Explaining suicide in Italian counties

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Abstract:(da finire)

With the present work, the authors intend to create a descriptive model of economical, social and climatic characteristics of a territory, aiming to assess the impact of these factors on suicide rates. The model will be tested on Italian counties (110 observations), counting on data obtained by ISTAT.

Introduction:

Topic

Several papers have tried to propose an explanatory framework to describe how climate conditions affect individuals' mental health. Climate may affect it both directly through extreme climate change, which exposes people to trauma, or indirectly, as some climate's characteristics may affect physical activity and mental health. Extreme temperature or humidity rates have an influence on individuals' physical health as it becomes more energy consuming to do physical activity, to work or to travel, but also mental health could be negatively affected as climate erodes physical environments, which subsequently damage social environments and thus, mental condition. Health is defined by the World Health Organisation as a 'state of complete physical, mental and social well being and not merely the absence of disease or infirmity' (World health organisation, 1948). Mental health is one of the key components that define general health and it can be seen as an alteration in thinking, mood, behavior, and associated distress or impaired functioning. Usually, problems related to mental condition can be considered to be either uncommon (schizophrenia, anxiety and personal disorders) or common (depression, dementia, physiological distress). The WHO showed that among almost 90% of people who died by suicide in high-income countries at least one mental disorder was present, while those affected by more than one mental disorder were experiencing significantly higher risks of committing suicide. The relationship between mental health (and the related suicide rates) and climate still needs to be studied into details, but some scholars identified extreme heat as a factor that is often associated with a general increase in aggressive, criminal and suicide rates (Bouchama A. 2007). Humidity has also been associated with mental functioning, especially with poorer concentration and elevated fatigue. Climate change is a phenomenon which is expected to have severe consequences on the mental health of millions of people too: the threat to physical health or the potential loss of home, jobs and familiars due to catastrophic climate changes negatively affects mental condition. Sunlight is another factor, which has been documented to have direct effects on climate related health problems such as depressive symptoms, anxiety disorders, and other mental problems usually peaking in the cold season when there is limited sunlight (Magnusson 2007). The debate about the impact of climate change on human health has only very recently included considerations of mental health. Climate can have an influence on our psyche in a varieties of ways: it can directly inflict more and more natural disasters on human settlements, which, as evidence suggests, increases anxiety-related or chronic severe mental problems; climate can also increase the risk of physical injuries or health problems, which are correlated with mental health; finally, climate can endanger the natural and social environment on which people depend for their well being.

Relevance

One obvious reason why this work is potentially interesting is that mental disorders and suicide are nowadays often discussed and debated both among institution in health's field and media. Indeed, according to the latest WHO report concerning suicide prevention [see the latest report by (WHO 2014), "Globally, among young adults 15-29 years of age suicide accounts for 8.5% of all deaths and is ranked as the second leading

cause of death (after traffic accidents). Among adults aged 30-49 years it accounts for 4.1% of all deaths and is ranked the fifth leading cause of death". This statement displays clearly the relevance of this issue, which is also greater considering that these estimation are often underrated because of the difficulties in recognizing suicide as a cause of death - will of committing suicide could be not recognized, families could prefer not to speak about it, and so on (see the note by ISTAT 2012). The above mentioned paper, moreover, is considered by several OECD countries as a strong stimulus to move further in suicide prevention. Among these countries, we are going to focus on Italy, particularly at provincial level. Our convention is that a focus on smaller-than-countries environments, does help in assessing how factors affecting suicides impact differently within the same country, thus highlighting a possible variance among regions which is overlooked by country-level aggregate data. In addition to this "micro-level" focus, we also intend to stress some environmental and climatic characteristics which could contribute to create "suicide-genic" environment. In fact, according to a recently developed body of studies, there is a correlation between environmental-climatic characteristics and mental health. So, considering mental disorder as a possible driver to suicide, we include these types of variables in our study trying to widen the range of explanatory factors for the phenomenon. The above mentioned link is often not considered, as some authors like Berry, Bowen, and Kjellstrom (2009) underline, therefore we believe that including them in the present paper could deliver interesting results and perhaps stimulate further research in this branch. We also do not neglect the use of more "orthodox" variables (i.e. related to economic and social dimensions) as control variables to develop a fairly comprehensive perspective. Looking for empirical evidence from Italian data, our aim is to add knowledge to existing literature reporting specific suicide patterns in Italy, among which we will look for evidence of the magnitude of climatic and environmental factors, believing that our wide-spectrum approach makes the present work interesting and innovative. Another interesting feature is the provincial focus which allows to underscore, in the end, contingent specific characteristics of the territory rather than the whole country. What is interesting is the the fact that provinces across Italy vary greatly with respect to both socioeconomic factors such as unemployment rate, income distribution, GDP per capita, the South being on average less wealthy and more unequal than the North, and also climatic characteristics differ from region to region. Recognizing these characteristics, will hopefully provide information to policy makers for setting efficient preventive strategies at a more manageable and flexible micro-level, serving as an input for tailored and focused polices.

Research questions:

As said above, this paper will focus on the relation between suicidal behaviors (an extreme consequence of mental disorders) and various factors concerning climate (Magnusson 2007) and socio-economic context.

Regarding *climate*, we want to test if the following hypotheses hold true:

- Suicide rate in a certain Italian county increases when the average temperature is low (Bouchama A. 2007).
- Suicide rate in a certain Italian county increases when the average temperature range is high
- Suicide rate increases when precipitations happen to be frequent.

Regarding the *socio-economical framework* instead, we want to verify the following hypotheses:

- Suicide rate increases when GDP per capita is high (OECD 2013).
- Suicide rate increases according to economic inequality (represented by the gini index).
- Suicide rate increases whereby unemployment rate is higher.
- Suicide rate is higher in more populated counties.

The hypotheses we want to test originate from a careful review of the relevant literature regarding mental disorders, suicidal patterns and the magnitude of climate impact on them.

Methodology:

Sources and data gathering

For the scope of this work, data for different variables were necessary for all of the Italian counties; in particular we looked for data about temperature, temperature range, precipitations, GDP, gini's index, unemployment, population, and naturally suicides, which is our depending variable. We decided to carry out our analysis on a single year, because of the higher complexity in data gathering process and given the time constraint this research is under. To have a significant result, we believed that recent data were necessary, so we identified 2009 as an acceptable compromise between proximity in time and availability of data for all of our variables, thus all data gathered and used regard 2009. Most of the data required were founded in the Italian National Institute of Statistics (ISTAT) database, and fortunately the missing ones were available in other databases of ISTAT-related agencies or in the Eurostat database. Accessing to the ISTAT database, which is similar to the OECD one, is free and easy, and data are clear and well structured. Nevertheless, we needed to process them in order to obtain so-called **tidy data**, required by R to analyze and modeling them. We recall a definition of tidy data, according to (Wickham 2014):

1. Each variable forms a column.
2. Each observation forms a row.
3. Each type of observational unit forms a table.

Given that, we firstly collected and downloaded all the data from ISTAT website (**http://www.istat.it/it/**) and from ISTAT-related agencies' databases. For practical reasons we carried out the tidying process in Microsoft Excel. Basically, we made sure that all names of different counties were the same in all data sets we downloaded (otherwise we simply renamed the counties), as well as checking that our values were expressed in the appropriate scale, further discussed below. For instance, we decided to re-scale GDP per capita from Euro to thousands Euros, to facilitate the interpretation of our results. To sum up, we downloaded data and tidied them using Excel obtaining three data frames, namely **gdp_data**, **socio_eco_data** and **climate_data**. Then we converted them in .csv format, easily readable by R, and finally we moved into R Studio to merge these three data frames. In the end we collected 110 observations, one for each Italian county, of 9 variables.

Considered variables and analysis structure:

The variable *suicide rate* is defined by the WHO as the standardized number of deaths by suicide every 100.000 inhabitants occurred in a certain country. We collected data about suicide rate for every Italian county, from the ISTAT database.

We adopted the variable *population* as a proxy of the degree of urbanization of the area. It describes the total number of people living in the county. Carrying out our analysis, we decided to take value for population in logarithmic scale. Also in this case, we found the data about population in the ISTAT database.

Regarding the variable *GDP per capita*, we found in the Eurostat database a precious source. Nevertheless, the data provided were expressed in Euro, deemed not to provide significant impact in our linear analysis since a one-euro variation is certainly too small to impact on suicide rate. Therefore, using Excel during our data cleaning process, we expressed GDP per capita in thousands Euro, so that our coefficient will represent the impact on suicide rate caused by a variation of 1000 Euro, perhaps delivering more significant results.

The *Gini Coefficient*, is the most common measure of income inequality. It varies between 0 and 1 and expresses inequality among values of the frequency distribution of income for our target counties. Even these data were available via Eurostat, which provides the index either including households' income from the rent of owned properties or not. Since in Italy, has been culturally widespread to invest in real estate, at least until the economic crisis of 2008 and the subsequent introduction of a strong tax levied on real estate

properties, we believe that adopting the Gini index including rent might better represent the Italian context. As expected, we also notice gini's index to be slightly higher in Southern counties compared to the Center and the North.

We included in our analysis also *unemployment rate* since economical, social and psychological consequences of job loss might have an influence in mental disorders and eventually in suicidal behavior. This data, provided by ISTAT refers to the share of the labor force that is without work but available for and seeking employment.

The variable *average temperature* simply corresponds to the value of the annual average temperature in a certain county expressed in Celsius degrees. Instead, *average temperature range* corresponds to the average difference between the maximum and the minimum temperature registered in the county, again expressed in Celsius degrees. Then, *precipitations* measures the annual quantity of rain expressed in millimeters. Those data about climate are obtained from CRA-CMA, a ISTAT-related agency, particularly the department for meteorology applied to agriculture (ISTAT 2012).

Lastly, we would like to include also *solar radiation* measuring the level of solar radiance in megajoul (MJ) per square meter. The Italian Air Force offers a meteorological service, which is responsible for the measurement of solar irradiance on the Italian territory. Although we intended to use this variable, county-level data were not available, so eventually we dropped it.

We believe that a linear model was an effective way to analyze our data frame because it could give a clear idea of the impact of the selected independent variables on suicides which we chose as to be the dependent variable. As the reader will observe below, we started from a linear model including all the variables we considered, then recognizing that some variables were particularly insignificant, we opted to remove two of them obtaining a simplified model which appeared fairly significant and interesting. In the end we carried out our analysis providing two linear models, whose interpretation will be discussed further, then we enrich the statistical output with some visual displays, particularly focusing on the relationship between suicides and climatic factors.

All the data gathered will be processed using "R" (see R Core Team 2014). We use as well some packages developed for R, namely **ggplot2** (see Wickham and Chang 2014), **stargazer** (see **???**), **repmis** (see Gandrud 2014), **car** (see **???**) and **knitr** (see **???**).

Case studies:

In a previous work, we tried to test the model we will use in this analysis on regional data. However, we faced the big issue of not having enough observations, given that Italy counts 20 regions and it resulted in a statistically not significant model. Nevertheless, we were fairly confident in the goodness of our model and interested in giving an answer to our research question, we therefore decided to test it again on a sufficient number of observations. This led us to move our analysis to a county-level, thus having available 110 observations. Eventually, in the present work we take into consideration all the Italian counties.

Descriptive statistics

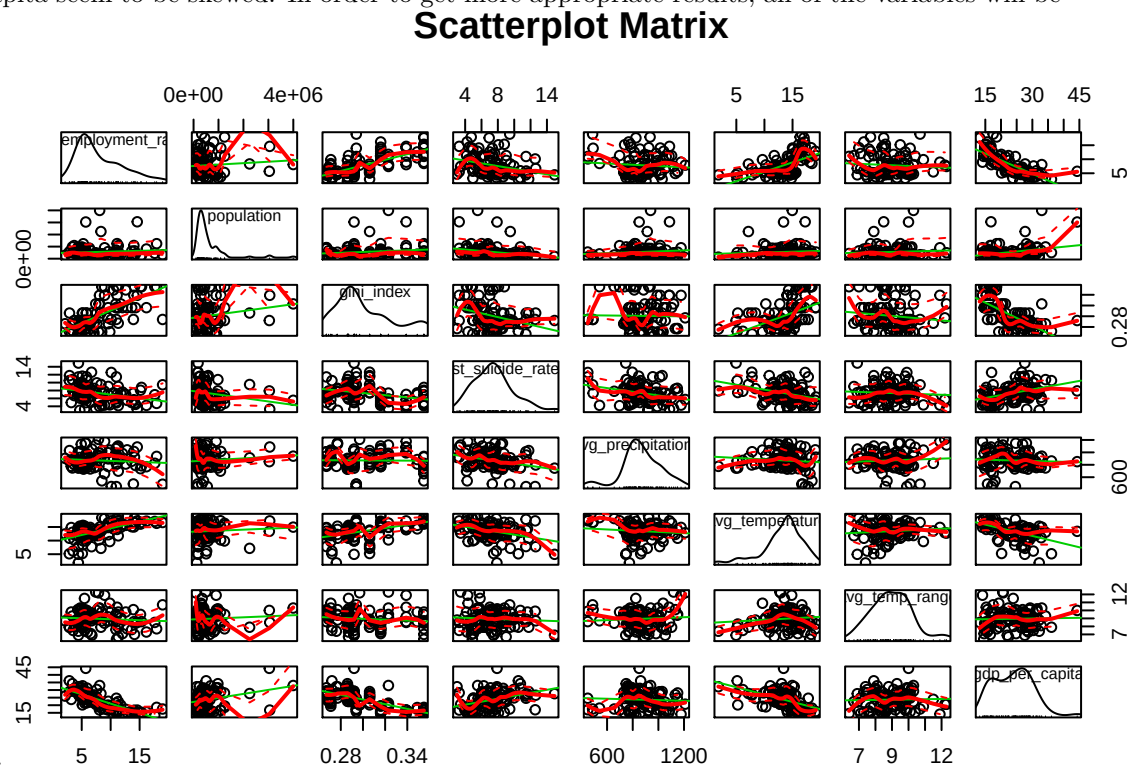
The table below presents the observations' ranging distributions of our data set. As it can be seen, the number of observations ranges from 103 to 110 observations. This is due to the fact that exactly during the year taken into consideration, i.e. 2009, some new provinces were created separating them from bigger counties. Not all of the sources we used for our data were up to date, so that the number of provinces results to be lower in some cases. By looking at the summary table created with the R studio **car** package, the assumption of great variance in both socioeconomic and climate variables across Italy is confirmed.

In order to look at the variables' distribution and find out whether we need to normalize them, we created a scatterplot matrix. From the table below, variables employment, population, gini index, average temperature

Table 1: Data Description

Statistic	N	Mean	St. Dev.	Min	Max
Unemployment rate	107	8.05	3.79	2.13	18.97
Population	110	540,306.80	582,856.20	57,329	3,997,465
Gini Index	107	0.30	0.03	0.27	0.36
St. suicide rate	108	7.49	2.68	0.00	19.19
Average precipitations	103	870.41	145.51	449.00	1,209.30
Average Temperatures	103	13.48	3.20	1.80	19.15
Average Temperature Range	103	8.95	1.16	6.40	12.30
GDP per capita	110	23.33	6.10	11.00	44.30

and GDP per capita seem to be skewed. In order to get more appropriate results, all of the variables will be log-transformed.



Proposed Model:

After having looked at the data and at their characteristics, it can be proceeded to the model estimation. As explained above, no panel data analysis will be conducted, instead we opted for an OLS estimation.

The initial model we want to estimate will therefore be the following:

$$LogStSuicideRate = \alpha + \beta_1 LogGDPPerCapita + \beta_2 LogUnemploymentRate + \beta_3 LogPopulation + \beta_4 LogGiniIndex + \beta_5 LogA$$

We use log-transformed variables, in order to correct for skewed distributions. The model should show if our initial hypothesis that standardized suicide rates of each one of the 110 Italian provinces is affected by climate and environmental factors, while other socioeconomic indicators are used as control variables. The

results of our first model estimation show that a positive and statistically significant relationship between GDP per capita and the standardized suicide rate exists, as expected. A one percent increase in GDP will increase suicide rate by 0,699 percent in Italian provinces. On the contrary, both population size and annual precipitations seem to have a negative effect on the standardized suicide rate: a one percent increase in population size and in annual precipitations is expected to decrease suicide rate by 0,174 and by 0,435 percent respectively. With regard to population size, the result seems to be contradictory, because we would expect small communities to better support and help people with mental disorders or even prevent these cases. The negative effect of population size on standardized suicide rate is therefore interesting from our point of view, and should be studied into more detail. It is common belief that suicide attempts peak during the cold and grey winter months. The negative coefficient of variable average precipitation, meaning that precipitations would actually prevent suicides from occurring, could be hard to be explained. However, recent research have demonstrated that actually suicides peak during spring and summer in most industrialized countries, rather than during the Winter months (Magnusson 2007) Bridges demonstrated that in Southern European countries suicide are more common during spring, therefore we can assume that this is true also in the Italian case. Since precipitations are more common in Winter, when suicide rates are typically lower in the Mediterranean area, average precipitations' negative coefficient confirms theory.

Table 2: Estimation of the First Model

	Dependent variable:
	St. suicide rate
GDP per capita	0.699^{***}
	(0.211)
Unemployment rate	0.086
	(0.106)
Population	-0.174^{***}
	(0.043)
Gini index	0.173
	(0.487)
Average Temperatures	-0.072
	(0.097)
Average Temperature Range	-0.066
	(0.211)
Average Precipitations	-0.435^{***}
	(0.147)
Constant	5.312^{***}
	(1.415)
Observations	103
R^2	0.372
Adjusted R^2	0.326
Residual Std. Error	0.264 (df = 95)
F Statistic	8.041^{***} (df = 7; 95)
Note:	*p<0.1; **p<0.05; ***p<0.01

Unemployment rate, gini index and variables regarding temperatures are not statistically significant, thus it was decided to run a second model dropping variable gini index, temperature range and unemployment rate. This is done in order to increase the model's reliability by getting rid of those factors that have shown not to explain variation in standardized suicide rate. The second estimation will therefore be as following:

$$LogSuicideRate = \alpha + \beta_1 + \beta_2 LogUnemploymentRate + \beta_3 LogPopulation + \beta_4 LogAverageTemperature + \beta_5 LogAveragePrec$$

As in the previous case, log variables are used, in order to correct for skewed distributions.

% Table created by stargazer v.5.1 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
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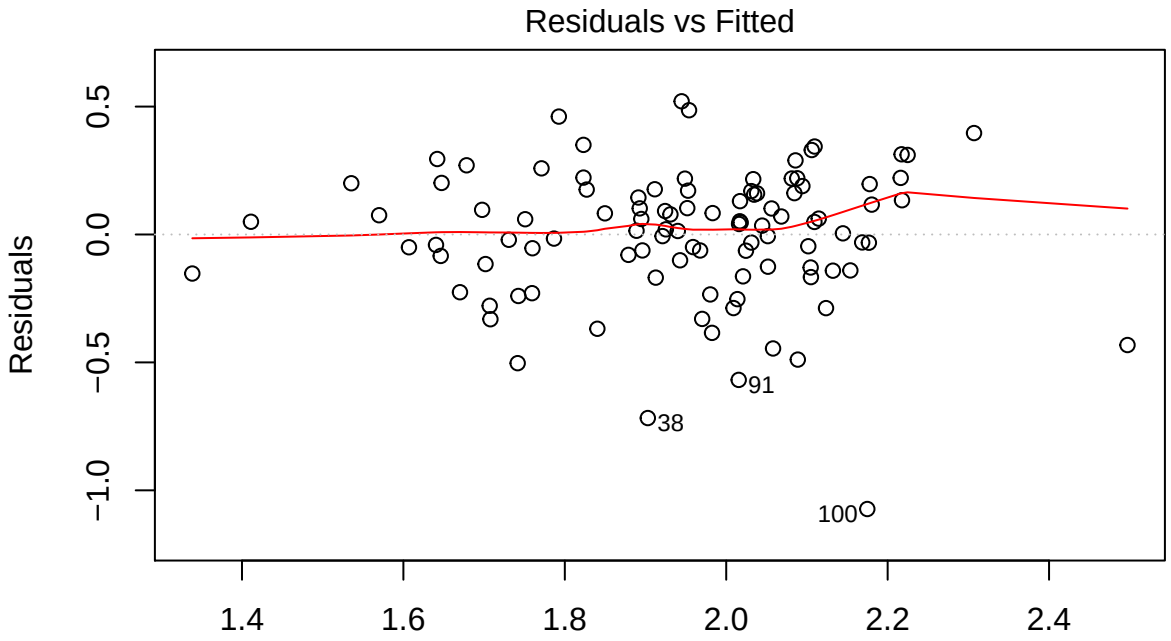
Table 3: Estimation of the Second Model

	Dependent variable:
	St. suicide rate
GDP per capita	0.529^{***}
	(0.117)
Population	-0.158^{***}
	(0.039)
Average Temperatures	-0.069
	(0.092)
Average Precipitations	-0.461^{***}
	(0.143)
Constant	5.622^{***}
	(1.123)
Observations	103
R^2	0.365
Adjusted R^2	0.339
Residual Std. Error	0.261 (df = 98)
F Statistic	14.086^{***} (df = 4; 98)
Note:	*p<0.1; **p<0.05; ***p<0.01

Compared to the first model estimation, the second one shows a higher adjusted R2 and also the significance of each individual variable has increased. A one percent increase in GDP per capita now increases the standardized suicide rate by 0,529 percent. The effect of population size is slightly reduced, the new coefficient being 0,158. A one percent increase in average precipitations now decreases suicide rates in Italian provinces by 0,461 percent.

After having interpreted the model, we test if it suffers from heteroskedasticity and if the errors are normally distributed by using the *plot* command. By looking at the following tables we can reject both: in fact, the residual versus fitted plot does not show significant signs of heteroskedasticity and also standardized residuals seem to be quite normally distributed. The model we estimated therefore seems not to suffer from any serious



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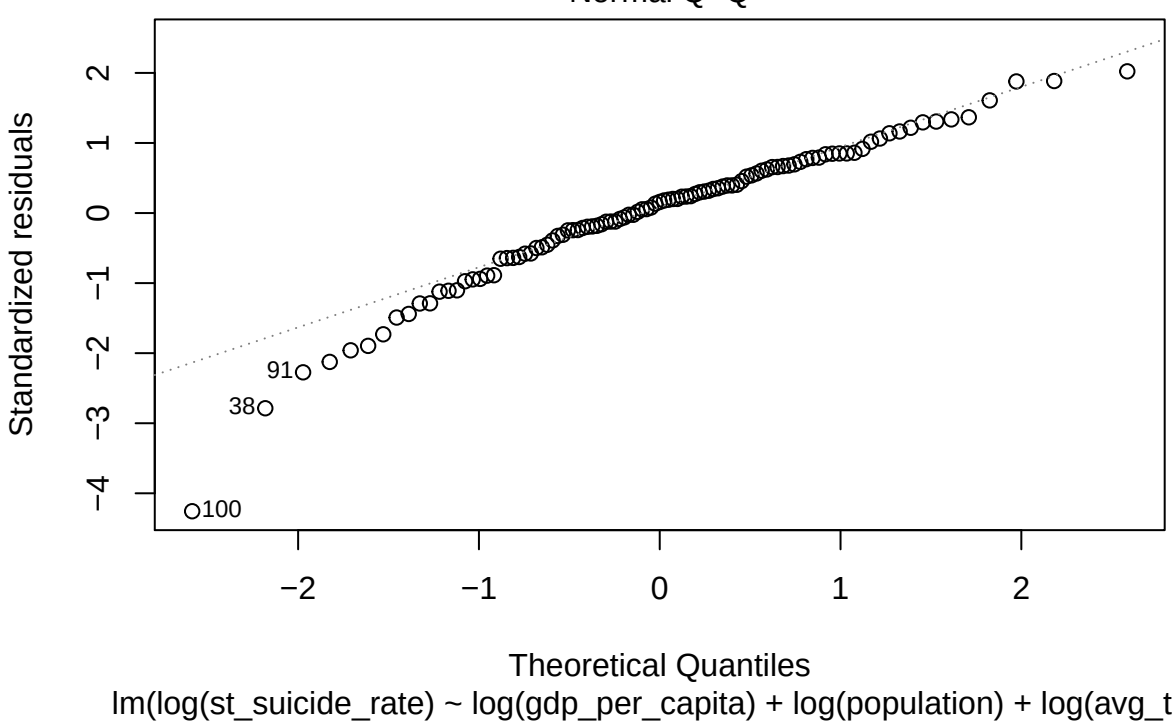
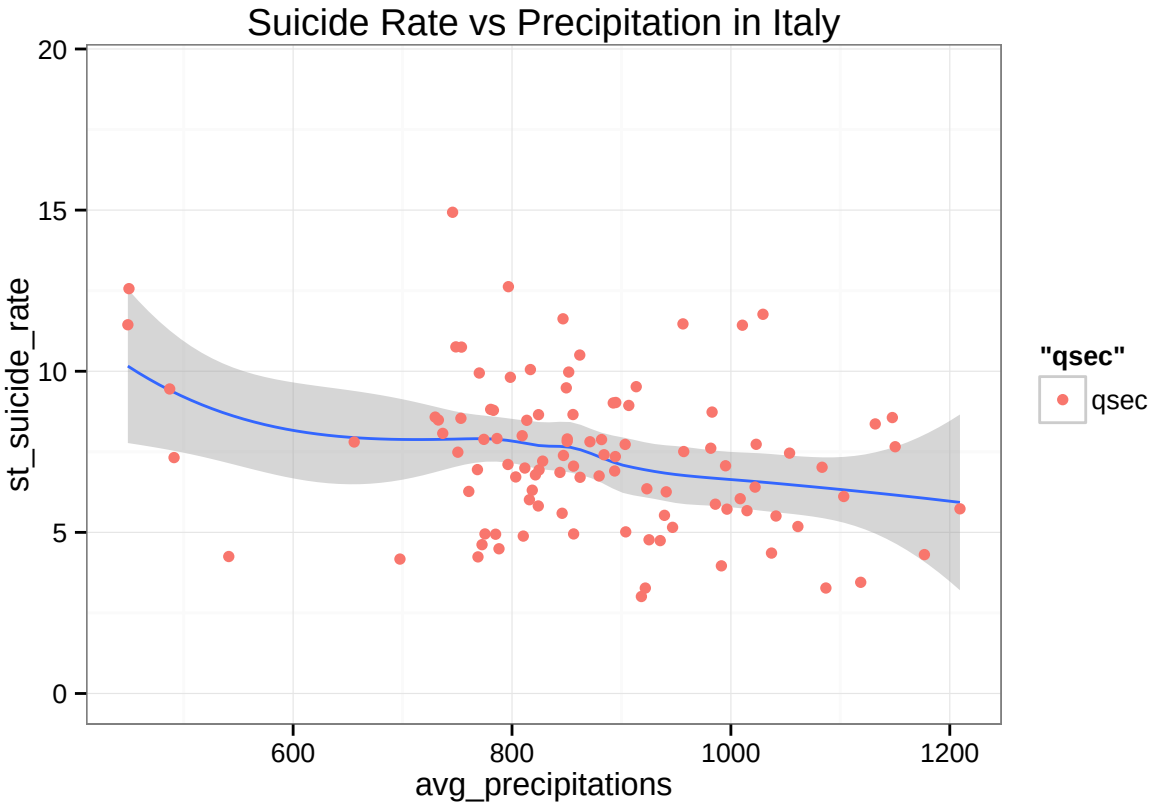


Main findings and discussion:

The goal of this research was to test if suicide behaviors are influenced by factors other than socioeconomic indicators such as unemployment rate or GDP per capita. Many researches have already demonstrated that a strong link between suicide rate and the economic and educational condition of individuals exist: overall, studies (Hilario Blasco-Fontecilla 2011) indicate that higher GDP per capita levels may actually increase suicide rates in certain regions of the world, like Latin American, Caribbean, India, and some

countries in South East Asia, while wealth has a negative impact on suicide in most of OECD countries. Apart from this, it was decided to include variables controlling for climate characteristics like yearly average temperature and precipitations and temperature range, in order to fill a research gap, since not many studies have tried to explain if climate indeed has an effect on suicidal behavior, and to test an hypothesis that the authors of this paper found to be interesting. The final estimated model we came up with after having expanded the number of observations (from the original 20 to the final 110) and after having dropped statistically insignificant variables shows that, of the climate factors we initially thought about, only average precipitations actually significantly affect standardized suicide rates across Italian provinces. Interestingly, the level of precipitations *negatively* affects suicide rate and not positively, as it is commonly believed. The magnitude of this relation (coefficient = -0,461) is not particularly strong, but the result is statistically significant. A graphical representation of the correlation is depicted below. According to the estimated model, a one percent increase in annual precipitations in one out of the 110 Italian provinces decreases the standard suicide rate of that province by 0,435 percent.

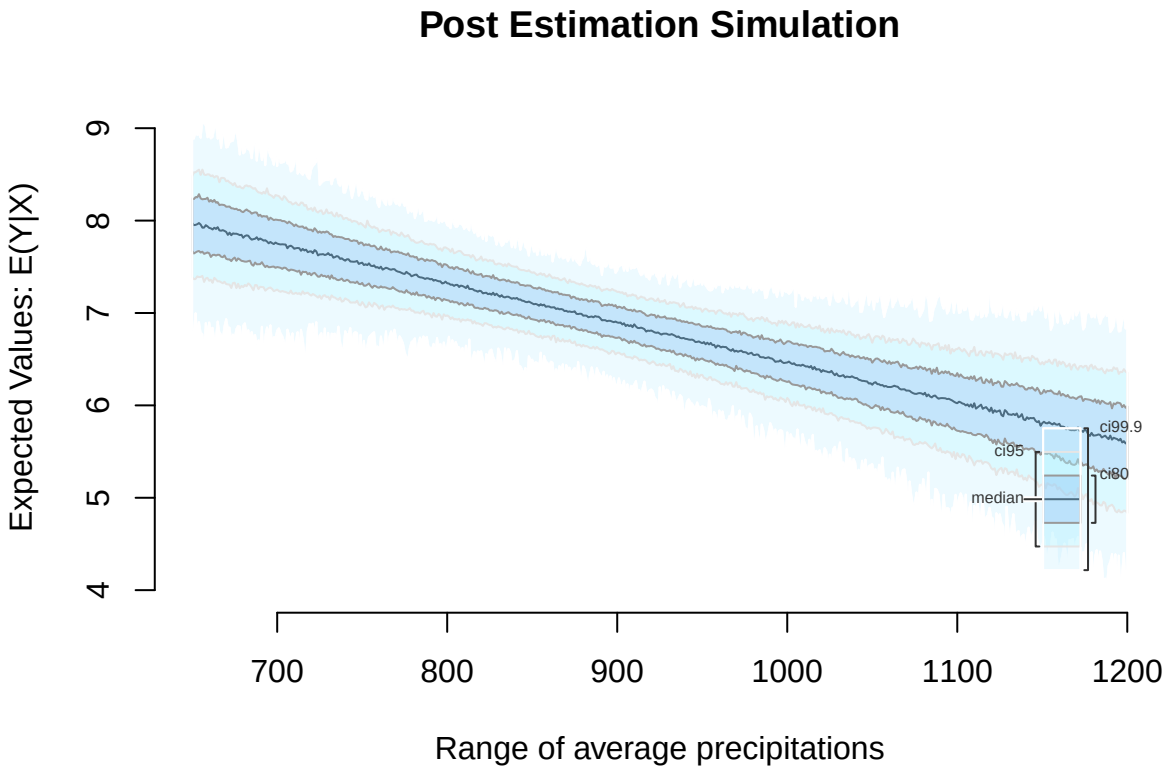


Moreover, this finding is in line with certain psychiatric theories that predict higher suicide attempts during Spring and Summer, not during Winter as most of us would tend to think. Studies have shown that especially in Southern Europe suicides are committed more often during Spring (Hilario Blasco-Fontecilla 2011), and it is therefore assumed that the same applies to Italy. Evidence from our estimated model confirms this for the Italian case.

Regarding the other variables we included in our model, only GDP per capita and population size resulted to be statistically significant. GDP per capita resulted in having a positive impact on suicide rate in Italy, a phenomenon that is not new to specialized studies in this field (Hilario Blasco-Fontecilla 2011). Also population size has a moderate impact on standardized suicide rate. In particular, a one percent increase in population size decreases suicide rate by 0,158 percent.

By using package *Zelig* a post estimation simulation was conducted by setting the range between 650 and 1200 mm of average rainfall during year 2009. The output table again shows that standardized suicide rates are expected to decrease from 8 to less than 6 deaths every 100.000 inhabitants, as precipitations increase to up to 1200 mm per year.

How to cite this model in Zelig: Kosuke Imai, Gary King, and Olivia Lau. 2014. "ls: Least Squares Regression for Continuous Dependent Variables" in Kosuke Imai, Gary King, and Olivia Lau, "Zelig: Everyone's Statistical Software," http://gking.harvard.edu/zelig



Conclusions and limitations:

In conclusion, climate factors do not have such a great impact on standardized suicide rates in Italian provinces in year 2009. Among the variables chosen to estimate the model, only annual average precipitation seems to influence suicide rate. The reason for this is that most of suicides take place in Spring and Summer, when heat and humidity affect body cooling, thus causing psychological and behavioral change, which may predispose a person to para suicidal behavior (OECD 2013). Interestingly, rain negatively affects suicide rates in Italian provinces instead of being positively correlated to suicidal behaviors, as it is commonly believed. This result is confirmed by other studies regarding this topic. In particular, researchers agree that suicides are not correlated to particularly bad weather conditions, since they rather occur during Spring and Summer months.

Overall, model's results were confirmed by psychiatric theories and evidence gathered during researches in OECD member countries. However, to get more precise and interesting results, the same research question could be applied to other developed countries, to test if the relationships between precipitations and suicide rate hold true only in the Italian context or if they also hold true elsewhere; moreover, the analysis could be extended including data of years other than 2009. In fact, this was the first year when most of OECD countries, including Italy, experienced the most severe recession since World War Two, therefore data regarding suicide rates might be biased.

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