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**Project reports for the**

**data visualization course**

# THE HAPPINESS WORLD REPORT


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# Index

**How happy are we?**

Happiness, understood as a measure of individual well-being, is a very dear and sensitive theme in the human mentality; in fact, although with so many facets and cuts of thought, since the ancient world various philosophers, writers and artists have contributed their thoughts on this subject. Starting from the State Constitutions, fruit of the era of the Revolutions - in particular within the Declaration of Independence of the United States of America of 1776 -, the pursuit of happiness was introduced as an inalienable right of the human being.

Precisely because of the proven importance of happiness, many public and private institutions and organizations have tried to measure its impact over time and in different countries; in particular, the dataset we decided to work on refers to data collected by Gallup World Pull[1], that since 2012 draws up the annual World Happiness Report.

Gallup has conducted its research keeping in mind those variables that have been most influential and significant in the pursuit of happiness, while knowing that it is also linked to other aspects, such as: genetic characteristics, socio-demographic and cultural factors, religious faith, political orientation, economic factors (such as income level and employment status).

The research is based on the criterion of the Cantril ladder: it is a technique invented by the American psychologist Albert Hudley Cantril in the early sixties, which consists in assigning a score between 1 and 10 (or alternatively from 0 to 10) a series of objects that are believed to be related to a property of the object of interest. The result is a series of scores assigned to the questions of a survey, concerning the evaluation of life; In particular, the detector asks respondents to think about a scale where at position 10 is placed the best version of life they can imagine, at 0 the worst one and finally to evaluate their current lives on that scale.

The scores come from representative samples at the national level: about 1,000 residents per country are interviewed, using as target population the entire non-institutionalized civilian population, aged 15 and over. The company asks each respondent to answer the survey questions in their own language to produce statistically comparable results and uses telephone surveys in countries where telephone coverage accounts for at least 80% of the population. Where phone penetration is less than 80%, face-to-face interviews are conducted.

The happiness score is given by six factors - economic output, social support, life expectancy, freedom, absence of corruption and generosity - which help to make life ratings more or less high in every country than they are in Dystopia, a hypothetical country that has values equal to the lowest national averages in the world for each of the six factors. They have no impact on the total score reported for each country, but explain why some countries have a higher ranking than others.

[1] It is an American analysis and consulting company founded in Washington by George Gallup in 1935. The company became famous in its first year of foundation for correctly predicting the outcomes of the exitpoll between Roosevelt and Landon, thanks to a sample approach).

## 1. The reference data set

### 1.1. Searching and Manipulating the Dataset

Starting from a search on the Kaggle platform, the dataset "World Happiness Report (preprocessed)" has been identified.It contains the observations from 2015 to 2020 and is an already partially clean version of another original dataset, so as to have the same observations for the same countries. This dataset was chosen because it presents a global and temporal observation of a phenomenon; thanks to this it was possible to carry out interesting analyses of geographical and temporal comparison.

The operations of manipulation and adjustment of the dataset were carried out on Python with the help of the Pandas library, very efficient to work on data in tabular format and on files in csv format. In particular, we wanted to combine the six separate data sets per year.This was possible because the variables considered in each dataset were the same; it was only necessary to give the same name to the corresponding columns of each dataset and add to each of them the column of the reference year. The goal of this manipulation was to have an integrated dataset so that it could be manipulated more easily on Tableau and since the join between the 6 different tables, even if possible in the program was not managed efficiently, giving problems. In particular, the following steps were taken:

1. Opening datasets on Python using the Pandas library with the command import pandas as pd and *pd.read_csv('...')*.
2. Creating the year column for each dataset: for example, df2015['Year']=2015
3. For each dataset the columns have been renamed identically, in order to have a perfect concatenation:
   df2015.rinominare(columns={'country':'Country', 'happiness_score':'Happiness Score', 'gdp_per_capita':'GDP', 'social_support':'Social Support', 'Health':'Health', 'Freedom':'Freedom', 'generosity':'Generosity', 'government_trust':'Government Trust', 'continent':'Continent'}'inplace=True')
4. The data sets for each year have been linked with the command df=pd.concat([df2015,df2016,df2017,df2018,df2019,df2020])
5. The decimal format has changed: data_15_20['Happiness Score']=data_15_20['Happiness Score'].str.replace('.' , ',', regex=False). astype(str)
6. You exported the file in csv format to make the views on Tableau.
7. On Tableau Desktop, the type of the string-to-date "year" variable has been changed to analyze the time series of interest.

| | Country | Happiness score | GDP per capita | Social support | Health | Freedom | Generosity | Government Trust | Dystopia residual | Continent | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Norway | 7,537000179290769 | 1,61646318435669 | 1,53352355957031 | 0,796666502952576 | 0,635422587394714 | 0,36201223731041 | 0,315963834524155 | 2,27702665328979 | Europe | 2015 |
| 1 | Denmark | 7,52199983596802 | 1,48238301277161 | 1,55112159252167 | 0,7925655245780941 | 0,626006722450256 | 0,3552804887294771 | 0,4007700681686399 | 2,31370735168457 | Europe | 2015 |
| 2 | Iceland | 7,50400018692017 | 1,480633020401 | 1,6105740070343 | 0,8335521221160892 | 0,6271626353263849 | 0,475540220737457 | 0,153526559472084 | 2,32271528244019 | Europe | 2015 |
| 3 | Switzerland | 7,49399995803833 | 1,5649795532226598 | 1,51691174507141 | 0,858131289482117 | 0,620070576667786 | 0,2905492782592769 | 0,3670072853565221 | 2,2767162322998 | Europe | 2015 |
| 4 | Finland | 7,468999862670901 | 1,44357192516327 | 1,5402467250824 | 0,80915766954422 | 0,6179508566856379 | 0,24548277258873 | 0,38261154294014 | 2,4301815032959 | Europe | 2015 |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 823 | Botswana | 3,478899956 | 0,997548997 | 1,08569479 | 0,494101733 | 0,50908941 | 0,033407487 | 0,101786368 | 0,257240534 | Africa | 2020 |
| 824 | Tanzania | 3,476200104 | 0,457163125 | 0,872674644 | 0,442677855 | 0,5093430879999999 | 0,27154091 | 0,203880861 | 0,718963385 | Africa | 2020 |
| 825 | Rwanda | 3,312299967 | 0,343242675 | 0,522876322 | 0,572383285 | 0,604087889 | 0,235704988 | 0,485542476 | 0,548444986 | Africa | 2020 |
| 826 | Zimbabwe | 3,2992000580000003 | 0,425564021 | 1,047835231 | 0,375037611 | 0,37740472 | 0,151349187 | 0,080928579 | 0,841031075 | Africa | 2020 |
| 827 | Afghanistan | 2,566900015 | 0,30070585 | 0,356433839 | 0,266051531 | 0,0 | 0,135234714 | 0,001225785 | 1,507235646 | Asia | 2020 |

Figure 1: Python linked dataset display

### 1.2. Description of the dataset

The integrated dataset contains the results of Gallup's 6-year applications.

The variables present are:

- **Continent**: nominal variable (qualitative) whose modalities are the Continents (Africa, Asia, Oceania, Europe, North America, South America).
- **Country**: nominal variable (qualitative) whose modalities are the 137 Countries examined.
- **Dystopia** residual: least happiness score possible from 0 to 10
- **Freedom**: variable interval (quantitative continuous), represents the portion, for each country, with which this variable affects happiness, that is the residual of regressing national average of response to the GWP question: "Are you satisfied or dissatisfied with your freedom to choose what you do with your life?".
- **GDP per capita**: gross domestic product per capita, is a variable interval that reflects the weight of GDP in the determination of the score of happiness in the country, in particular it is the residual regression of the national average of answer to the question GWP on the topic 'GDP'.
- **Generosity**: variable interval, represents the residual of regressing national average of response to the GWP question "Have you donated money to a charity in the past month?".
- **Government Trust**: variable interval, is the first main component of 5 measures: confidence in the national government, confidence in the judicial system and courts, confidence in the honesty of elections, confidence in the local police force, and perceived corruption in business. This principal component is then used to create a binary measure (0-1) of high institutional trust using the 75th percentile in the global distribution as the cutoff point; this way a country whose population tends to have a low level of institutional trust in the global distribution will have a low average institutional trust at the national level.
- **Happiness Score**: ordinal variable (quantitative) happiness score ranging from 0 to 10 (Cantril life ladder), it is the national average response to the question of life evaluations: "Please imagine a

ladder, with steps numbered from 0 at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time?".

- **Health**: variable interval, consists in the contribution of this variable to determine happiness in countries, is therefore the result of residual of regressing national average of response to GWP question.
- **Social support**: variable interval, is the national average of the binary responses (either 0 or 1) to the GWP question "If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them, or not?".
- **Year**: variable ordinal, (discrete quantitative) containing years from 2015 to 2020.

The year variable has been inserted following the above mentioned manipulations.
In addition, it should be noted that the variable Happiness score, for each country, is given by the sum of the others, ie: dystopia residual, freedom, GDP per capita, generosity, government trust, happiness score, health, social support.

## 2. Objectives of the analysis

The primary purpose of this project is to analyze the Happiness score and its components in each country and for each year in the dataset. In particular, we want to observe which are the countries that we can define as the most happy and which have the worst score, both in terms of annual and in terms of growth of the happiness score compared to 2015, that is the starting point of our analysis.
Also, following a funnel structure suggested by the Mantra[2] of the Data visualization, we want to evaluate which are those variables that are considered the most influential (as they have a 'greater weight' in the composition of the happiness score, what their trend over time and for which countries are the most varied.
Finally, once we finished the analysis described above, we found it interesting to look specifically at the trend of the Happiness score and its variables for that country that was on average more unhappy, and we tried to explain, through some considerations, what could be the causes of this trend.

[2] Ben Schneiderman, 'Overview First, Zoom and Filter, Details on Demand'

### 3. Temporal evolution of the phenomenon

#### 3.1 Focus on the Continents

The variables under consideration are mostly quantitative variables so it is appropriate to use the tools of descriptive statistics to be able to visualize their distribution.

In particular, in figure 2 we observe the box plot that shows the average level of the Happiness score in every Continent in 2020 calculated by the arithmetic mean[3] of all countries in each geographical area.

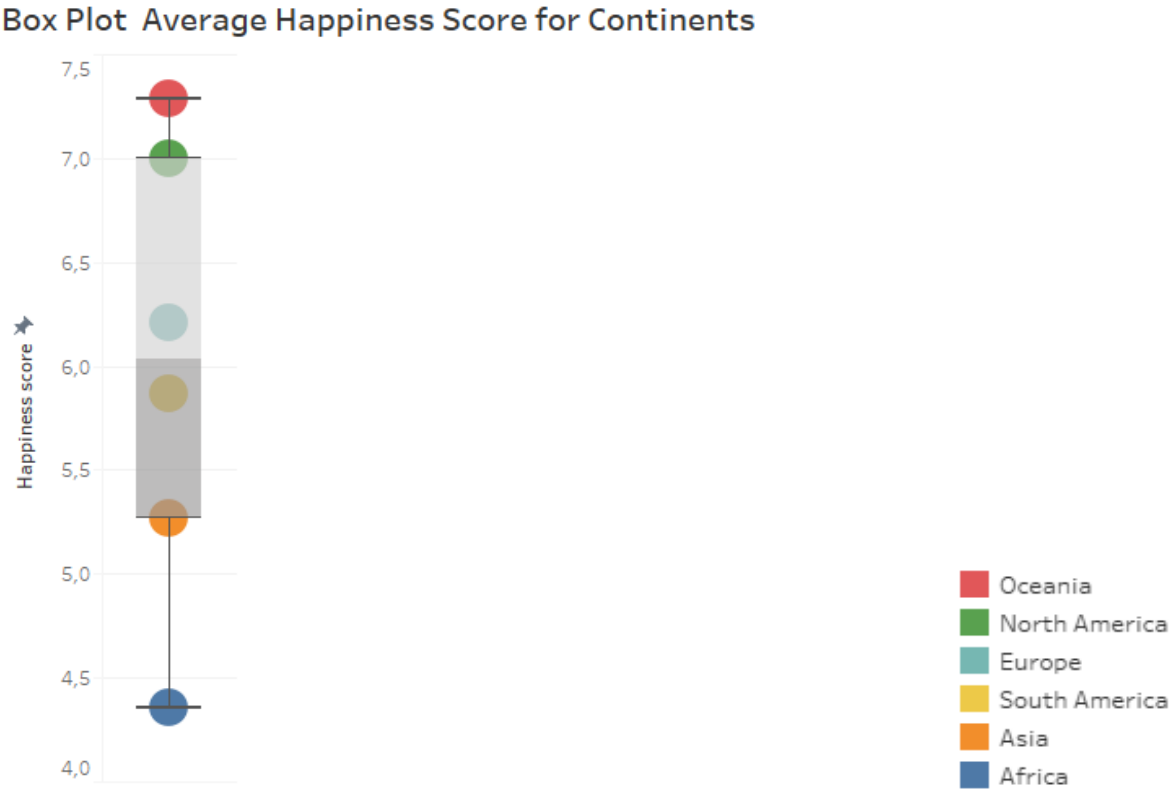



Figure 2: box plot of Continents

Observing the box plot we can see that the highest average Happiness Score is reached by Oceania with a score of 7.29, while on the opposite whisker is the African continent: the positions of the two continents reflect in fact as in the first the attention to the citizens, that can thus develop its own being without limitations or censorship, is established and functional; while in the second, on the African continent, many individuals still live in conditions where the development of their ego and the achievement of happiness are not among the main prerogatives of governments.

For completeness, here are the box plots related to previous years.

[3] At the statistical level we must stress that it was possible to use the average rather than the median since the absence of outliers was verified

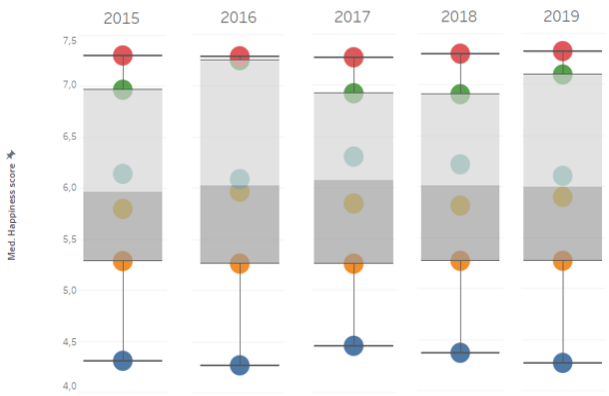



Figure 3: Average happiness score's box plot for Continent in all the 6 years (from 2015 to 2020)

The positions of the Continents are constant in all six years in analysis: the first and the last position are always covered respectively by Oceania and Africa because of the diametrically opposite values reached by some components (for example, the levels of trust of the Government Trust component), then follow Asia South America Europe and North America.

The observation of boxplots allows us to divide the world into two zones: above the median, that is the central value of the happiness score in a given year, we always find the Continents more 'happy'; below it we find those less.

Therefore, we can say that the happiest continents are, with the exception of Oceania (placed on the upper baffle), those of the Boreal Hemisphere: Europa (located in the second quantile) and North America (located at the upper end of the third quantile); while those more 'sad' in the Southern Hemisphere: South America (positioned within the second quantile), Asia (positioned at the lower end of the first quantile) and finally Africa (placed on the lower whisker).

In general, Oceania is in a very good position from the point of view of all variables (Figure 4): in particular, it is a positive spike[4] for the Government Trust and Generosity variables. On the opposite side, using the same view for the Health variable, it is observed that Africa positions itself as a negative spike.

[4] Spike: spike means a sudden deviation from an average trend of such magnitude that it does not constitute an outlier in statistical terms.


Figure 4: dot plot of three of the six components of the happiness score

This can be proven by observing the following line chart (figure 5), which shows the trend of the Happiness Score in each continent from 2015 to 2020.

The trend is quite linear, especially for Oceania and Asia.

However, it can be observed that Europe is speculative compared to North America: the years in which North America reaches the highest levels (2016 and 2019) are the same in which Europe has the worst performance; and has a similar trend compared to Africa: both continents worsen in 2016, have a small recovery in 2017 and then roll back in 2019, in terms of average happiness level.

The trend evidenced from the diagram could be justified from the series of economic historical observations from which often deduces like the American continent advances behaviors (trend of stock exchange, customs and consumptions) that will be then adopted by the European continent.

Moreover 2016 is a particularly happy year for North America, so much so as to reach almost the level of oceanic happiness.

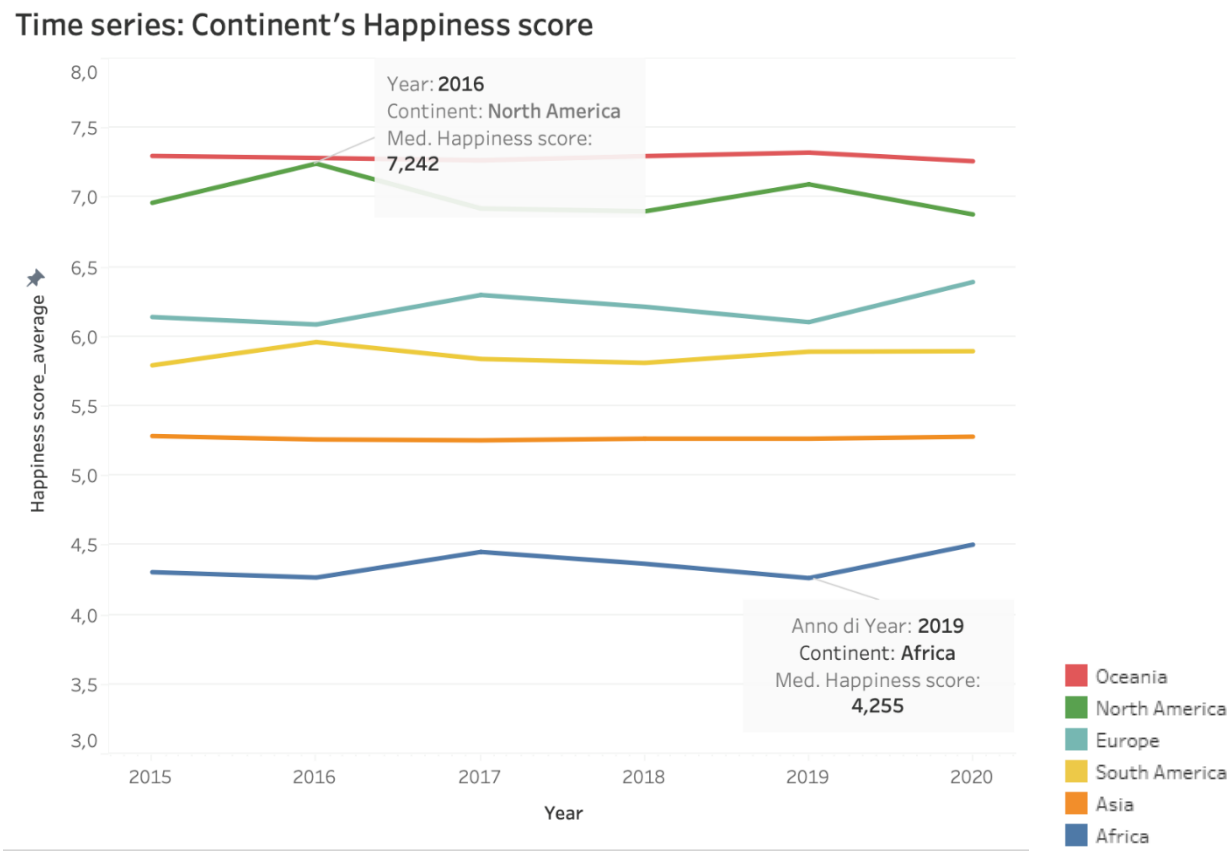



Figure 5: Time series of Continent's happiness score and its legend

Since it is not so evident the variation of the course in the various years, we bring back in figure 6 the percentage difference of the course of the average Happiness score regarding 2015 for each of the Continents. The choice of 2015 as the reference year is explained by the fact that it represents the starting situation with respect to which we observe any improvement or deterioration in terms of happiness in the various continents.

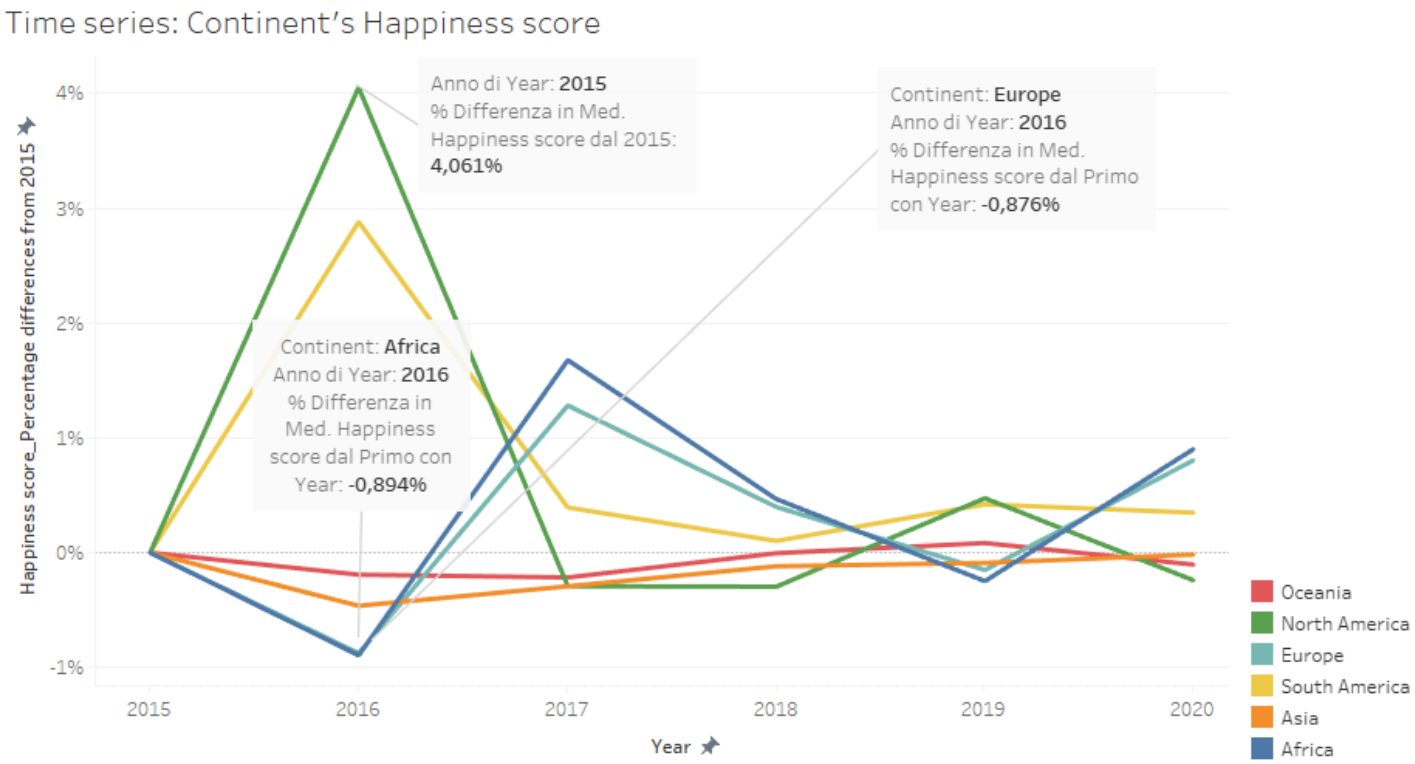



Figure 6: Line chart on percentage differences in average happiness score for Continent with 2015 as bases-year

Looking at the line chart above, we can see the change in the score in the various years: the dotted line of 0% indicates the reference situation of 2015, the points above this line indicate an improvement in percentage terms, while the points below a worsening.

Analyzing therefore the course in figure 6 we notice how much evidenced in the time series of figure 5: Europe and Africa have a similar course, so much that the two lines are contiguous and sometimes overlapping(corresponding to 2016: this indicates that the two continents have undergone the same change in percentage terms compared to the previous year); Asia and Oceania have variations close to 0% to support the affirmation of constant trend over the 6 years, while North America and South America are the continents that vary most.

It is interesting to observe in 2020 the improvement of the happiness score of Africa compared to the situation of 2015 (represented by the dotted line at 0%), clearly higher than the improvement of other continents.

### 3.2. Focus on Countries

Moving towards a more detailed analysis, we observe how the Happiness score of each country analyzed in the time frame considered varies.

A Radial chart has been created that, through redundancy[5] on the use of color shades and the length of the bars, shows the level of the Happiness Score[6] in the 137 countries involved in the survey and, to make the reading even clearer, the name of some states has been entered.

Looking at the legend, we can see that 5 color ranges have been used that from the lightest to the darkest capture the increase in the score of happiness: the countries represented by shorter lines and lighter colors are those in which the Happiness score is lower; Conversely, the countries represented by longer and darker lines are the happiest based on the parameters used.

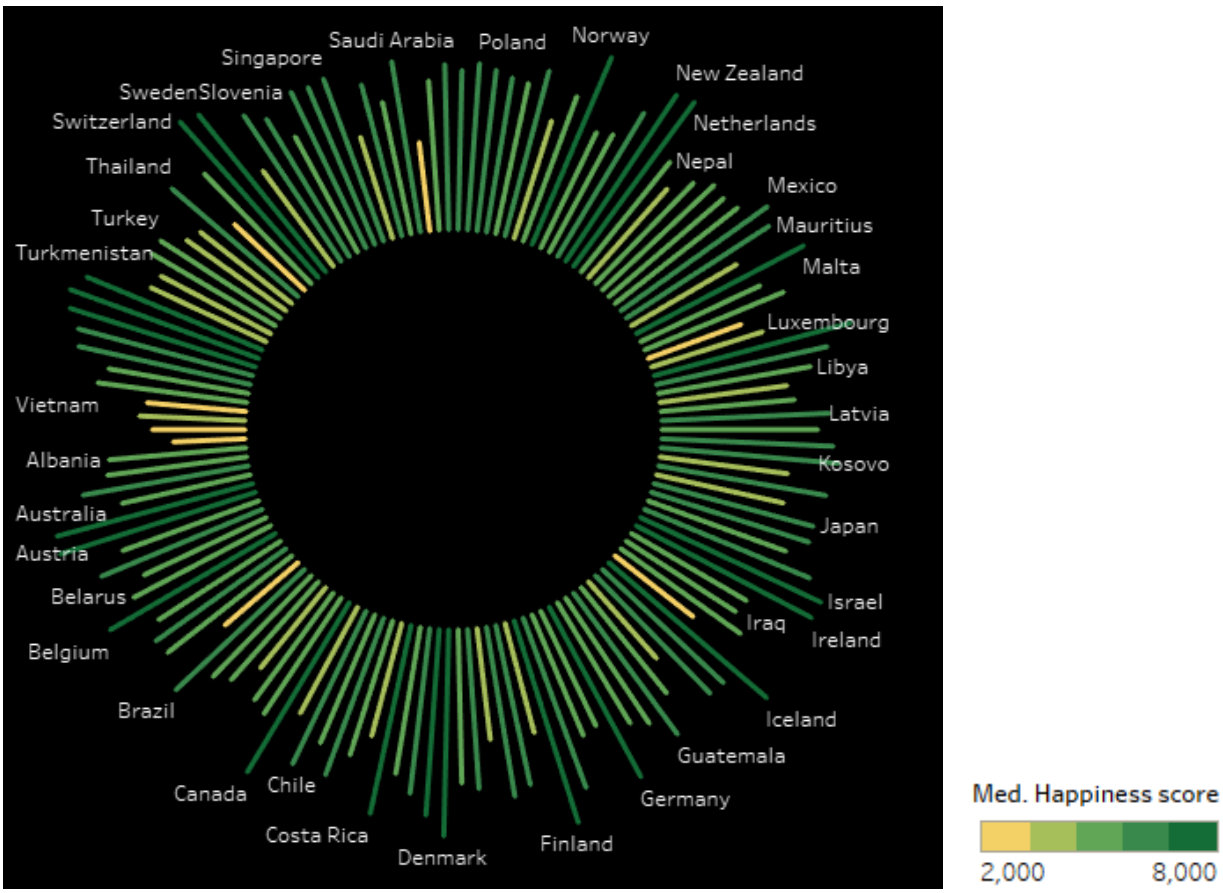



Figure 7: Radial chart of Average Happiness score and its legend

[5] Redundancy: data visualization technique that allows to convey the same entity through the use of more than one graphic attribute, to be sure to convey information clearly to the recipient.

[6] It is important to point out that at a statistical level the average of the Happiness score is actually calculated only when using the 'All' year filter, that is, when you take in a single view all the years simultaneously; otherwise if you filter for the specific year you display the value recorded in the specific country (ie it is as if the average was calculated with denominator 1).

In order to facilitate better orientation between the countries considered, a map (figure 8, in the image is represented the filtered situation for the year 2020) that recalls what has already been inserted in the Radial Chart, respecting its legend.

The motivation to use a representation on a planisphere, although redundant in terms of information conveyed (since it is the same as the radial chart), lies in the intrinsic power of this data visualization: the communication of a perceptible information at a glance is very efficient and effective because it is able to get quickly and directly to the cognitive system of the observer. Moreover, thanks to the familiar reference of the geo-location of states on the world map, it is easier for the observer, in our opinion, to fully grasp the information about a specific state.

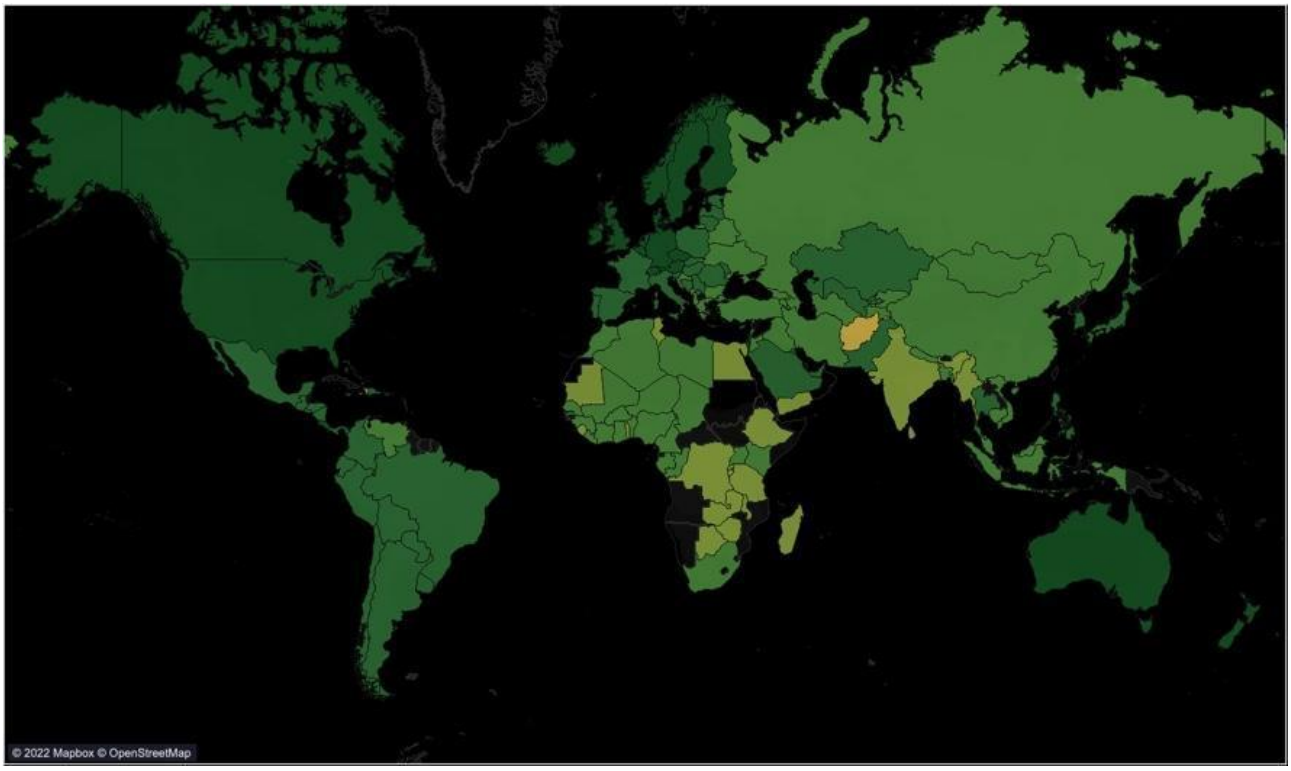



Figure 8: planisphere depicting the happiness score for the year 2020

So the interaction between Figure 7 and 8 on the Tableau Public software allows the observer to easily grasp, in line with their needs, which countries are more or less happy: if he simply wanted to observe which countries have a higher happiness score, he would simply have to search the radial chart for the longest and darkest rays. If instead you want to focus on observing the values of a specific country, it would be much easier to identify the State of interest on the map: by clicking on it the program 'will filter the status' and will show directly on the radial chart which radius that country corresponds to.

Finally, it is important to point out that in order to allow the observation of the changes, the variable "anno"[7] has been inserted between the filters, in such a way as to allow an easy displacement between the periods and observe the behavior of the happiness score in each of these.

For example, if we wanted to observe the area in which most of the countries with a low happiness score are located, we will immediately notice that in the African continent there is a greater number of countries colored in light green; vice versa, in North America and Australia.

It is important to observe how at first sight it would seem that the happiest continent is Europe or North America, given the dark green colouration of the countries, but to say this would not be correct: not all countries are colored dark green (eg: Mexico or Italy are a lighter shade than the US and Norway).

Therefore, to say that one of these two is the happiest continent would be a mistake, the result of a careless observation: we must be focused when analyzing a data visualization, especially if it is one that meets the criterion of originality, or a different display of standards (such as pie charts and scatterplots).

The observer, therefore, must be concentrated in order to avoid reaching erroneous conclusions dictated by superficiality and haste.

## 4. The components of the Happiness score in Countries

### 4.1. Which are the components that determine the greatest happiness score

Then the analysis moved from a global point of view (value of happiness score in continents and countries) to a local one through the analysis of the individual components of the score and their value within proxy countries.

The variables Social Support, Health, Government Trust, Generosity, GDP per capita, Freedom, are the six components that determine, through the sum of their levels and that of Dystopia residuals, the level of the Happiness score of each country.

The name of the six components per se is self-explanatory in highlighting what they indicate; The value of Dystopia residuals instead contains the residues of the regression model calculated on the basis of values equal to the lowest national averages in the world for each of the six factors: represents for each country the level of happiness that would be there if all six components were at their lowest score.

In the following stacked bar charts (figure 9) we see the variables that make up the Happiness score in the 5 happiest countries and the 5 least happy countries in the world respectively.

[7] the filter "anno", as evidenced in note 5, shows the average value of the happiness score if the 'all' filter is used at the same time every year, if you filter year by year you get an average score with denominator 1 or the score actually observed by Gallup World Pull.

These 10 proxy countries have been chosen on the basis of the average classification (that is calculated on the 6 years in analysis) of all the states: for each variable (component) the average from 2015 to 2020 has been calculated, and subsequently were ordered in descending order of the sum of these components. Finally, to select the top 5 and the last 5 has filtered by country entering only those of interest.

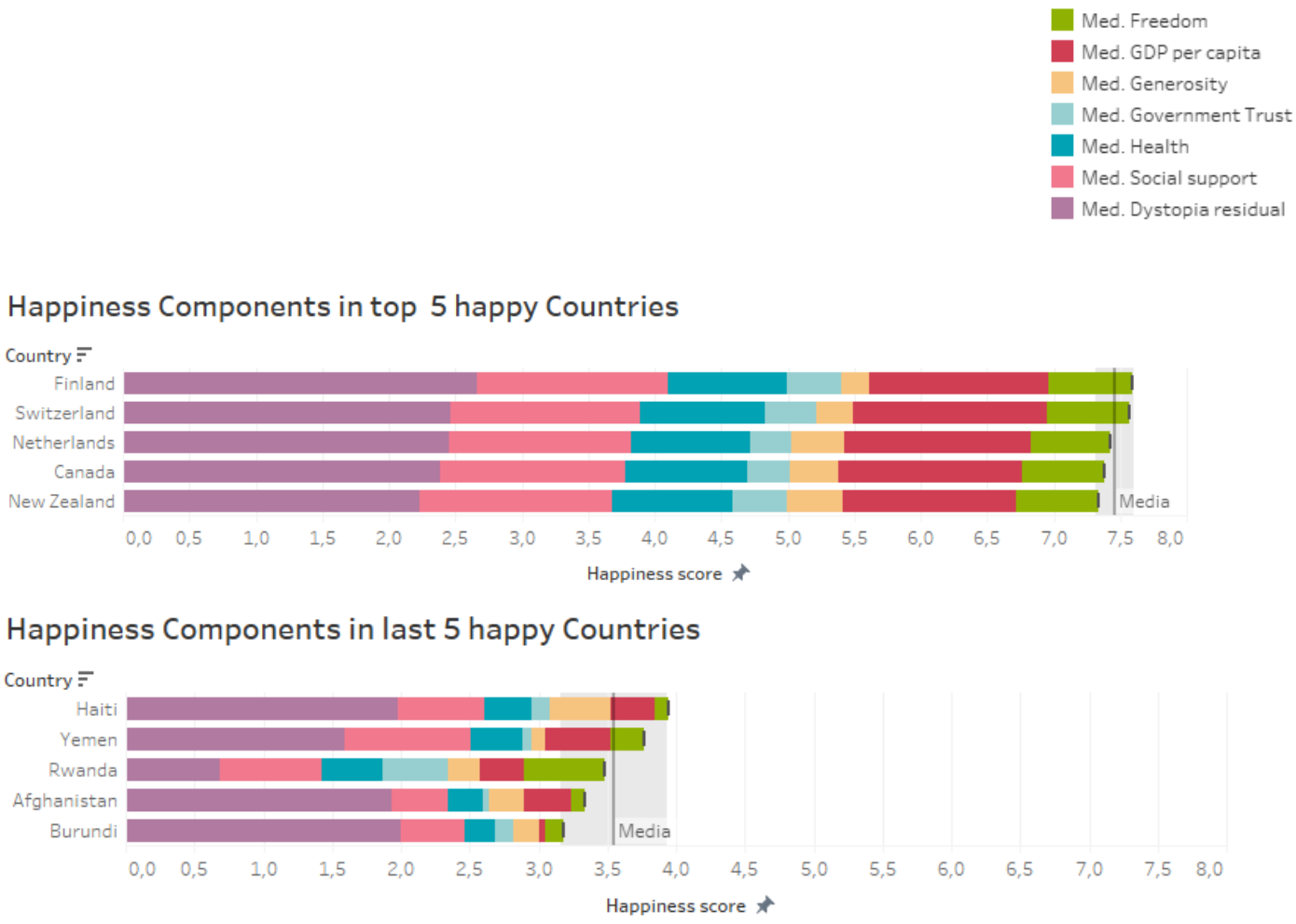



Figure 9: stacked bar chart of the 5 happiest countries and 5 saddest countries

From a brief overview, we can see that the variables are more evenly distributed among the happier countries. In particular, it is evident that Social support and GDP per capita are the variables that have a greater weight on the determination of the value of the Happiness score; to follow the variables Health, Freedom and finally almost to the same extent Government trust and Generosity.

More interesting is the analysis of the components of the 5 less happy countries. In the saddest countries, it cannot be said, as before, that there is a homogeneous distribution of the components: For example, it is

evident that in Yemen GDP per capita is considered a variable of greater weight on happiness score than it is in other countries and especially than it is in Burundi.
In addition to GDP per capita, we observe that Freedom is also a variable that varies quite widely from country to country: in Rwanda it occupies a portion of happiness score much higher than it is in Afghanistan for example. This means that, in Rwanda, although there are socio-economic difficulties, citizens perceive that they are quite free in their choices.

Moreover, it is interesting to analyze another phenomenon: the saddest but freer countries (where the freedom component is wider) are the same ones where the generosity level is lower; vice versa for the opposite case. this evidences as often in the situations of great difficulty the mutual aid becomes more emphasized.
In addition to this, in these 5 last happy countries we can see a lower level of engraving of the variable Health and the component Government trust on the Happiness score: this is easily confirmed by observing that are included for most Third World countries, in which living conditions, sanitary, medical, but also political are precarious and sometimes extreme. Here too we can observe the relevant weight of social support, which is therefore confirmed to be a determining variable in the composition of the Happiness score.
It is important to remember that residual dystopia (in purple) is not a real component in the happiness score; rather, it serves to make clear why some countries have a better ranking than others, because it represents the distance of each state's happiness score from a hypothetical country called Dystopia, which has the minimum value of each of the variables in question.

### 4.2.Time variation of variables

Once observed how these variables make up the average happiness score between 2015 and 2020, it may be interesting to observe how these vary over time within the countries analyzed above.
Figure 10 and 11 depicts this trend; and, since the happiness score is given by the sum of these six, it is clear why it reaches a higher value on the same scale.

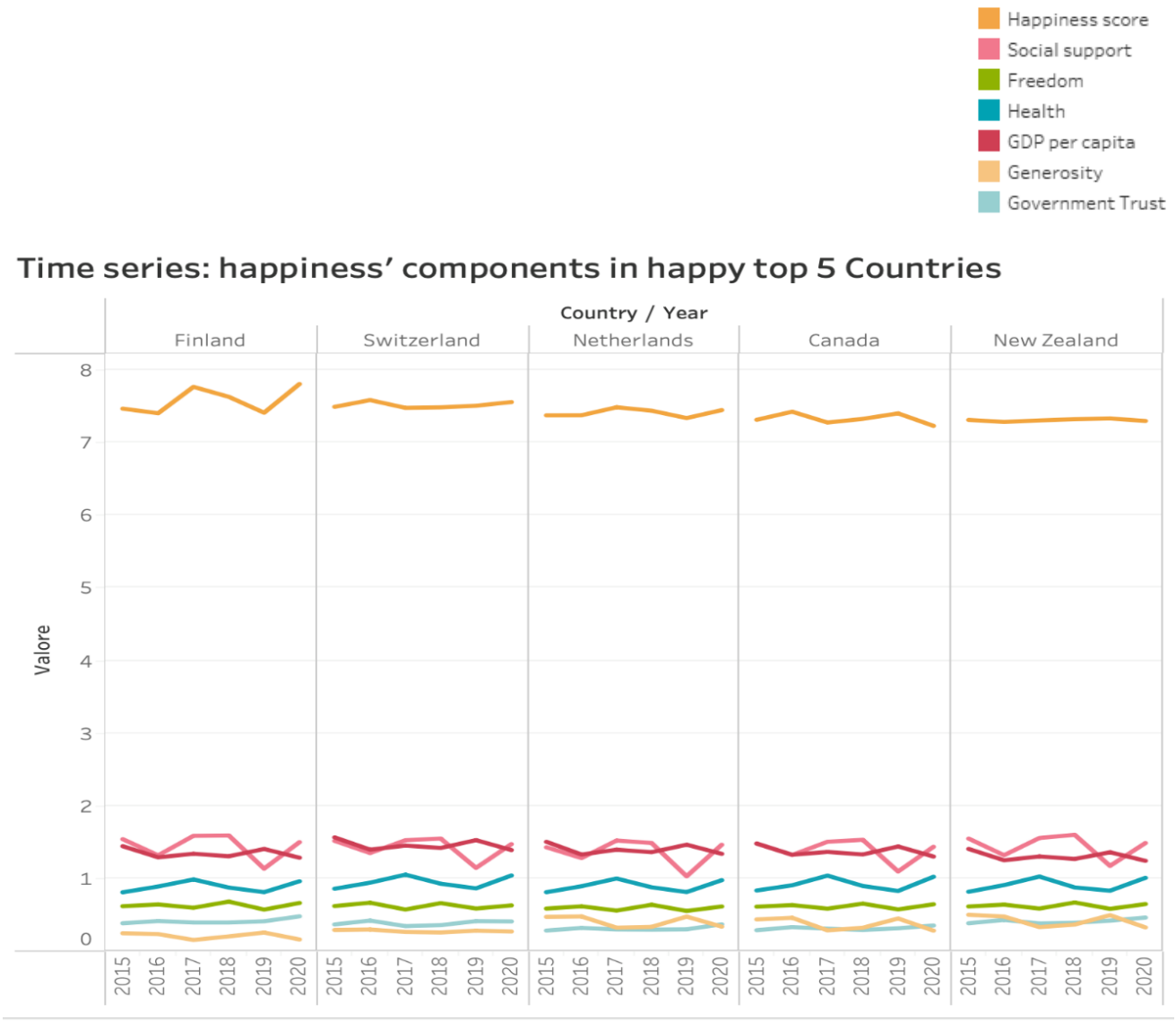



Figure 10: Time series of the happiness score and its components for each of the 5 happiest countries and its legend

In the 5 happiest countries the trend is rather constant in each of the 6 components, with the exception of social support that in each state reaches its minimum in 2019 and then grows back the following year.
instead as regards the variables 'Generosity ' and 'Health' we notice how low they are in each country (that is, they determine in a smaller portion the score of happiness) and in particular how they are reversed in the Netherlands and Canada to indicate that in the six years under analysis the level of these components has undergone minimal variations is that happiness in these countries is minimally determined by health and health factors.

Shifting the focus to what is instead the trend of the happiness score, we note that Finland has the most discontinuous trend (in the sense that it is the country that varies the most), although in the period of time considered is the one that averages a better score.

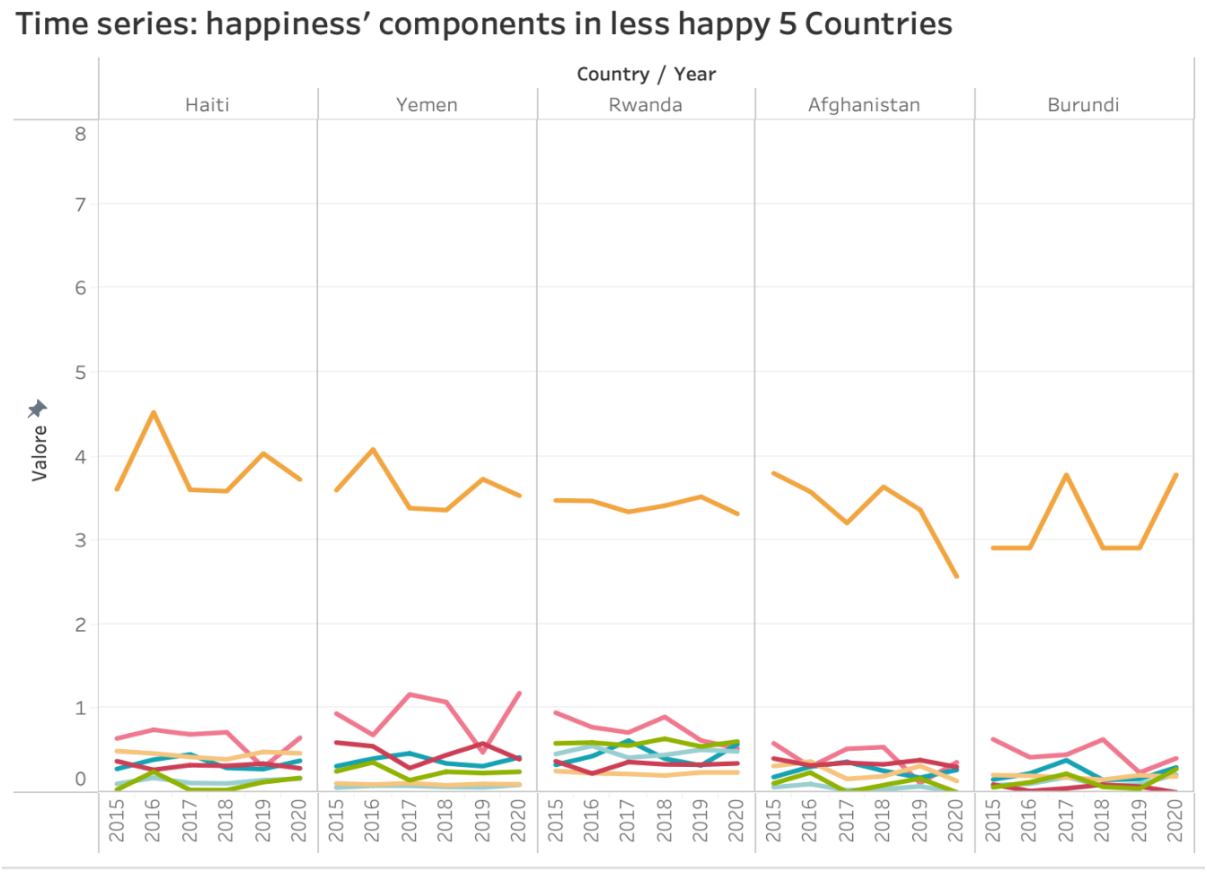



Figure 11: Time series of the happiness score and its components for each of the 5 saddest countries

As for the time series of figure 11, reporting the last 5 happy Countries, it is clear the erratic trend for any variable, including the happiness score, in each country.

In addition, the happiness score followed the same trend, with different variations, in all 5 less happy countries, with an improvement between 2015 and 2016, followed by a worsening in 2017, a second improvement in 2018-2019 and subsequently a further worsening in 2020 (delicate year due to the outbreak of the pandemic from Covid-19). The only country in contrast is Burundi: between 2019 and 2020, in fact, the happiness score improves.

It is important to draw attention to the fact that in these countries often the component variables are very close to or equal to the zero level, as can be observed especially in Afghanistan.

In fact, in this state there are two variables that reach the absolute 0, both in 2017 and 2020: Freedom and Government Trust. In addition, Afghanistan is the country that has had the worst worsening in terms of Happiness score since 2015. The anomalous and interesting situation of this country will be analyzed at the end of this work because of the atypical situation it represents.

### 5. Regression model and clustering

At this point of deepening, the following question has been asked: is it possible to divide, or group, States on the basis of the happiness score and the values of the socio-demographic components related to it, thus determining sets of "similar" States?

This objective has been pursued through various steps summarized in three steps:

1. Development of linear regression models between happiness score and each of its components
2. Creation of a new determinant, or better, variable, called "Development"
3. Development of the linear regression model between Happiness score and new component
4. Clustering of countries on the basis of contributions from the new component

The starting point was then the implementation of six linear regression models (one for each component) between the variable 'Happiness score' and the others, obtaining the results in figure 12.

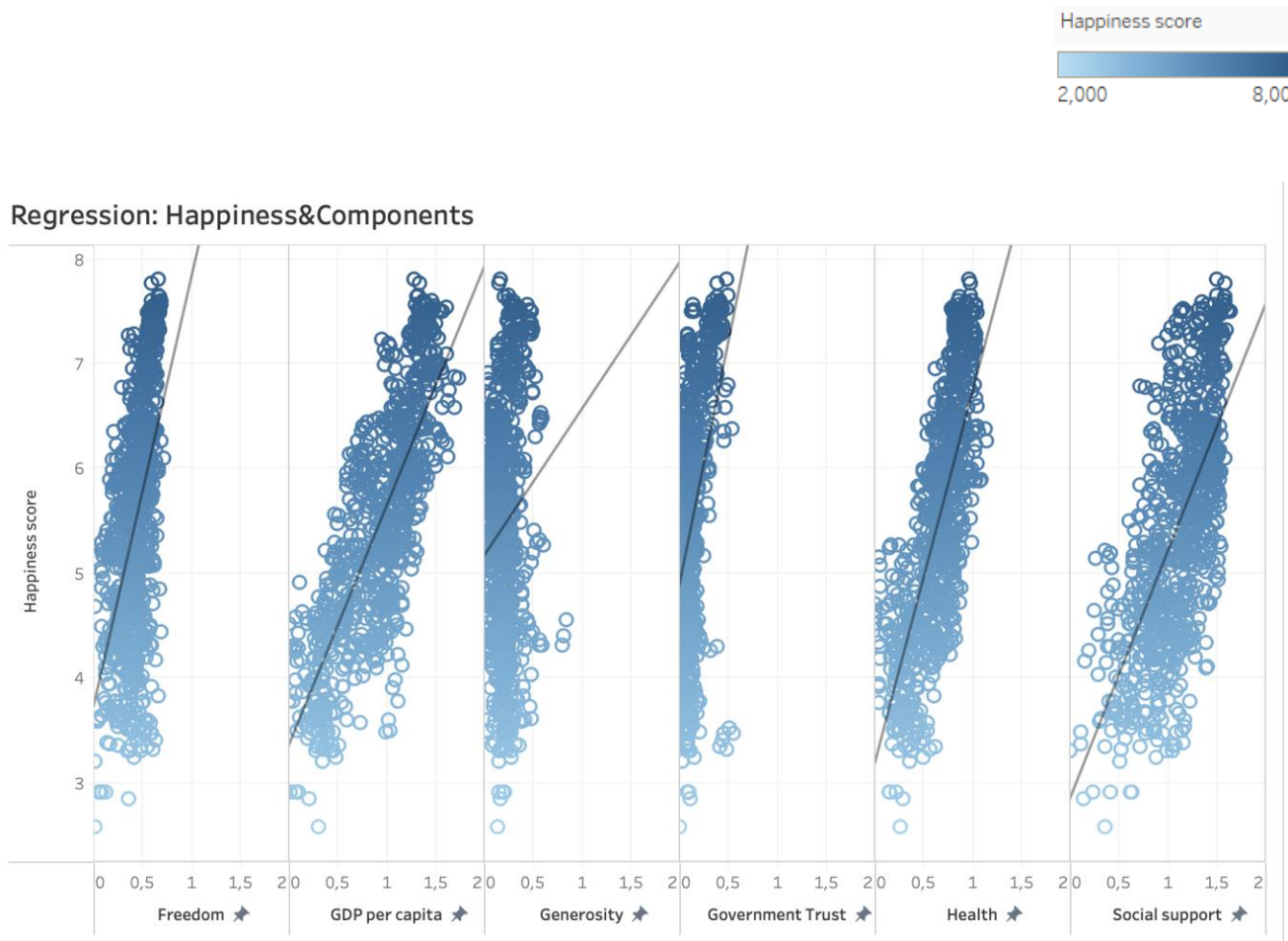



Figure 12: Linear regression models between Happiness scores as a function of each of the six components

Observing graphically the orientation of the points along the regression line, we can draw the following conclusions:

- the variable GDP is the component more correlated[8] to the happiness; in fact the points are oriented in homogeneous way along the straight line and the coefficient of determination of the model, that is the R2 - which represents the percentage of variance of 'Happiness score' explained by the component in analysis - amounts to 0.63. Therefore, we can say that the GDP component explains 63% of the variability of the Happiness score in all countries and in all years.
- The second most important component to explain the variability of the happiness score is Health, with a contribution of 56.7% (R2 of the model amounts to 0.567); follows the social support component, with an R2 of the model that amounts to 0.438.
- Finally, in fourth and fifth place are respectively the component Freedom and Generosity with contributions to the explanation of the variability equal, respectively, a: 29% and 22%. The last place is held by the variable Government trust, which with an R2 equal to 0.19 explains the variability of the Happiness score for 19%.

Next, the coefficients of determination of each of the models developed were taken as weights to create a new variable called "Development". The latter is therefore the linear combination of the happiness score components weighted by the respective R2 of the regression models constructed above, depending on their impact on the score.

The new variable has been named "Development" as it tries to capture, respectively for each Country, its development in economic terms (thanks to the component GDP per capita ) and social (thanks to the other components Freedom, Generosity, Social Support, Health and Government Trust). In this way we can explain why the variability of the scores: countries that report higher values in the variables that make up the happiness score, can be considered more developed countries than those that, conversely, achieve contributions to the lower score.

Later, a new regression model was built between the newly constructed Development variable and the Happiness score.

The figure below (figure 13) shows, plotting on the regression line all the observations present in the dataset, the clear existence of a linear relationship between the two variables: compared to the six models defined above, This new model is able to better explain the overall variability, in particular explains about 74% (the R2 amounts to 0.7422) as it manages to capture at the same time the contributions of the six components.

[8] the more the points are oriented along the regression line, the greater the relationship between the component and the happiness score.

The peculiarity of scatter plots consists in the possibility of dividing them into quadrants to identify the observations characterized by high values or less for both variables: we obtained this way, starting from the upper left quadrant and proceeding clockwise, 4 zones:

- the 'undeveloped and happy' zone, characterised by high values for the dependent variable (happiness score) and low values for the independent variable (development)
- the 'developed and happy' zone, characterized by high values both the dependent and independent variable
- the 'developed and sad' zone, characterised by high values for the independent variable and low values for the dependent variable
- the 'undeveloped and sad' zone, characterised by low values for both variables

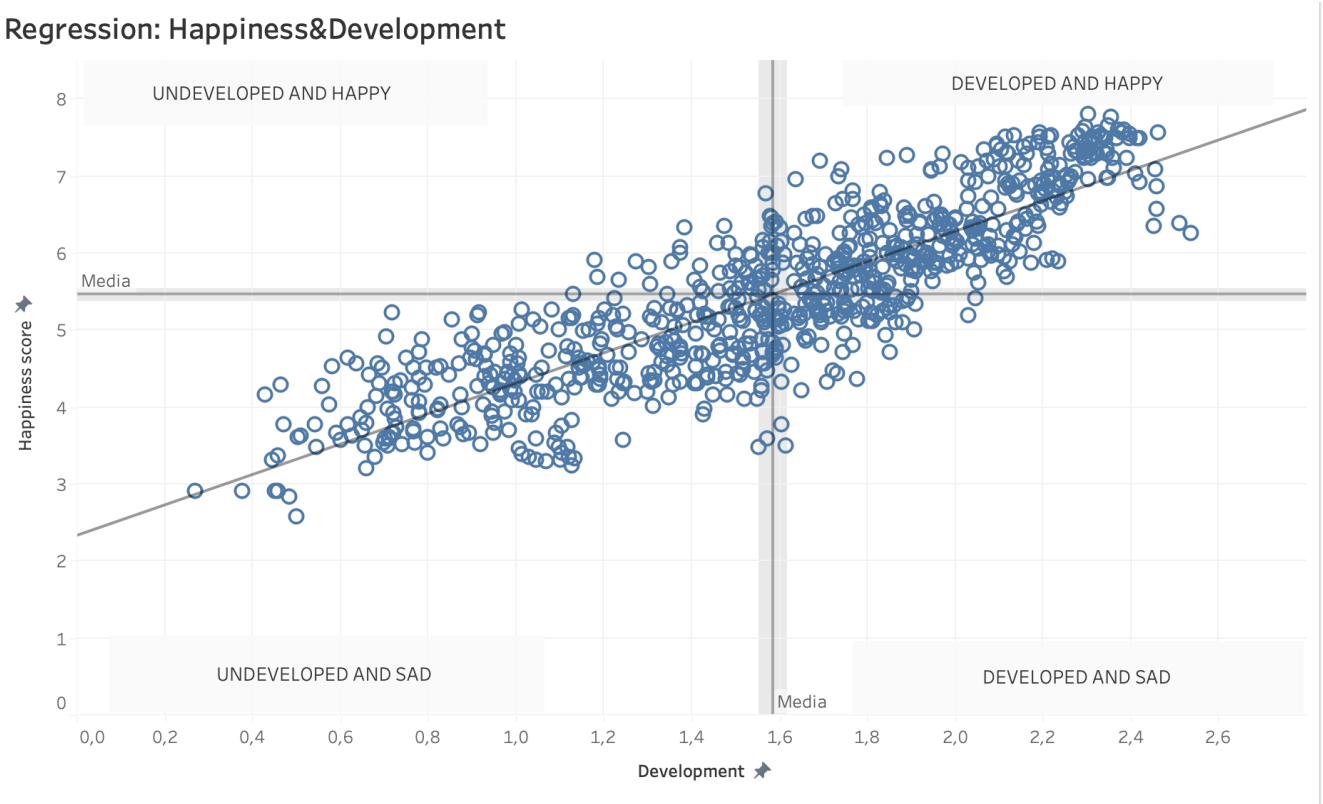



Figure 13: Happiness score scatter plot of regression model vs Development variable

Then we calculated for each country the average value (in the 6 years under analysis) of the two variables (happiness score and development) and finally we arrived at the desired result: the clustering of countries in 5 groups, as observed in figure 14.


Figure 14: Regression model of clustering

The countries are states divided into the following clusters:

- **<u>Cluster 1:</u> Most Undeveloped and saddest** Afghanistan, Benin, Burkina Faso, Burundi, Chad, Congo (Kinshasa), Ethiopia, Guinea, Haiti, Ivory Coast, Liberia, Madagascar, Malawi, Mali, Niger, Rwanda, Sierra Leone, Tanzania, Togo, Uganda , Yemen, Zimbabwe.
- **<u>Cluster 2:</u> Undeveloped and sad** Albania, Armenia, Bangladesh, Botswana, Cambodia, Cameroon, Congo (Brazzaville), Egypt, Gabon, Georgia, Ghana, India, Iran, Iraq, Kenya, Mauritania, Morocco, Myanmar, Nepal, Nigeria, Pakistan, Palestinian territories , Senegal, South Africa, Sri Lanka, Tajikistan, Tunisia, Ukraine, Zambia.
- **<u>Cluster 3:</u> Mostly developed but neither sad or happy** Mostly developed but not sad or happy Algeria, Azerbaijan, Belarus, Bolivia, Bosnia and Herzegovina, Bulgaria, China, Croatia, Dominican

Republic, Ecuador, El Salvador, Greece, Guatemala, Honduras, Hungary, Indonesia, Jamaica, Jordan, Kosovo, Kyrgyzstan, Latvia, Lebanon, Libya, Malaysia, Mauritius, Moldova, Mongolia, Montenegro, Nicaragua, Paraguay, Peru, Philippines, Portugal, Romania, Russia, Serbia, Turkey, Turkmenistan, Uzbekistan, Venezuela, Vietnam.

- **Cluster 4: Developed and happy** Argentina, Bahrain, Brazil, Chile, Colombia, Cyprus, Estonia, France, Italy, Japan, Kazakhstan, Kuwait, Lithuania, Malta, Mexico, Panama, Poland, Saudi Arabia, Slovakia, Slovenia, South Korea, Spain, Thailand, Uruguay.
- **Cluster 5: Most developed and most happy** Australia, Austria, Belgium, Canada, Costa Rica, Denmark, Finland, Germany, Iceland, Ireland, Israel, Luxembourg, Netherlands, New Zealand, Norway, Singapore, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States .

The result obtained is the following:

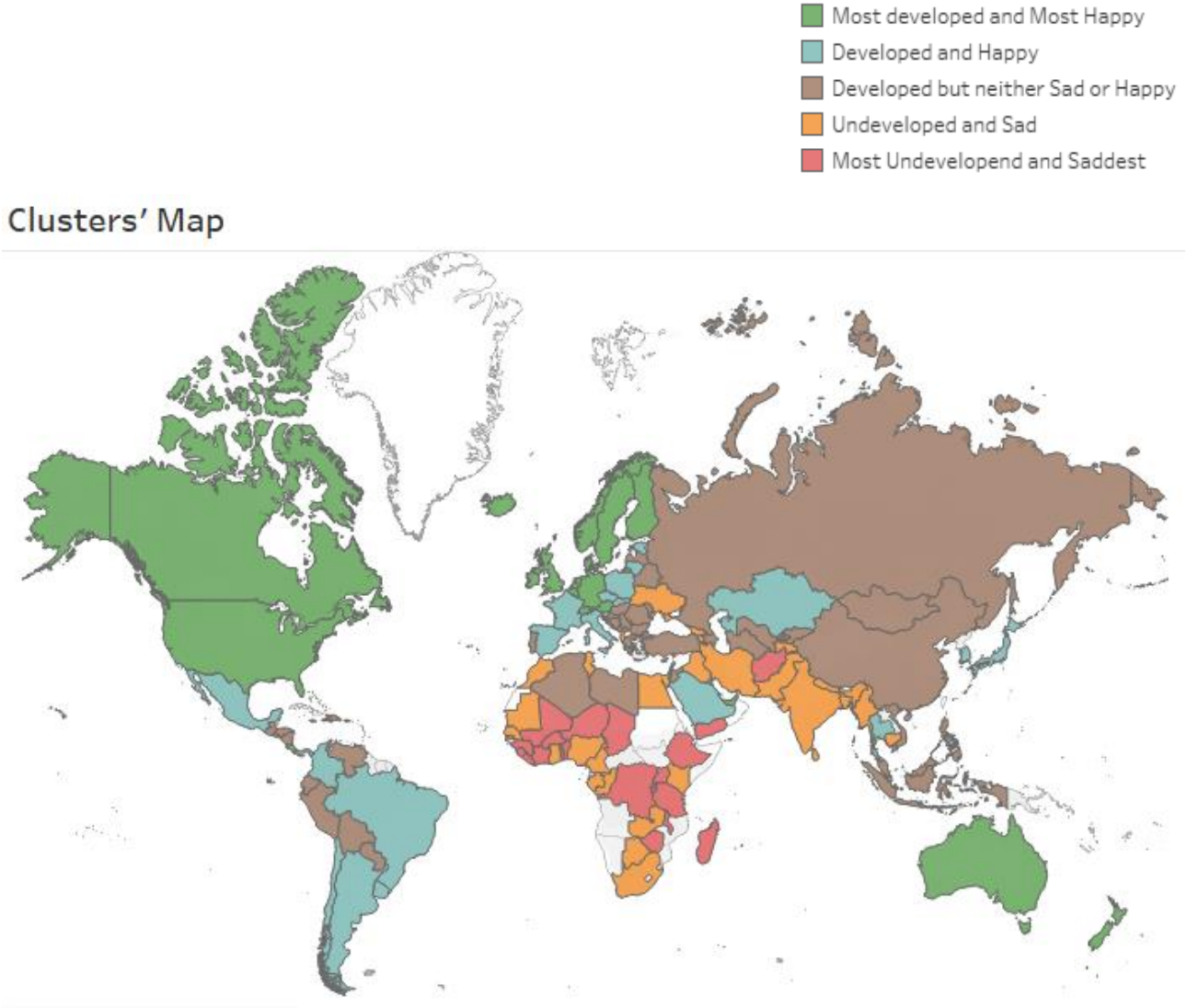



Figure 15: Clusters' map and its legend

Let’s go into the specific characteristics of each cluster.

1. **Most Undeveloped and saddest**

Figure 16: Most Undeveloped and saddest Countries

In this cluster we observe the least developed and less happy countries (the range of development is from 0.42 to 1.06, the range of average Happiness score varies between 3.19 and 4.54); are the so-called third world countries, characterized by values for both variables - happiness score and development - very low. These are states, mainly African with the exception of Afghanistan where the levels of the components of the score and the level of development are minimal. Here the living conditions and the degree of trust in the Government are low. The gap between power and population is very wide and sometimes unbridgeable, especially for economic and political reasons. In fact, in these countries the levels of wealth and development are the lowest observed, so much so that humanitarian intervention by richer countries is necessary.

**2. Undeveloped and sad**

Figure 17: Undeveloped and sad Countries

In this cluster there are undeveloped countries (the development range is from 0.96 to 1.66) and not very happy (the range of Happiness score varies between 3.77 and 5.40), characterized by a level of development and happiness below the general average: These are mainly developing countries that have started their economic growth with the new century.

### 3. Mostly developed but neither sad or happy

Figure 18: Mostly developed but neither sad or happy Countries

Here are included developed countries but not too happy (the development range is from 1.38 to 1.98, the range of Happiness average score varies between 4.69 and 6.35). It is the most heterogeneous cluster of the 5, in which countries characterized by fairly high levels of economic development but with average levels of happiness are listed. They are countries where development has already started for some time but for cultural reasons, not measured in this study (for example, political instability or other economic factors), the happiness of the inhabitants is not at its peak.

### 4. Developed and happy

Figure 19: Developed and happy Countries

In this cluster there are developed countries and happy (the range of development is from 1.74 to 2.16, the range of Happiness average score varies between 5.70 and 6.69), in which all infrastructure and state structures are functioning. These are mainly European and South American countries in which state welfare is one of the cornerstones of economic development and the proper functioning of structures determines a rather high level of happiness. The difference with the next cluster, which groups the countries considered as the best, lies in the fact that here the average level of happiness almost a point lower.

## 5. Most developed and most happy

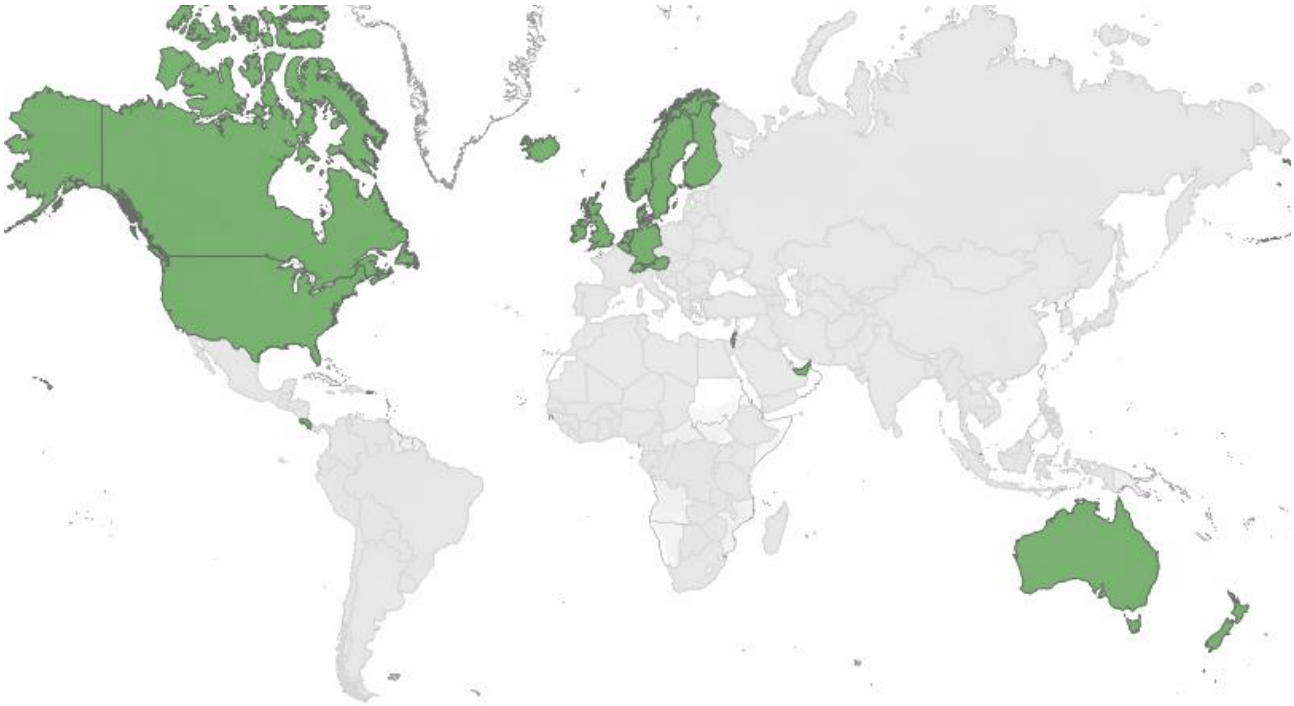


Figure 20: Most developed and most happy Countries

Here are the most developed and happiest countries (the development range is from 1.91 to 2.4; the Happiness score range varies between 7.15 and 7.58), characterized by economic growth levels, per capita wealth rates and very high levels of confidence in government. They are essentially North European countries, of North America and of the Australian continent; moreover, between these Countries Israel and the United Arab Emirates stand out.

The linear combination of these factors, expressed by the value of the development variable, allows us to categorize these countries as the best in which to lead a life of happiness and well-being declined in all its forms (from the wealth of the individual to social security, to life expectancy).

However - following the controversy surrounding the living conditions of workers during the World Cup in Qatar - , it seems appropriate to consider that the presence of the United Arab Emirates in this group is justified by the fact that in this country wealth is concentrated in the hands of a few super rich, who are also the only ones to be considered citizens of this country as autochthonous and, consequently, the only “true” Emirates. Therefore, the data of this State does not reflect the true condition of all its inhabitants but only of the few owners of all riches.

## 6. Focus: Afghanistan

At the end of the analysis, we wish to carry out a further rapid analysis on the situation in Afghanistan, as previously mentioned.

To pick up the thread of the speech, let us focus on the graph that led us to want to deepen the situation in Afghanistan.

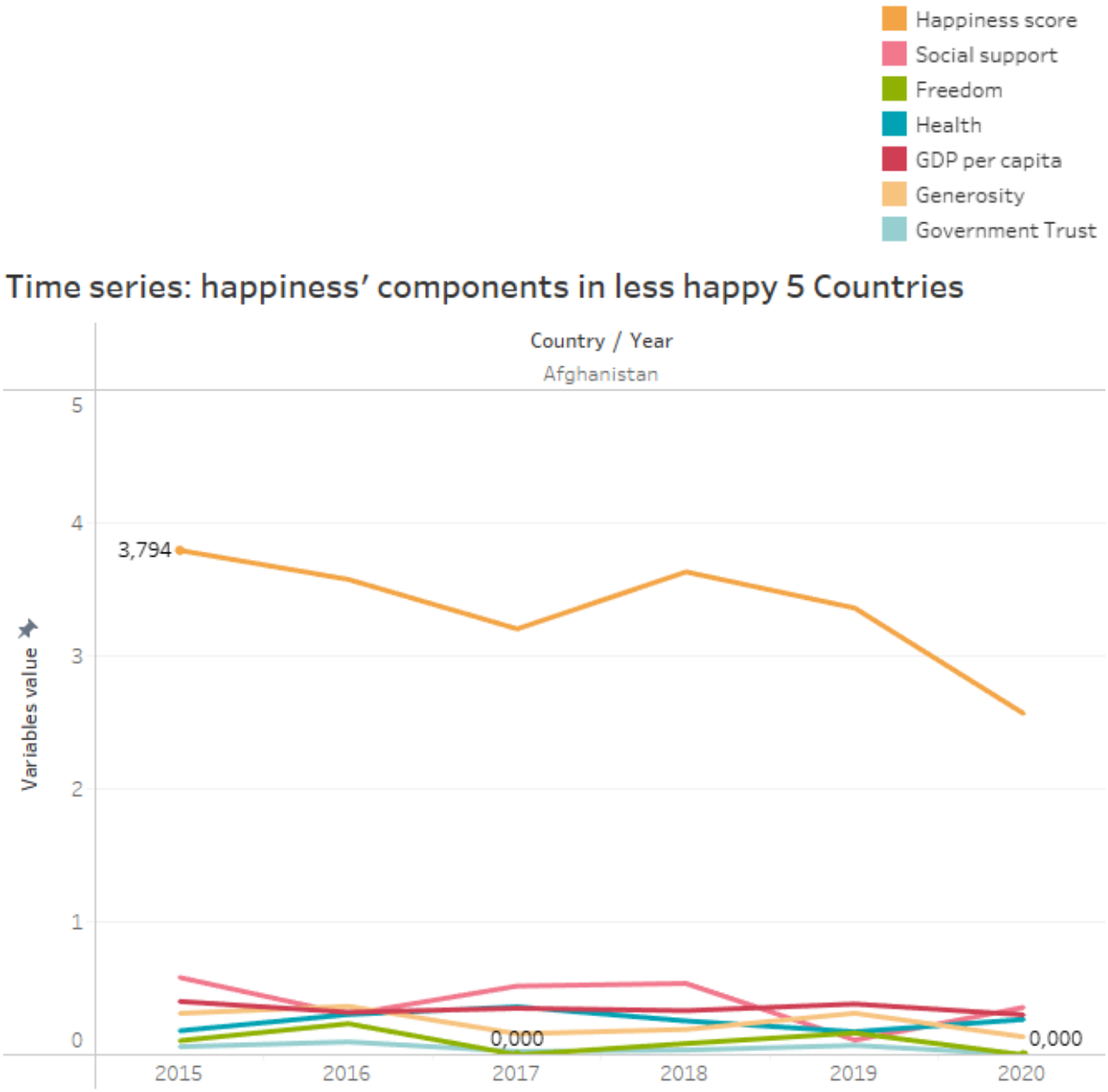



Figure 21: Zoom for Afghanistan Country from figure 12

We see that over the last five years this Country has lost the most in terms of happiness. Although it is not the worst, or the saddest, it is still the Country that shows the most marked difference in terms of score in the analyzed time frame. In fact, from this graph in figure 21, extrapolated from the previous line chart of

figure 12 concerning the details for the 5 most unhappy countries, we notice that the level of the happiness score is dramatically precipitated from 2018 to 2020.

This fall is due to the decreasing trend that affected the variables involved in the period considered. It is therefore appropriate and interesting to observe the annual trend of each variable, as we can see in figure 22. Here, the choice of the bar chart is explained by the need to make the most of the levels that each variable presents in each year; moreover, to show the trend in the levels observed during the entire period, were also inserted lines that relate to the trend of the phenomenon for the single component: we note that in suits and six the trend is that of a continuous worsening in the time frame of reference.

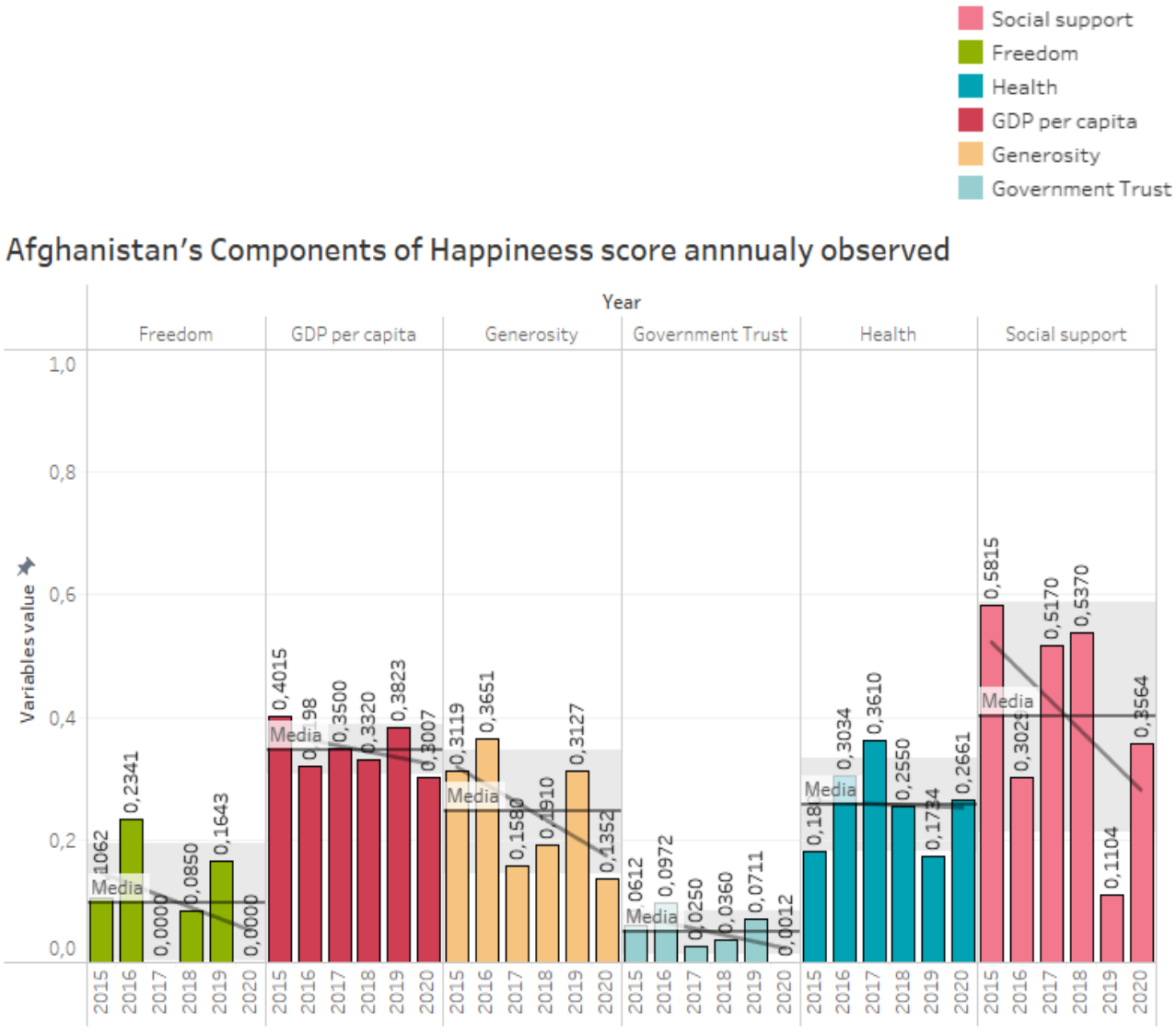



Figure 22: Afghanistan components year by year

In particular, the level of 0 in 2017 of the variable freedom is redundant, also found in 2020 together with the Government Trust. As you can imagine, these are two variables that often go hand in hand: in fact, a government that exercises power through repression and coercion, certainly reduces perceived levels of freedom. We are aware that there are several factors that contribute to increase or decrease confidence in

a government, but in a Country with a notoriously complex state situation such as Afghanistan, it cannot be ruled out that the correlation between the variables freedom and government trust can be explained by the repression exerted by the institutions on the population.

To make even more evident this deterioration in the quality of life in Afghanistan from 2015 to 2020, we report below the line chart showing the percentage change of each variable with reference to 2015.

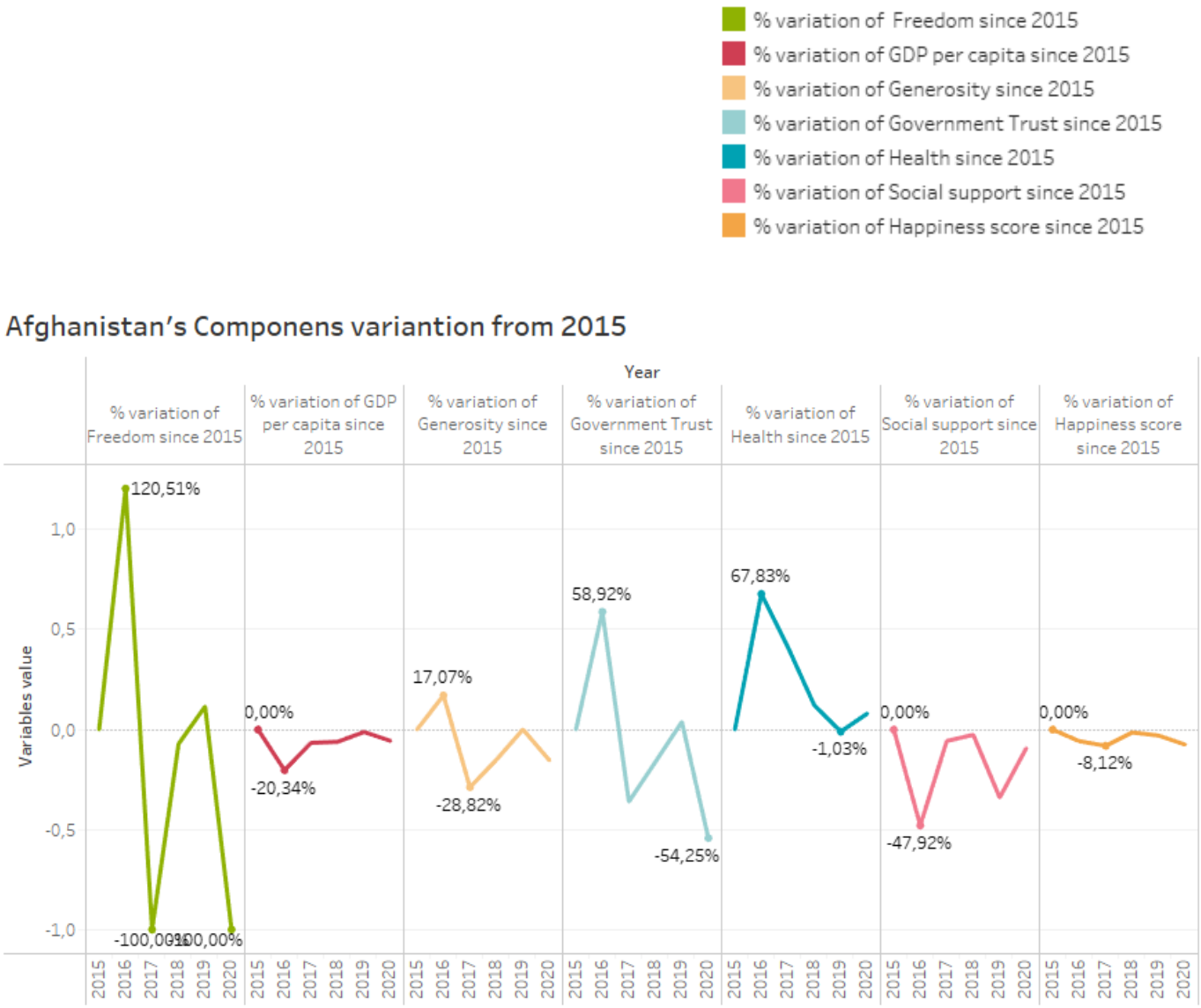



Figure 23: Percentage change of each component compared to 2015 for Afghanistan and its legend

During the analysis, the component that has undergone the greatest fluctuation is the 'Freedom', with a positive peak in 2016 (in which it improved by 120% compared to the previous year) and two negatives in 2017 and 2020, year in which it worsened by 100% compared to the initial situation.

The components GDP and social support, always being below 0% indicate that over time these two components have continuously worsened compared to the situation of 2015: for the first variable the deterioration is in the range [-21%,-1%], for the second [-48%,-2%].

The only variable, seen in 2020, improved compared to 2015 is the Health component.
Finally, the Government trust component is among those that worsened most in 2020, with a collapse of more than 54%.

But how can this be justified?
Undoubtedly the driving factors, not directly grasped by the analysis, were many: firstly, the precarious socio-economic condition (further aggravated by the pandemic) that, for a decade now and in particular for ethnic and cultural minorities, makes Afghanistan not a simple country to live in, and finally its own internal question about political instability. Reporting a news story, we could say that the peak of this negative trend was observed with the arrival of the Taliban in August 2021.

## 7. Quality Assessment of Data Visualization

To be sure that you have created a good Dataviz, it is essential to evaluate the quality of the latter, to make changes and improvements if there are elements that confuse users or lead them into error.
Effectiveness, efficiency and user satisfaction during usage are the three main characteristics that a visualization must possess. The infographic must allow the user to interpret it in the simplest and most intuitive way possible, without however going to hide important information.

To evaluate our Dataviz we used three different types of techniques:

1. **Heuristic evaluation**
   It is based on the observation of users as they interact with the infographic and as output we obtain a list of problems concerning usability, very useful to make improvements. The 'think aloud' technique was used, so users were asked to express their feelings aloud while using the infographic.
2. **Psychometric questionnaire**
   After having users interact with the infographic, they were asked to fill out a questionnaire where they evaluated the qualitative dimensions.
3. **User tests 12 participants**
   Each user was assigned three tasks to complete, for each task the time with which this task was completed was measured.

### 7.1. Heuristic test

For this type of evaluation, 3 users were taken into consideration who were asked to interact with the infographic for a few minutes and, as previously mentioned, the users' comments aloud were observed using the 'think aloud' technique.

We moved on two levels: the formative comparison, that is during the development of the project, then concerned a longitudinal and cross sectional comparison: the first involves the comparison between two different versions of the same dataviz, the second concerns the comparison between two different dataviz.

Below we have reported the problems detected for each user:

| | |
|---|---|
| **User 1** | Within the radial chart, it would prefer the use of a different color range than the yellow-red, in order to make the difference between the various countries clearer. Moreover, understanding was not very intuitive, especially in bar charts. It would prefer the presence of additional filters in some infographics and suggests a different sorting of data in others. |
| **User 2** | He noted that in some time series the changes are too small and so the changes are difficult to observe. It proposes truncating the axes and adding labels to better describe some points.<br>The user points out a preference to line charts over the area charts. |
| **User 3** | Looking at the 'Top 10 Happy' and 'Top 10 Unhappy' infographics in the line chart and bar chart, the user stresses that it would be better to reduce the number of countries under consideration for greater clarity.<br>In addition, the respondent notes the lack of clarity on some units of measurement and labels on the axes. |

#### 7.1.2 Changes made

Following user considerations during the heuristic test, the following changes were made.

Within the radial chart was chosen the yellow-green color range, considered more appropriate.

Following the test of comparing two different versions of time series (happiness' components in happy top 10 and last 10 Countries), it was necessary to reduce the number of countries from 10 to 5, in such a way as to make the view of the data clearer for the user and limit errors.

The same reduction was also made within the bar chart, in which it was also considered appropriate change the order of the components by value, in order to facilitate the reading and understanding of what this graph wants to convey; moreover, filters for year and feature have been added.

In the clusters the line of representation of the correlation between the variables "development" and "happiness has been added; moreover, the clusters, precedence ordered numerically, have been renamed

on the base of the characteristics reached from each of them: for example, the best cluter has been renamed that "Most happy and developed Countries".

Finally, the tests showed that users prefer line charts over area chart, because they believe that the latter increases the difficulty of understanding the infographic without providing any added value compared to a line chart. Within the line charts, users expressed a greater preference for graphs showing the compound growth rate, considered more informative.

### 7.2. Psychometric questionnaire

In order to evaluate the quality of the data visualization, the psychometric questionnaire with Cabitza-Locoro scale was chosen. It requires to give a rating on a scale from 1, very little, to 6, very much, of the observed infographics, in terms of:

- Usefulness
- Clarity
- Informativeness
- Loveliness

Finally, an overall assessment was requested, always on a scale of 1 to 6.

The questionnaire was submitted to 24 users; below is a table showing the number of subjects that have a certain score attribute to each variable.

| Score | Utility | Clarity | Informativeness | Beauty | Value as a whole |
|---|---|---|---|---|---|
| **1** | 1 | 0 | 0 | 0 | 0 |
| **2** | 1 | 0 | 2 | 0 | 0 |
| **3** | 2 | 1 | 1 | 1 | 0 |
| **4** | 6 | 8 | 6 | 6 | 6 |
| **5** | 11 | 13 | 9 | 8 | 16 |
| **6** | 3 | 2 | 6 | 9 | 2 |

Next, we report the graphical representation of the results obtained by each variable, observing the percentage value.


Figure 24: bar charts for each variable

It can therefore be said that there has been a high overall approval, especially with regard to beauty and informativeness, particularly appreciated.

Next, we can see a Stacked Bar Chart where the values attributed to each variable (from 1 to 6) have been grouped into 3 subgroups, where the group 3-4 wants to represent the uncertain values. In addition, a confidence interval of 5% has been reported.

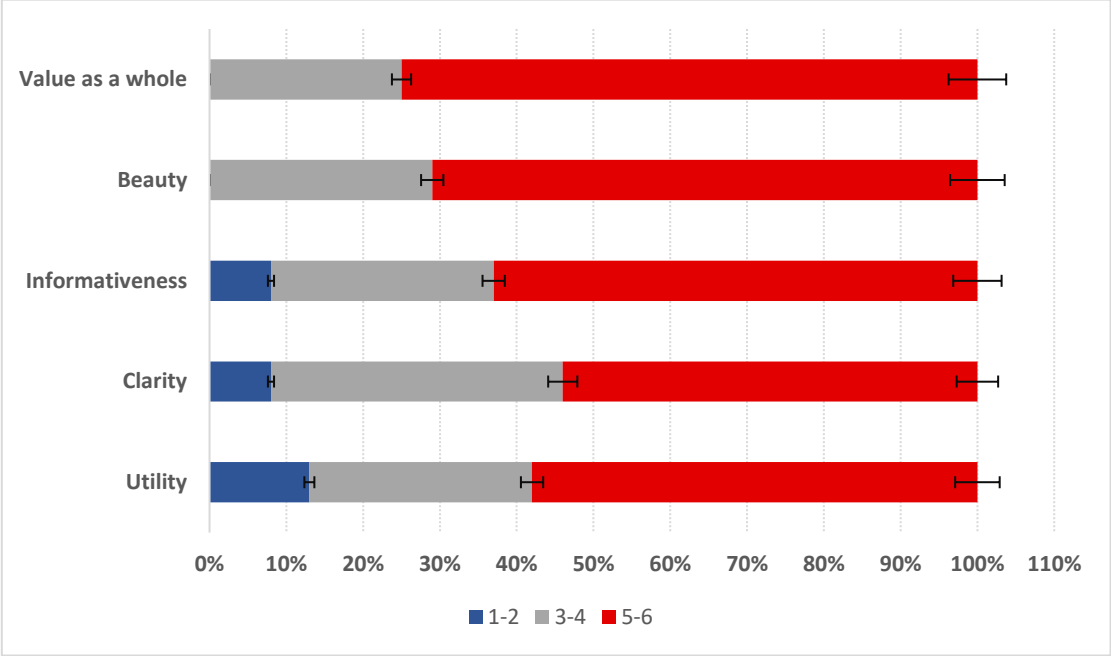



Figure 25: Stacked Bar Chart grouping the values attributed to each variable

Through the graph just reported, it is evidenced that the results of the questionnaire stretch towards positive values, especially regarding the beauty and the total value.

Finally, through a corrplot, we wanted to analyze the possible existence of a correlation between the parameters under assessment. The results of the correlations obtained were therefore observed graphically, in order to facilitate the reading.

| | Utility | Clarity | Informativeness | Beauty | Value as a whole |
|---|---|---|---|---|---|
| Utility | 1 | 0,01 | 0,12 | -0,02 | 0,1 |
| Clarity | 0,01 | 1 | -0,2 | 0,31 | 0,18 |
| Informativeness | 0,12 | -0,2 | 1 | 0,43 | 0,71 |
| Beauty | -0,02 | 0,31 | 0,43 | 1 | 0,79 |
| Value as a whole | 0,01 | 0,18 | 0,71 | 0,79 | 1 |

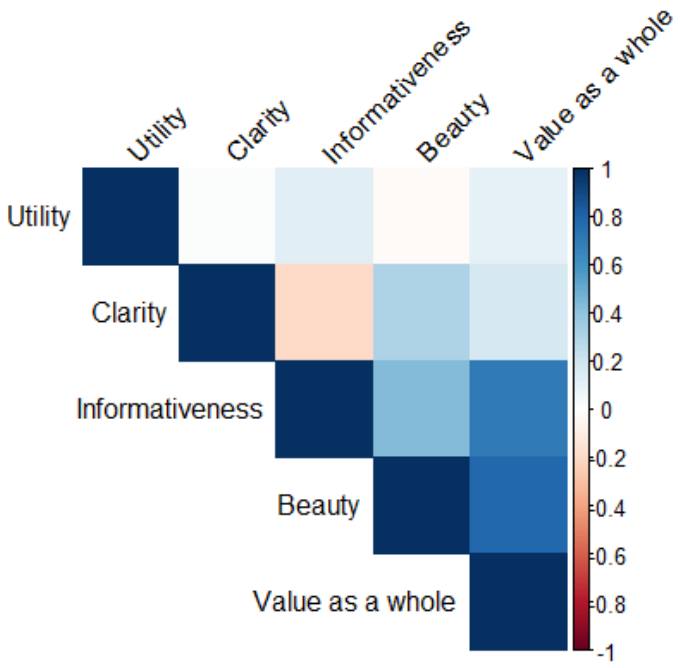



Figure 26: Corrplot of the variables

Already from the table showing the values of r, we can see the high correlation between Beauty and value as whole, as well as for informativness and value as whole. On the other hand, we can see a negative correlation between Clarity and informativeness. In addition, it should be noted that the values showing a perfect correlation are those that refer to a variable related to itself, so are not relevant.

What has just been said is evident from the corrplot, which is the graphic representation of what has just been reported in figures. In particular, using the color (from blue to red, through white), the greater or lesser correlation between the parameters subject to the questionnaire is highlighted. The boxes with shades of blue show a greater positive correlation: the more intense the blue, the greater the correlation. Conversely, those shades tending to red show a tendent negative correlation, as we can observe precisely between the Clarity and informativeness parameters.

### 7.3. User test

The user test consists of a quantitative assessment of the control and evaluation of the data viz, its efficiency and effectiveness[9].

The 12 users surveyed were asked to complete, based on the observation and interaction of the dashboard, the following tasks:

[9] Efficiency and effectiveness are two properties of data viz that are captured by the usability concept of visualization. They consist in the possibility to use the visualization in order to reach a goal proportionally to the effort required (relationship between the resources available and those used) and in complete and correct way.

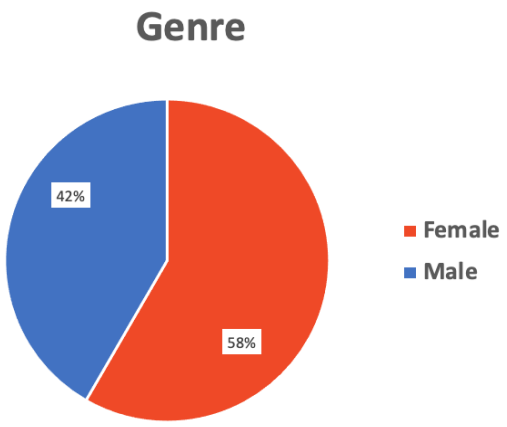
1. In reference to the first dashboard, it was asked to invite those two countries of the Asian continent that, in 2017, reached respectively the maximum and the minimum level of happiness.
2. The second task required users to look at the dashboard showing the bar charts of the 5 countries with the best and worst ranking in terms of happiness score: He wondered what was the least incisive variable on the composition of the Happiness score among the top 5 Countries and the last 5 Countries and, in particular, in which Country for each of the two graphs we observed what was required.
3. Looking at the dashboard showing the regression models of each variable with respect to the Happiness score, this is to highlight which variable was the most explanatory of the happiness score.

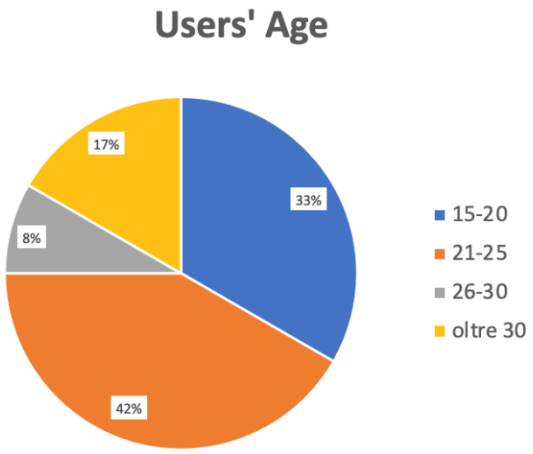
The following table shows the characteristics of the users interviewed:

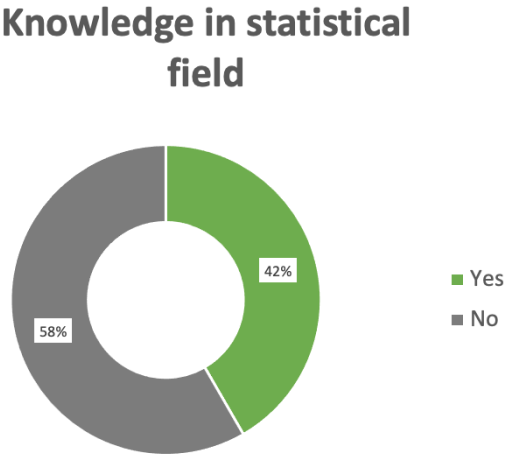
- Gender: male or female → F/M
- Age
- Expert: it means that the user know the basis of Statistics: yes or no → Y/N

| User | Gender | Age | Expert |
|---|---|---|---|
| **User 1** | F | 26 | Y |
| **User 2** | F | 17 | N |
| **User 3** | F | 23 | N |
| **User 4** | M | 24 | Y |
| **User 5** | F | 55 | N |
| **User 6** | M | 16 | N |
| **User 7** | M | 19 | N |
| **User 8** | M | 55 | Y |
| **User 9** | F | 25 | Y |
| **User 10** | F | 17 | N |
| **User 11** | F | 23 | N |
| **User 12** | M | 24 | Y |

Below are the graphs which represents as a percentage of the total of 12 users surveyed, the proportion of each characteristic associated with users.




Here we report the table on the timing and other observations associated with the performance of each task by users.

- Task successfully completed independently
- Task completed successfully asking for clarification
- Task completed with errors

| USER | TASK | Exec times | Task accomplished | N erorrs | User's comments |
|---|---|---|---|---|---|
| USER 1 | 1 | 43 sec | Yes | 0 | Difficulty in reading country names |
| | 2 | 37 sec | Yes | 0 | - |
| | 3 | 7 sec | Yes | 0 | - |
| USER 2 | 1 | 39 sec | yes | 0 | Difficulty naming the correct bar in the radial chart |
| | 2 | 21 sec | yes | 0 | Request for clarification |
| | 3 | 13 sec | yes | 0 | - |

| | | | | | |
|---|---|---|---|---|---|
| USER 3 | 1 | 40 sec | Yes | 0 | Support in using the dashboard required |
| | 2 | 55 sec | Yes | 0 | - |
| | 3 | 51 sec | Yes | 1 | Required explanation of regression concept |
| USER 4 | 1 | 42 sec | Yes | 0 | - |
| | 2 | 60 sec | No | 1 | Misunderstanding of the task |
| | 3 | 48 sec | Yes | 0 | Required explanation of regression concept |
| USER 5 | 1 | 42 sec | No | 1 | Doesn't understand you have to interact with the dashboard |
| | 2 | 57 sec | Yes | 1 | Swap components |
| | 3 | 55 sec | Yes | 1 | Required explanation of regression concept |
| USER 6 | 1 | 40 sec | No | 0 | Required support to understand whether to observe radial chart, map or both |
| | 2 | 28 sec | Yes | 0 | Required support in the task on less happy countries |
| | 3 | 50 sec | Yes | 0 | Required explanation of regression concept |
| USER 7 | 1 | 35 sec | Yes | 0 | - |
| | 2 | 51 sec | Yes | 0 | - |
| | 3 | 11 sec | Yes | 0 | Understand the concept of regression thanks to his mathematical knowledge |
| USER 8 | 1 | 64 sec | Yes | 0 | - |
| | 2 | 60 sec | No | 0 | Requires support in variable discovery |
| | 3 | 7 sec | Yes | 0 | - |
| USER 9 | 1 | 50 sec | Yes | 0 | - |
| | 2 | 42 sec | No | 0 | Required support on the meaning of the components |
| | 3 | 30 sec | Yes | 0 | - |
| USER 10 | 1 | 47 sec | Yes | 0 | Dashboard filter operation support required |
| | 2 | 32 sec | Yes | 0 | - |
| | 3 | 75 sec | No | 1 | Does not know the concept of regression and does not ask for clarification |
| USER 11 | 1 | 31 sec | Yes | 0 | |
| | 2 | 29 sec | Yes | 0 | |
| | 3 | 58 sec | No | 1 | Does not know the concept of regression and does not ask for clarification |
| USER 12 | 1 | 53 sec | Yes | 0 | - |
| | 2 | 41 sec | Yes | 0 | - |
| | 3 | 12 sec | Yes | 0 | - |

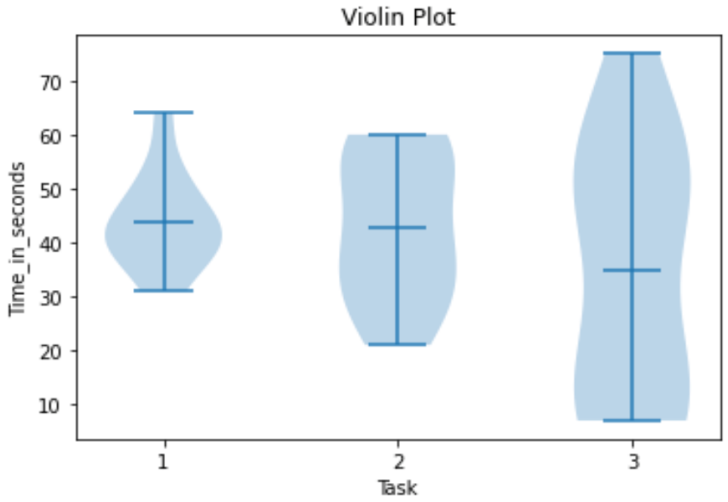



Figure 27: violin plot of the execution times of the three tasks

In figure 27 we can notice the distribution of density and the average of the times of answer to the tasks: the first demand, being that less complicated, is that one that introduces greater homogeneity in the timings: Individuals took an average of 43 seconds and most of them thickened in the range of 40-50 seconds.

Moving towards the observation of the other two tasks we notice how the average time is reduced in response 3 and this is due to the fact that an expert knows the concept of regression and therefore responds to the task much faster than non-experts. In addition, we can see that the timing distribution is much more homogeneous: in fact, violin plots almost take a rectangular shape - not 'amphora'- and wide (especially in the third request) precisely because, increasing the difficulty of the questions, The time taken to arrive at a response has increased.

This is further confirmed by the box plot of figure 28, which we show because there are represented the response times of individual users to each task. Here, the bar represents the median while “x” is the average response time.

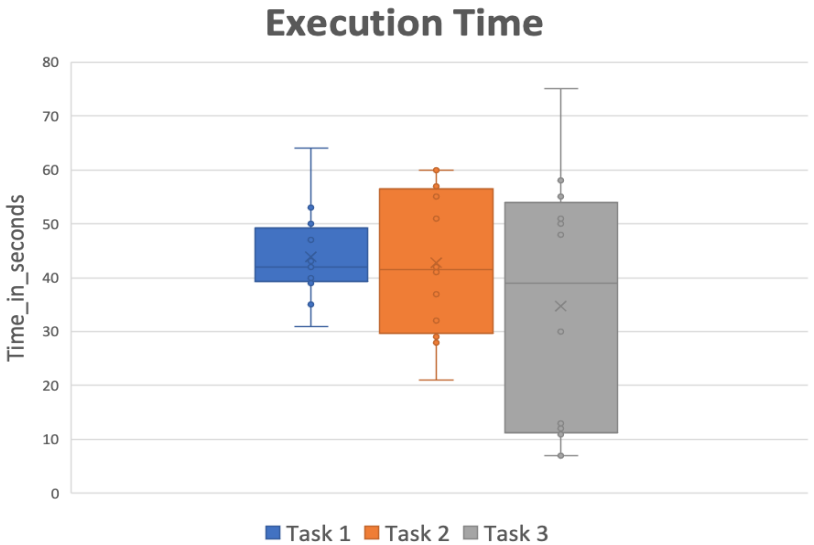



Figure 28: box plot related to the three tasks

They observe the interquartile range of the box plot and the violin plot, we can notice that it results lower in the first task. On the opposite side, the third task turns out to be the one with a greater interquartile range; this is explained because this task is the most complex as it requires basic statistical skills, in the absence of which a person has a greater difficulty in giving the answer and, consequently, needs more time to reason. For this reason, the demand appears with greater variability in response times: experienced individuals (ie those with previous knowledge) were able to respond very quickly; non-experts, on the contrary, have taken much longer and have also made many more mistakes, as we will analyse later.

Based on the collected sample, we check the efficiency and effectiveness of the visualization, i.e. the time taken to carry out a task correctly and completely[10].

We consider:

- average time completion of male vs female
- average time completion of experts vs non-experts

The Null hypothesis (H0) of the T-test is the fact that there is no difference between the averages completion times of these two sub-samples (in all the tree tasks):

- **Male vs Female**

P value and statistical significance: The two-tailed P value equals 0.9267

By conventional criteria, this difference is considered to be not statistically significant.

Confidence interval: The mean of Female minus Male equals 0.53

95% confidence interval of this difference: From -11.15 to 12.22

Intermediate values used in calculations:

t = 0.0927

df = 34

Standard error of difference = 5.751

| | Female | Male |
|---|---|---|
| **Mean** | 40.67 | 40.13 |
| **SD** | 16.00 | 18.36 |
| **SEM**[11] | 3.49 | 4.74 |
| **N** | 21 | 15 |

[10]The following web resource was used for T tests: https:///www.graphpad.com/quickcalcs/ttest1.cfm

[11] Both notes refer to the fact that the Standard Average Error (SEM) measures what is likely to be the sample average (mean) of the actual population average. The SEM is always smaller than the SD.

- **Experts vs Non experts**

P value and statistical significance: The two-tailed P value equals 0.8333

By conventional criteria, this difference is considered to be not statistically significant.

Confidence interval: The mean of Expert minus Non Expert equals -1.22

95% confidence interval of this difference: From -12.90 to 10.46

Intermediate values used in calculations:

t = 0.2121

df = 34

Standard error of difference = 5.748

| | Expert | Non Expert |
|---|---|---|
| **Mean** | 39.73 | 40.95 |
| **SD** | 18.51 | 15.86 |
| **SEM** | 4.78 | 3.46 |
| **N** | 15 | 21 |

We then tested the Effectiveness, so the correctness and Completeness of response. The collection of this data has been highlighted in the table showing the characteristics in the performance of the tasks, using the colors green, yellow and red described above. We have obtained the following results:

| TASK | Correct answers | Correct with help answers | Wrong answers |
|---|---|---|---|
| **Task 1** | 8 | 3 | 1 |
| **Task 2** | 6 | 4 | 2 |
| **Task 3** | 5 | 3 | 4 |

Graphically the proportions of the results obtained are as follows, in figure 29:

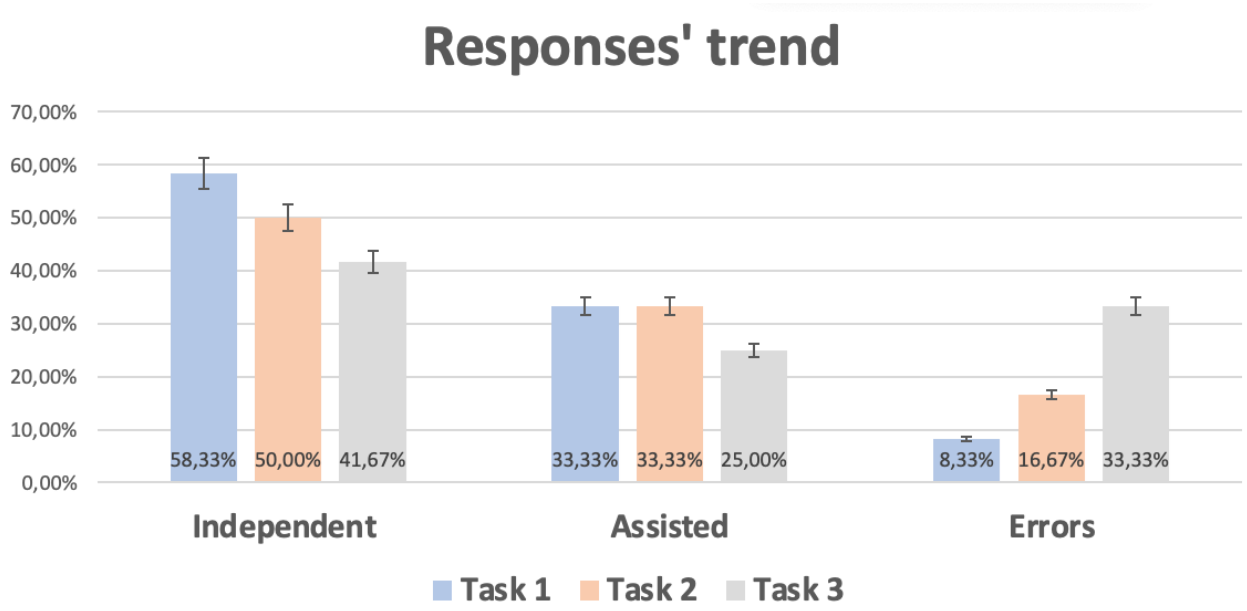



Figure 29: Responses trend

The bar chart shows what was stated above: the percentage of correct answers (and complementarily of errors) decreased between the first and third request, from a correctness of 58.33% to 41.67% in the third task.

On each rectangle there are also 5% error bars that capture the presence of intrinsic uncertainty in the measurement process of any phenomenon; the bars indicate that the percentage read should be understood with a possibility of error of +/- 5%.

To actually test this, we finally built a 2x2 contingency table to test the H0 null hypothesis, to assess that there is no association between the total number of errors made by experts in all tasks and those committed by non-experts: for each user we took the answers to all three tasks and verified whether or not they belong to the expert group.

The test results are as follows[12]

| | ***ERROR*** | ***NON ERROR*** | **TOT** |
|---|---|---|---|
| ***EXPERT*** | 1 | 14 | 15 |
| ***NON EXPERT*** | 6 | 15 | 21 |
| **TOT** | 7 | 29 | 36 |

[12] the test was carried out using the following web resource: http:///graphpad.com/quickcalcs/contingency1.cfm

The results of a Fisher's exact test[13] were not statistically significant.

The two-tailed P value equals 0.3168

The association between rows (groups) and columns (outcomes) is considered to be not statistically significant.

Therefore, since it was not statistically significant, there is no association between the mistakes made by experienced and non-expert individuals and we can conclude that the two groups of people were not influenced in any way during the response phase.

## 8. Conclusions

We can conclude by saying that the happiness of countries is an extremely multiform phenomenon, it is a concept that changes with the variation of the aspects taken into account. Certainly, as Gallup has proved by showing its report, it is a phenomenon strongly subject to citizens' expectations and contingent socio-economic circumstances. However, it should be considered that the results of an analysis of this type can vary greatly on the basis of the variables taken into account: it is not by chance, in fact, that the countries of northern Europe, on average among the happiest in the world in all the years of the analysis, are notoriously the region with the highest suicide rate in the world. This proves that happiness is an extremely relative concept, which has been analyzed here with an eye focused on socio-economic rather than psychological and social aspects.

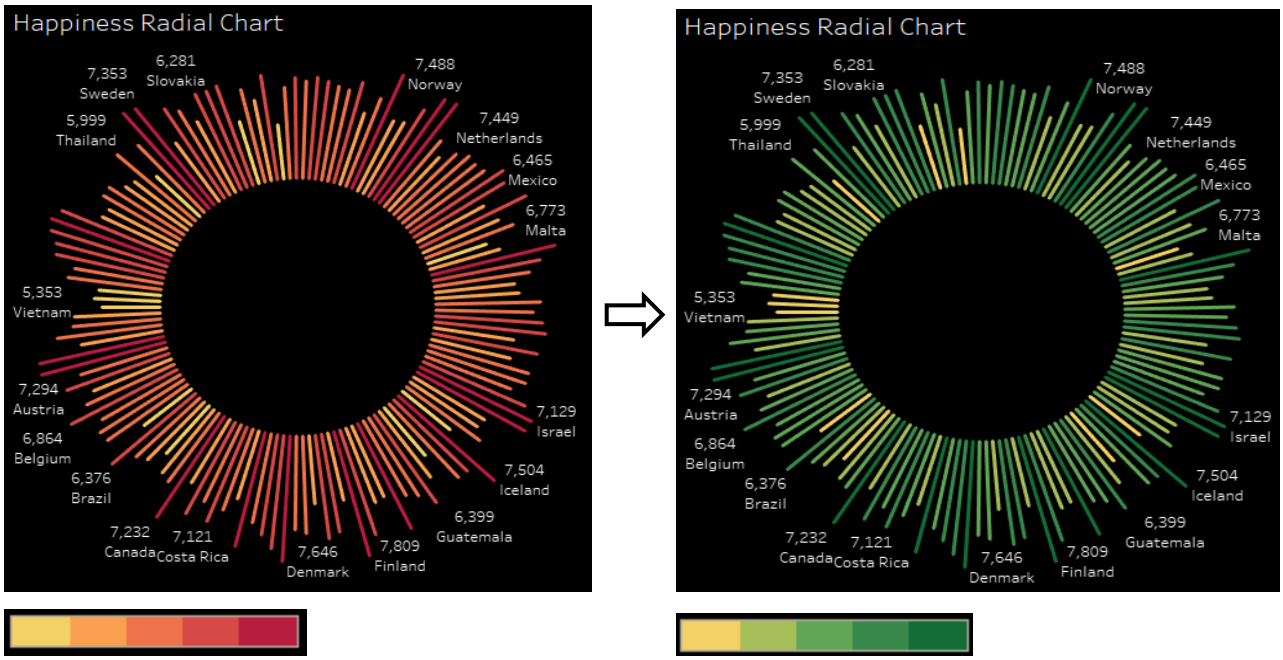
Finally, we would like to clarify when a project of this type has conveyed to us the importance of developing new forms of infographics to try to communicate the message in an efficient and original way, as well as the importance of evaluation, by experts and not of the work done. Each interviewee in fact, through his previous knowledge, sensitivity and critical eye has made improvements and suggestions that we, during the development of the analysis, had not grasped.

[13] Fisher's exact test is a statistical significance test used in the analysis of contingency tables. Although in practice it is employed when sample sizes are small, it is valid for all sample sizes. It is named after its inventor, Ronald Fisher, and is one of a class of exact tests, so called because the significance of the deviation from a null hypothesis (e.g., P-value) can be calculated exactly, rather than relying on an approximation that becomes exact in the limit as the sample size grows to infinity, as with many statistical tests. (Wikipedia)

**Appendix**

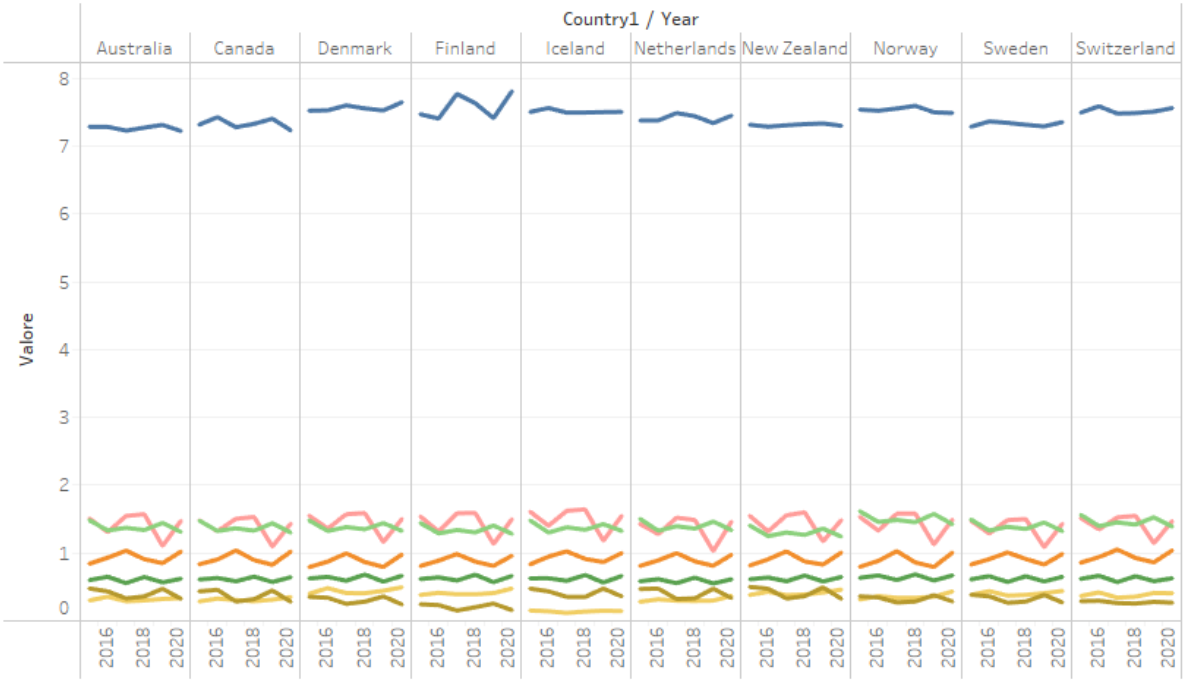
Below we report, for completeness, the graphs used to develop the heuristic test, which were the subject of comparison and, in particular, have undergone subsequent changes as a result of what was expressed by the respondents.

1.



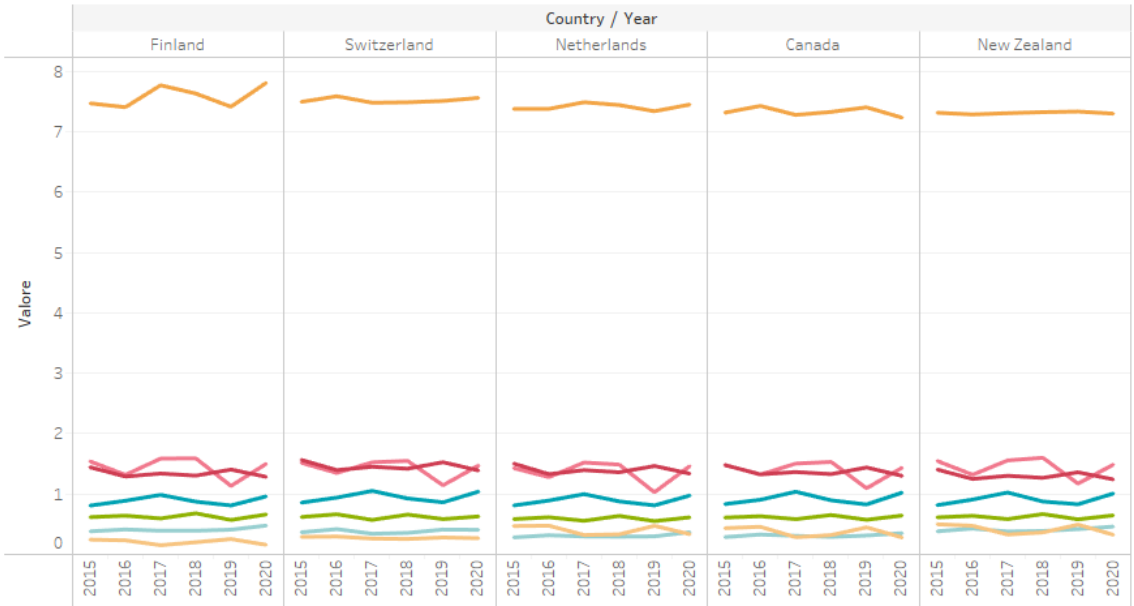

2.

Time series: happiness' components in happy top 10 and last 10 Countries




⇩

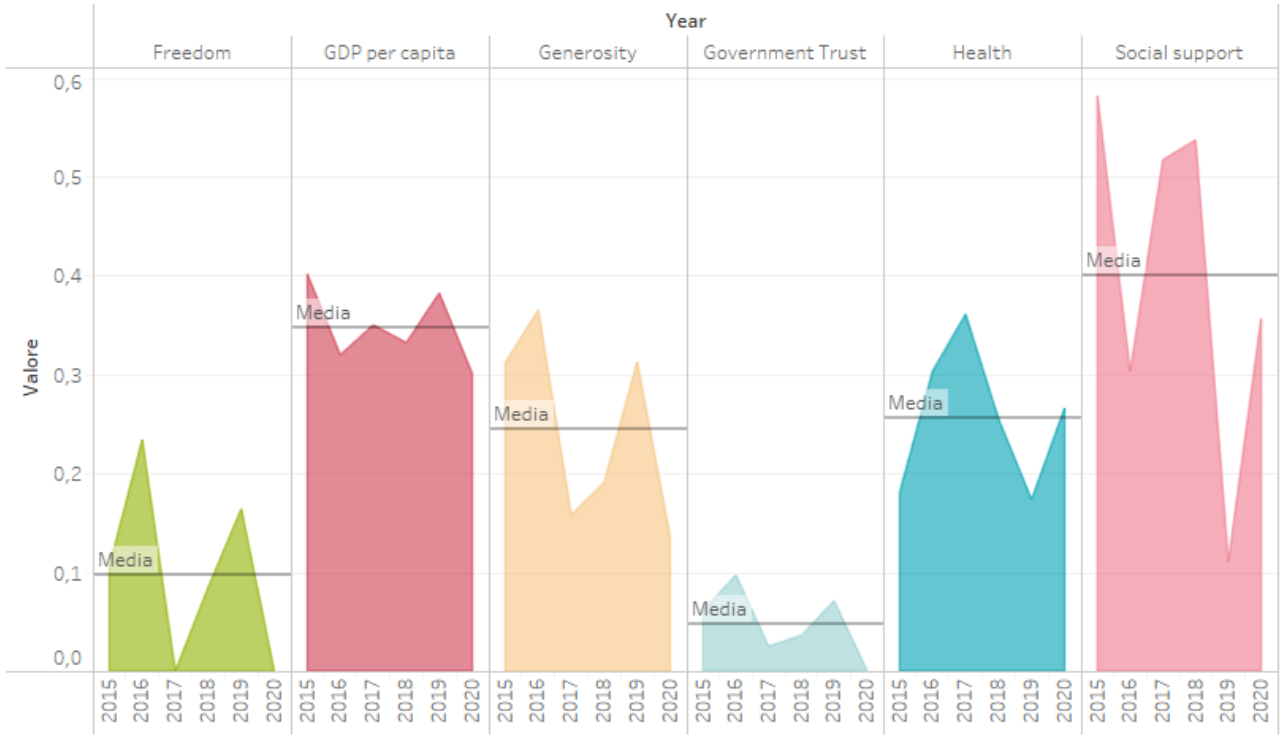
Time series: happiness' components in happy top 5 Countries

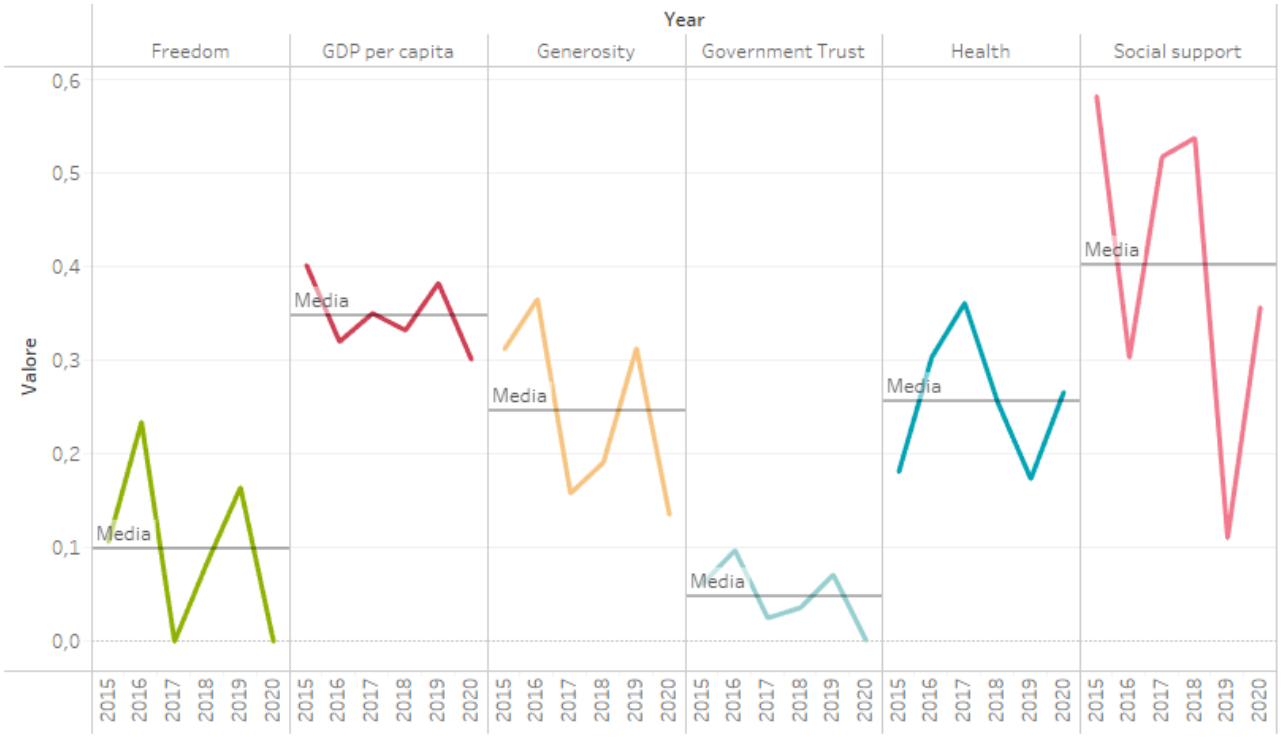



The same change has been done for the last happy Countries in the World.

3.

As for Afghanistan, the choice between line chart and area chart was proposed; the choice fell on the line chart. In addition, a preference was then expressed to the line chart showing the compound growth rate compared to the previous line chart.



## Afghanistan's Componens variantion from 2015