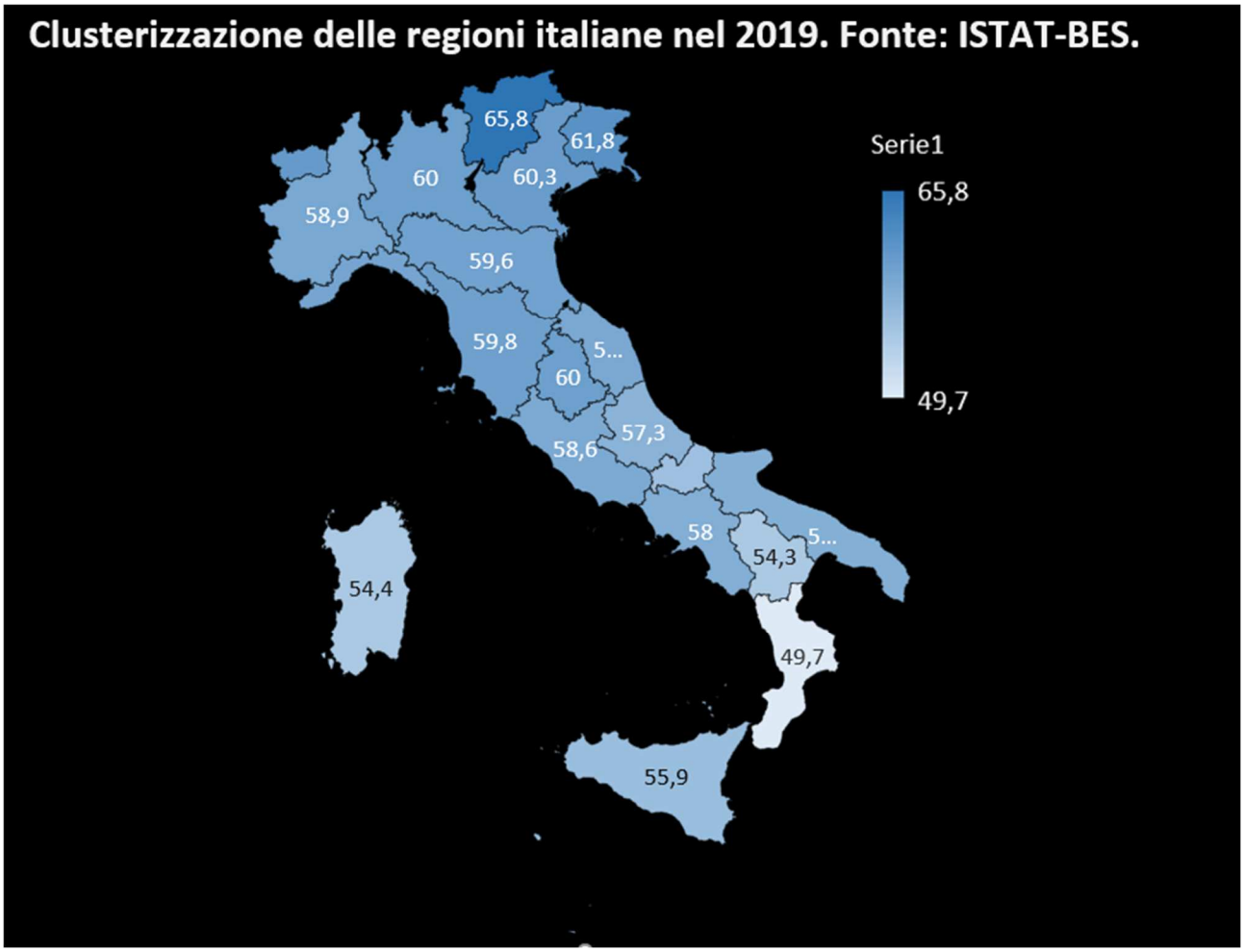
0.1
0
Piemonte
Valle d'Aosta/Vallée d'Aoste
Liguria
Lombardia
Veneto
Friuli-Venezia Giulia
Emilia-Romagna
Toscana
Umbria
Marche
Lazio
Abruzzo
Molise
Trentino-Alto Adige/Südtirol
Campania
Puglia
Basilicata
Calabria
Sicilia
Sardegna
Feature 1
C1
C2
C3
Cluster

	2019	Feature 1	Cluster	Silhouette
14	55.5	Molise	C1	0.601675
13	57.3	Abruzzo	C1	0.611635
12	58.6	Lazio	C1	0.624088
11	58.8	Marche	C1	0.667623
10	60.0	Umbria	C1	0.65206
9	59.8	Toscana	C1	0.679833
8	59.6	Emilia-Romagna	C1	0.679151
7	61.8	Friuli-Venezia G...	C1	0.681044
6	60.3	Veneto	C1	0.682875
4	60.0	Lombardia	C1	0.684642
3	59.2	Liguria	C1	0.676446
2	60.7	Valle d'Aosta/V...	C1	0.686952
1	58.9	Piemonte	C1	0.675069
5	65.8	Trentino-Alto A...	C2	0.5
20	54.4	Sardegna	C3	0.645233
19	55.9	Sicilia	C3	0.583555
18	49.7	Calabria	C3	0.622137
17	54.3	Basilicata	C3	0.644691
16	57.8	Puglia	C3	0.523921
15	58.0	Campania	C3	0.593687




Sardegna
Trentino-Alto Adige/Südtirol
Lazio
Puglia
Calabria
Friuli-Venezia Giulia
Liguria
Molise
Valle d'Aosta
Toscana
Basilicata
Piemonte
Veneto
Abruzzo
Campania
Emilia-Romagna
Lombardia
Umbria
Sicilia
47.5 - 50.0
50.0 - 52.5
52.5 - 55.0
55.0 - 57.5
57.5 - 60.0
60.0 - 62.5
62.5 - 65.0

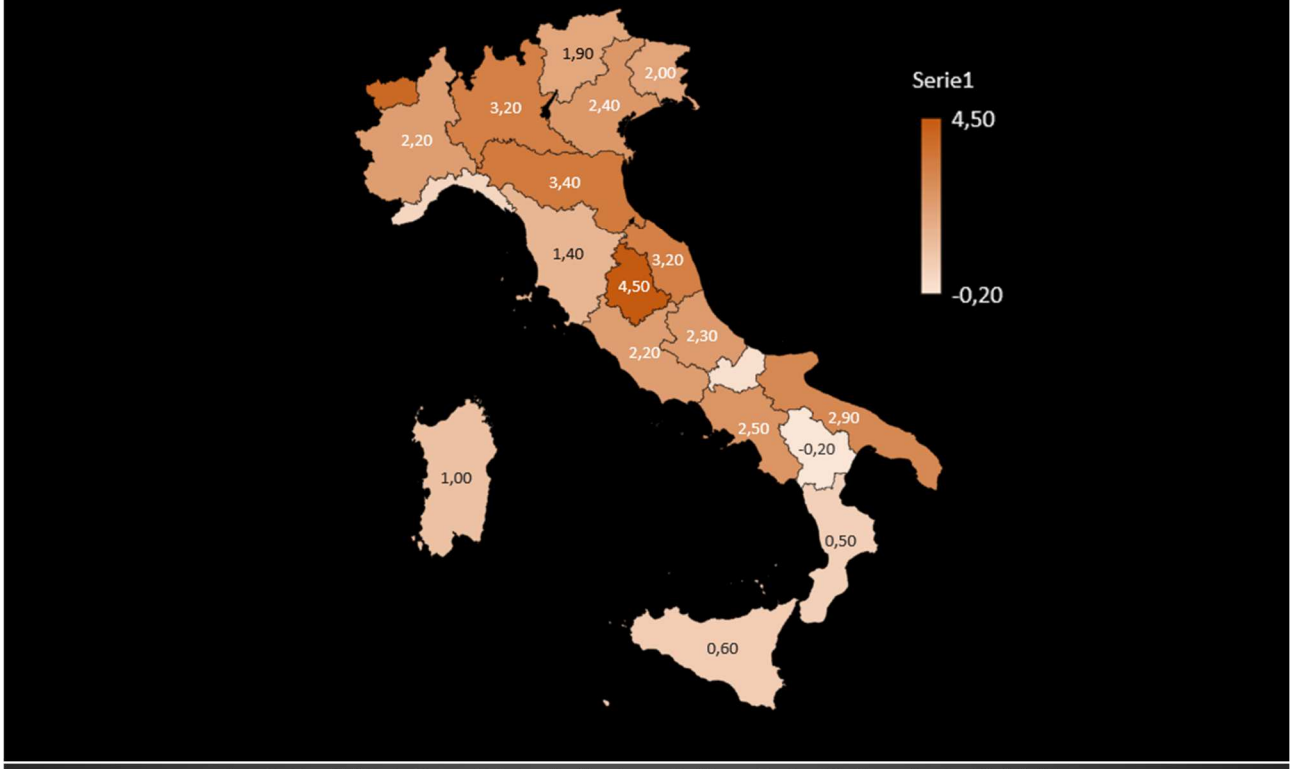

C1
C2
C3
Trentino-Alto Adige/Südtirol
Toscana
Friuli-Venezia Giulia
Liguria
Valle d'Aosta/Vallée d'Aoste
Emilia-Romagna
Lombardia
Veneto
Piemonte
Umbria
Marche
Lazio
Abruzzo
Molise
Puglia
Sicilia
Campania
Basilicata
Sardegna
Calabria
47.5 - 50.0
50.0 - 52.5
52.5 - 55.0
55.0 - 57.5
57.5 - 60.0
60.0 - 62.5
62.5 - 65.0


Clusterizzazione delle regioni italiane nel 2019. Fonte: ISTAT-BES.
65,8
61,8
60
60,3
58,9
59,6
59,8
5...
60
57,3
58,6
58
5...
54,3
54,4
49,7
55,9
Serie1
65,8
49,7

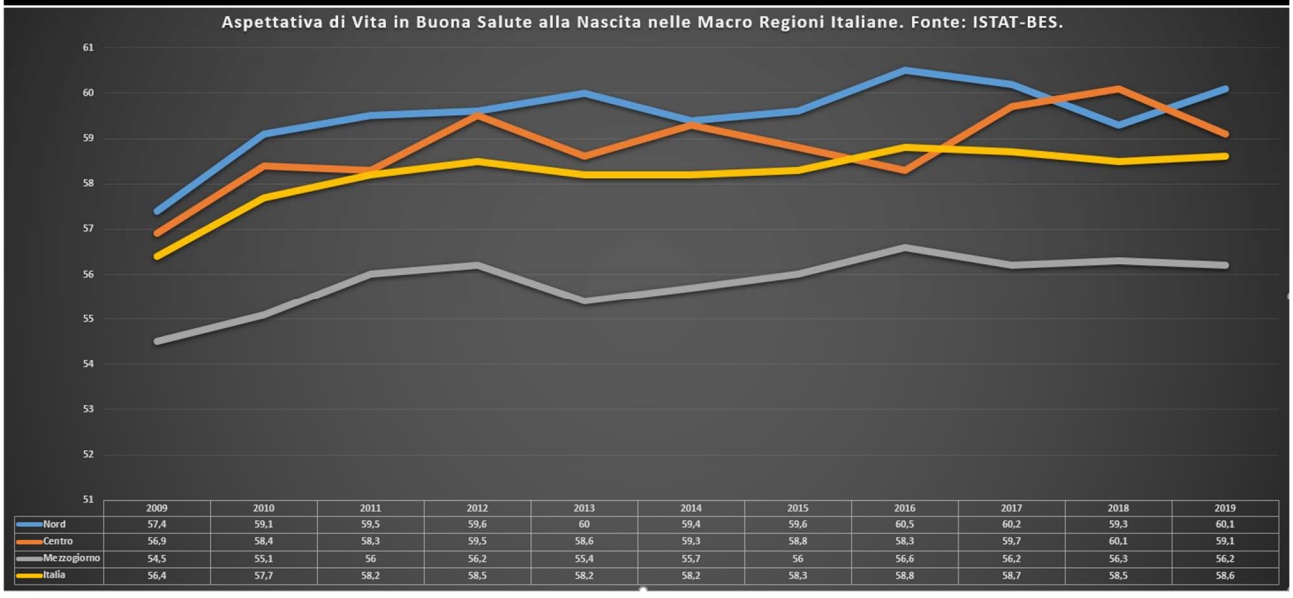
Speranza di vita in buona salute alla Nascita		
Rank	**Regioni**	**2019**
1	*Trentino-Alto Adige/Südtirol*	65,8
2	*Friuli-Venezia Giulia*	61,8
3	*Valle d'Aosta/Vallée d'Aoste*	60,7
4	*Veneto*	60,3
5	*Lombardia*	60
6	*Umbria*	60
7	*Toscana*	59,8
8	*Emilia-Romagna*	59,6
9	*Liguria*	59,2
10	*Piemonte*	58,9
11	*Marche*	58,8
12	*Lazio*	58,6
13	*Campania*	58
14	*Puglia*	57,8
15	*Abruzzo*	57,3
16	*Sicilia*	55,9
17	*Molise*	55,5
18	*Sardegna*	54,4
19	*Basilicata*	54,3
20	*Calabria*	49,7
	Media	58,32

Var Percentuale Aspettative di Vita in Buona Salute			
N	**Regione**	**Var Ass**	**Var Per**
1	*Umbria*	4,50	8,11
2	*Valle d'Aosta*	4,00	7,05
3	*Emilia-Romagna*	3,40	6,05
4	*Marche*	3,20	5,76
5	*Lombardia*	3,20	5,63
6	*Puglia*	2,90	5,28
7	*Campania*	2,50	4,50
8	*Abruzzo*	2,30	4,18
9	*Veneto*	2,40	4,15
10	*Lazio*	2,20	3,90
11	*Piemonte*	2,20	3,88
12	*Friuli-Venezia Giulia*	2,00	3,34
13	*Trentino-Alto Adige*	1,90	2,97
14	*Toscana*	1,40	2,40
15	*Sardegna*	1,00	1,87
16	*Sicilia*	0,60	1,08
17	*Calabria*	0,50	1,02
18	*Liguria*	0,30	0,51
19	*Molise*	0,00	0,00
20	*Basilicata*	-0,20	-0,37
	Media	2,02	3,57

Variazione assoluta aspettativa di vita in buona salute alla nascita tra il 2009 ed il 2019. Fonte: ISTAT-BES.



Aspettativa di Vita in Buona Salute alla Nascita nelle Macro Regioni Italiane. Fonte: ISTAT-BES.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Nord	57,4	59,1	59,5	59,6	60	59,4	59,6	60,5	60,2	59,3	60,1
Centro	56,9	58,4	58,3	59,5	58,6	59,3	58,8	58,3	59,7	60,1	59,1
Mezzogiorno	54,5	55,1	56	56,2	55,4	55,7	56	56,6	56,2	56,3	56,2
Italia	56,4	57,7	58,2	58,5	58,2	58,2	58,3	58,8	58,7	58,5	58,6

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Piemonte	57	58,5	59,4	59,5	57,9	58,9	58,3	59,4	58,4	59,2	58,9
Valle d'Aosta/Vallée d'Aoste	57	59,2	60,5	61,5	59,1	59,7	60,2	59,9	60,1	61,1	60,7
Liguria	59	61	60,5	62,9	60,8	59,2	59	59,8	60,4	58,5	59,2
Lombardia	57	58,5	59,7	58,5	60,7	59,6	59,1	60,5	59,9	58,8	60
Trentino-Alto Adige/Südtirol	64	65,1	64,9	64,6	65,5	65,9	67,6	67,3	67,1	67,7	65,8
Veneto	58	59,2	58,4	59,5	59	58,4	59,5	58,7	59,6	59	60,3
Friuli-Venezia Giulia	60	58,8	61,1	61,4	60,4	59,8	60,2	60,6	61,3	60	61,8
Emilia-Romagna	56	59,4	58,8	59,8	60,2	59,5	60,9	62,3	61,3	59,2	59,6
Toscana	58	61,2	60,5	60,6	59,6	60,9	60,4	59,4	61,2	61,7	59,8
Umbria	56	57,4	58,6	57,3	60	59,9	59,6	58,2	58,5	58,2	60
Marche	56	57,5	58,1	59,9	59	58,9	58,9	57,4	59,1	60,1	58,8
Lazio	56	57	56,8	58,9	57,5	58,2	57,6	57,7	58,9	59,3	58,6
Abruzzo	55	56,1	59,1	57,7	58,8	57,3	58,5	56,7	60,5	57,2	57,3
Molise	56	56	59,5	59,7	57,5	56,6	56,3	57,5	59,7	57,6	55,5
Campania	56	55,1	55,8	57,6	55,7	55,7	56,1	57,3	56,4	56	58
Puglia	55	56,9	56,4	55,8	55	57,7	57,2	57,8	57,4	57,5	57,8
Basilicata	55	53,6	56,1	54,7	52,8	54,8	57,3	53,3	54,4	55,9	54,3
Calabria	49	51,4	50,3	51,5	52,3	51,3	50,2	51,7	52,2	52,9	49,7
Sicilia	55	55,7	56,7	56,7	56,2	56	56,5	57,8	55,7	56	55,9
Sardegna	53	52,6	56,4	54,8	53,9	53,3	54,8	54,1	55,1	57,6	54,4