UNDERGRADUATE RESEARCH

SUICIDE, CLIMATE, AND ECONOMY: A COUNTY-LEVEL ANALYSIS

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Abstract

This study analyzes the impact of income, unemployment, and climate on county level suicide rates in the United States. In order to ensure a robust measure of climate is applied, average temperature and average maximum temperature are analyzed. The data set used in the investigation includes observations from 1999 to 2018 for 2,892 counties. Our results show that increases in income lower the rate of suicide while increases in unemployment raise it. Higher mean and max temperatures are predicted to lower the rate of suicide.

Key Words: Climate, Income, Unemployment, Suicide

JEL Classification: I00, I12, Q55

Introduction

According to the Center for Disease Control and Prevention (CDC) (2020), from 1999 to 2018 the United States saw a 65% increase in suicide deaths, from approximately 29,100 in 1999 to 48,300 in 2018. The CDC reports that suicide is the 10th leading cause of death in the United States and is a growing epidemic. There is no one cause for the increase in suicide rates. Declining mental health and economic adversity are two of the widely proposed reasons for the increase in suicide rates. As such, many public health efforts are addressed at these two potential causes. An area of increasing interest is the impact of climate on suicide. In light of potential drastic changes to climate in the future, the role of climate in suicide has begun to draw attention from researchers and policymakers alike.

In this paper we analyze the impact of climate, income, and unemployment on the county level rate of suicide in the United States. Data analyzed are from 1999 to 2018 for 2,892 counties. Using regression analysis we find that higher rates of income lead to a decrease in rates of suicide and so do higher mean and maximum temperatures. Higher rates of unemployment are predicted to lead to increases in the rate of suicide. (A full discussion of the data analyzed can be found in the Data section of the paper.)

The paper proceeds as follows. A brief literature review highlights a selection of important research on suicide in the United States. Next the estimation strategy and data are presented. Results follow this presentation. The paper concludes by placing our results in the broader literature and discussing potential implications of our findings.

Literature Review

Case and Deaton (2017, 2020) present one of the most alarming recent trends in the United States, a steady decrease in life expectancy over the past 30 years. This decrease is due to what Case and Deaton refer to as an increase in "deaths of despair." Deaths of despair are deaths attributed to drug overdose, suicide, and alcohol-related liver mortality. The decline in life expectancy is largely due to increased deaths of despair among middle-aged white males. This trend raises many important questions because middle-aged males are not typically a group defined by lower socioeconomic status or poor mental health. One of the key properties of this trend is the correlation between education and suicide for various levels of educational attainment. Case and Deaton show that white males with lower levels of education are much more likely to commit suicide than those with a bachelor's degree or higher. This is particularly true for individuals with less than a high school diploma. Case and Deaton are unsure of the causal mechanism between education and suicide, they speculate that education could serve as a proxy for material resources, higher rates of employment, and more access to physical and mental health care.

Putnam (2020) argues that declines in social capital, and the sense of belonging and strong social support it represents, is also contributing to the increase in deaths of despair. People who have higher levels of social capital are more likely to experience a sense of belonging and support from their community reducing the likelihood to resort to suicide. Case and Deaton (2017, 2020) agree with Putnam, for instance they speculate that declining religious affiliation may be contributing to rising rates of suicide.

When analyzing suicide at the county level important geographic and community level factors are identified. Steelesmith et al. (2019) find that rural communities are likely to have high rates of suicide because less of their populations have medical insurance and there is typically easier access to gun shops. Rossen et al. (2018) also find that rural counties have higher rates of suicide than urban counties. Additionally, Rossen et al. find the suicide rate in rural counties is increasing faster than in urban counties.

Burke et al. (2018) explore the impact climate may have on suicide. Their study considers both the United States and Mexico. Using an extensive data set that begins in 1968 for the United States and 1990 in Mexico they find that higher temperatures lead to higher rates of suicide. Because of the extensive time series applied in their analysis, Burke et al. speculate that this effect will be persistent over time as global mean temperatures rise due to climate change. Their analysis suggests that climate's impact on suicide rates is comparable to "economic recessions, suicide prevention programs or gun restriction laws" (p. 723). As will be shown, our results do not match Burke et al., but as they note the relationship between climate and mental health is still not completely understood.

Estimation Strategy

In developing our estimation strategy we follow Stock and Watson's (2015) treatment of Levine, Beck, and Loayza (2000). Levine, Beck, and Loayza investigate the sources of economic growth over the long run. We use their framework to understand which long run factors may be behind county level suicide rates. We believe the county level rate of suicide is a function of economic and climate factors:

$$Suicide\ Rate = b_0 + b_1(Avg\ Per\ Capita\ Income) + b_2(Avg\ Unemployment) + b_3(Climate) + u$$

The CDC publishes the *Suicide Rate* as a county measure of suicides per 100,000 residents from 1999 to 2018, thus it is a total over this time period. The measurement of the dependent variable compels us to represent the independent variables in a novel manner. Specifically, averages of the independent variables are applied. This allows us to increase the cross-sectional variation in our sample at the expense of time-series variation. This decision was made so that small counties would be included in the sample. In the future, replicating the study with panel or time-series data would be a prudent way to investigate the robustness of these results. The independent variables we chose to use were per capita income, unemployment, and two different measures of climate: annual mean and average maximum temperatures.

b_1: Average Per Capita Income. This variable is calculated as the average per capita income for each county from 1999 to 2018. We predict that the income coefficient will be negative. A higher income will lead to lower rates of suicide. Individuals with higher incomes are more likely to be able to have access to and afford mental health resources and health care.

b_2: Average Unemployment Rate. For this variable we apply the average annual unemployment rate for each county over the years 1999 to 2018. We predict that the coefficient on unemployment will be positive. A higher rate of unemployment will lead to a higher rate of suicide. When people are able to work they are likely to have a sense of purpose and belonging.

b_3: Climate. This variable is measured in two different ways from 1999 to 2018. Average temperature is the average monthly temperature across the time frame analyzed. Average maximum temperature is the average monthly maximum temperature. Because the measures are highly correlated, only one measure is applied in an each estimation. Climate is measured in two ways as a way to ensure results are robust. Based upon Burke et al. (2018) we expected the coefficients to have a negative sign, as will be shown in the Results section, our hypothesis was not borne out in the data.

It is worth highlighting the unique role of climate in the study, it acts as both an explanatory and control variable. In the short run, policy makers are not able to alter the climate, but that does not mean they should not be aware of its relationship with the rate of suicide. Additionally, while it is possible for climate to directly impact mortality (e.g. extreme heat waves) it likely only indirectly impacts suicide. It is plausible that changes in the climate can produce adverse living conditions which diminish mental well-being and in turn impact the rate of suicide.

Data

The following table presents each variable's source (also provided in the References). All data are for the years 1999 to 2018 for 2,892 different counties in the United States. Some counties were not included in the data set due to not having measures of suicide rates. The appendix includes scatterplots of the suicide rate versus the explanatory variables.

Variable	**Source**
Suicide Rates per 100,000	The CDC wonder database (a total number of suicides between 1999-2018)
Income per Capita	U.S Bureau of Economic Analysis (measured annually between 1999-2018)
Unemployment Rate	U.S Bureau of Labor Statistics (measured annually between 1999-2000)
Maximum and Mean Temperatures	National Oceanic and Atmospheric Administration (measured monthly between 1999-2018)

Table 1
Summary Statistics of Variables

Variable	Mean	Median	Std Deviation	Minimum	Maximum
Avg. Income	32,920	31,581	8,310	16,493	148,200
Avg. Unemployment	6.159	5.970	1.871	2.420	21.21
Avg. Mean Temperature	55.09	55.20	8.245	16.57	76.51
Avg. Max Temperature	66.15	66.23	8.585	23.35	88.35
Suicide Rates	15.44	14.70	5.360	4.900	75.20

Results

In our analysis we considered the possibility of there being a linear and nonlinear relationship between the variables. In preliminary analysis both a log-log and log-linear function were considered as ways to capture a potential nonlinear relationship. Both specifications yielded the same qualitative results, so for the sake of brevity only the log-log is presented. In each of our regressions, ordinary least squares (OLS) is applied with heteroskedastic robust standard errors. In Model 1, we analyze Average Income, Average Unemployment, Average Mean Temperatures, and Suicide Rates. Results are presented in column 1 of Table 2. This model has an R^2 of 0.115 (adjusted R^2 = 0.114) and the F-statistic (49.012) is significant at the 1% level. While average income is statistically significant, it is not economically significant. Our results suggest that a $1,000 increase in average income would not alter the suicide rate. Indeed, the estimated coefficient is so small that even an increase of $10,000 would not yield a full one-unit

change. Average Unemployment is significant at the 5% level, a one point increase in unemployment is expected to cause a 0.2708 increase in the rate of suicide. The Average of Mean Temperature in this model was significant at the 1% level and indicated that a one degree increase in the mean temperature would cause a 0.1812 decrease in the rate of suicide.

Table 2 – ***Dependent Variable: Suicide Rate (per 100,000)***

Variable	(1)	(2)
Intercept	28.431*** (1.293)	28.220*** (1.426)
Average Income	-0.000*** (0.000)	-0.000*** (0.000)
Average Unemployment	0.271** (0.111)	0.244** (0.111)
Average of Mean Temperature	-0.181*** (0.020)	
Average Maximum Temperature		-0.146*** (0.020)
R^2	0.115	0.092
$\bar{R}^2$	0.114	0.091
n	2,649	2,649

Note: Standard errors are given in parentheses under the coefficients. The number of observations is denoted *n*. *** Significance at the 1% level, ** significance at the 5% level, and * significance at the 1% level.

In our second model Average Income, Average Unemployment, Average Maximum Temperatures, and Suicide Rates are analyzed. Results are presented in column 2 of Table 2. This model had an R^2 of 0.092 (adjusted R^2 = 0.091) and the *F*-statistic (40.000) is significant at the 1% level. As in Model 1, all the independent variables are significant at the 5% level. Similar to our first model, Average Income is statistically significant at the 1% level but not economically significant. The Average Unemployment was significant at the 5% level and indicates that a one point increase in unemployment would cause the suicide rate to increase by 0.2448. The Average Max Temperature was significant at the 1% level, a one degree increase in maximum temperatures would lead to a decrease by 0.1462 in the suicide rate.

Before turning to the nonlinear estimations we will discuss the economic significance, i.e. the practical impacts of a change in an independent variable on the suicide rate. In absolute value, unemployment has the largest impact. This suggests that a marginal change in the unemployment rate, more than a change in income or climate, has important impacts on individual's decision to end their lives. While none of the estimated coefficients are notably large in absolute terms, it is important to remember that the dependent variable being analyzed

corresponds to loss of life. Suicide is a tragedy and any reasonable attempt to lower the suicide rate ought to be considered.

In our third model we investigated the possibility of a nonlinear relationship between income, unemployment, climate, and suicide by taking the natural log of each variable. Results are presented in column 1 of Table 3. This model had an R^2 of 0.127 (adjusted R^2 = 0.126) and *F*-statistic (82.11) that is significant at the 1% level. Contrary to the linear models estimated unemployment is no longer statistically significant. The reader is reminded that in a log-log model the estimated coefficients represent the impact of a one percentage point change in the independent variable. For example, if income increase by one percentage point, a county's suicide rate is expected to decrease by approximately 0.446 percentage points. The impact of an increase in average temperatures is slightly higher, an approximate decline of 0.566 percentage points.

Table 3 – ***Dependent Variable: Logarithm of Suicide Rate (per 100,000)***

Variable	(1)	(2)
Intercept	9.584*** (0.507)	9.586*** (0.546)
ln(Average Income)	-0.446*** (0.039)	-0.444*** (0.039)
ln(Average Unemployment)	0.000 (0.030)	-0.014 (0.030)
ln(Average of Mean Temperature)	-0.566*** (0.049)	
ln(Average Maximum Temperature)		-0.542*** (0.058)
R^2	0.127	0.103
$\bar{R}^2$	0.126	0.102
n	2,649	2,649

Note: Standard errors are given in parentheses under the coefficients. The number of observations is denoted *n*. *** Significance at the 1% level, ** significance at the 5% level, and * significance at the 1% level.

The fourth and final model presented modifies Model 3 by replacing the natural log of the average temperature with the natural log of the maximum temperature. Results are presented in column 2 of Table 3. This model had an R^2 of 0.103 (adjusted R^2 = 0.102) and the *F*-statistic (66.678) is significant at the 1% level. The results are similar to Model 3.

One puzzling difference between the linear and nonlinear specifications is unemployment's statistical significance in the latter. The simplest explanation is that unemployment may only have a linear relationship with the suicide rate. Case and Deaton (2015)

offer another explanation, that unemployment does not impact the suicide rate. Regardless, more work is needed to understand the relationship between labor markets and the suicide rate.

Conclusion

In this study we investigate potential causal relationships between suicide and the climate, along with economic factors such as unemployment rates and income. Our results suggest that economic factors and climate impact suicide rates. More adverse economic conditions, whether in the form of lower income or higher unemployment, are predicted to increase the suicide rate. A result worth investing in is why there appears to be a linear relationship between unemployment and the rate of suicide but not a nonlinear relationship.

Counter to our initial expectations, a warmer climate is expected to decrease the suicide rate. While this result is counter to studies like Burke et al. (2018), the relationship between climate and suicide rates is far from completely understood. Our study represents simply an exploratory analysis on the matter. More research is needed.

While our results are robust, the relatively low values of R^2 and high values of regressions' intercepts suggest there are important causal channels that have not been accounted for in our analysis. Further research could seek to incorporate more county level factors such as social capital, educational attainment, and access to health care. Suicide has no one single cause.

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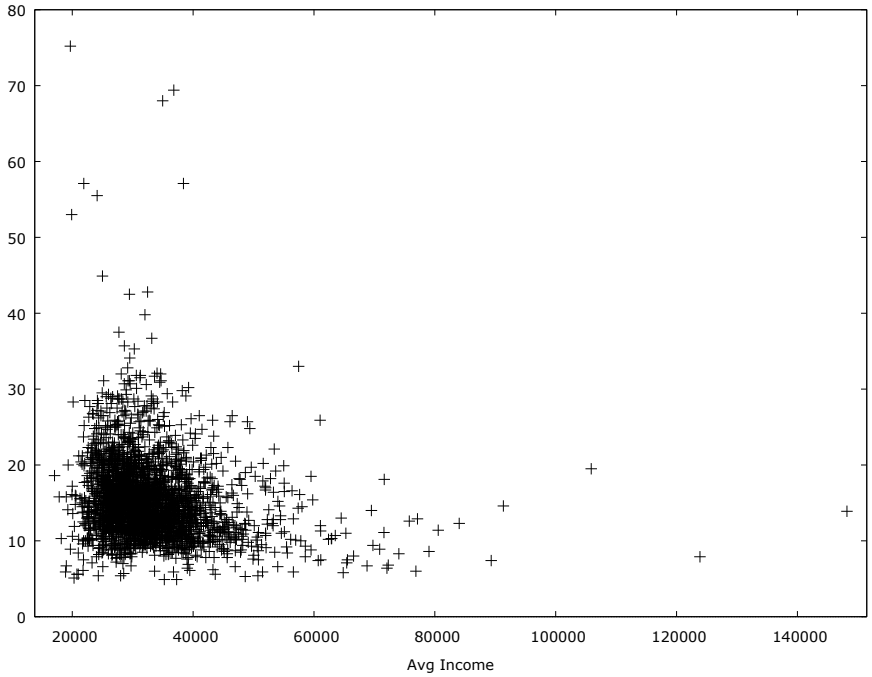
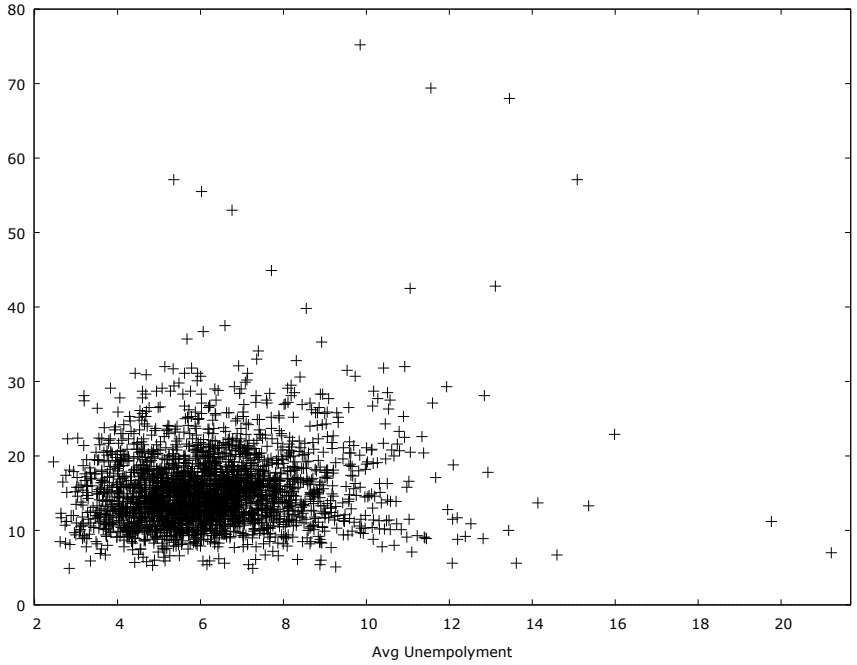
Appendix

Scatterplot of Suicide Rate versus Independent Variables

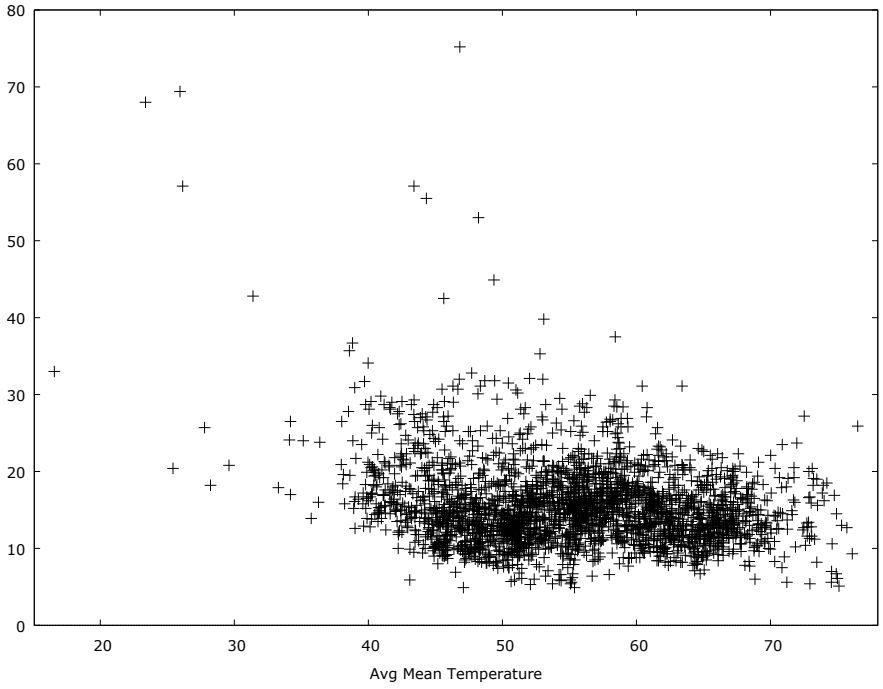
Suicide Rate and Average Income



Suicide Rate and Average Unemployment



Suicide Rate and Average Mean Temperature



Suicide Rate and Average Maximum Temperature