

On the wrong side of the grass: do GDP per capita and unemployment tell enough about suicide and what about firearms?

Fedotov Maxim*

March 2020

Introduction

In this paper I refer to suicide not only as a personal tragedy but also as a puzzle of socioeconomic development. This paper is devoted to self-harm connection to dynamics of GDP and unemployment and civil firearm holdings.

Every act of suicide is precisely unique. As I use an aggregated data on suicide and other indexes, I mostly refer to macro-regularities of worldwide suicide statistics. My first hypothesis is that the higher unemployment increases suicide rates. The second hypothesis is that GDP per capita itself doesn't explain perfectly the economic effect on suicide rates or should be treated very carefully to derive this effect. The third is that the greater number of civilian firearms holdings may increase suicide rates. The individual level of suicidal behavior, particularly its social, developmental, personal psychology parts, is the basis for my explanation of observable relationships.

I take in consideration *only* completed suicides (deaths by intentional self-harm) while suicide attempts and other cases of intentional self-harm that do not result in death are left out.

The paper proceeds as follows: Section I is devoted to Data, Section II – Findings on suicidal behavior at individual level, Section III – Macro models in academic literature, Section IV – Results of analysis regarding GDP and unemployment, Section V – Results of analysis regarding civilian-held firearms, Section VI – Conclusion.

*M.V.Lomonosov Moscow State University, 3rd year student [301]

I Data

I collected two panels for two parts of this paper. One panel contains data on 69 countries for 15 years, from 2000 to 2014. The main characteristics are following ones: *suicide rates* – deaths from intentional self-harm (per 100k population), *assault rates* – deaths from assaults (per 100k population), *unemployment* – the share of the total labor force that is without work but available for and seeking employment (ILO estimates or national estimates if available), *GDP* – gross domestic product of country (thousands of constant 2010 US\$), *GDP per capita* – same per capita, *fertility* – weighted average of live births per woman, *internet* – individuals who have used the Internet (from any location) in the last 3 months as a percentage of total country population, *secondary education* – people enrolled in secondary education as a percentage of population of appropriate age, *region* – geographical region where country is located.

Another panel contains data on 149 countries for 2 periods, 2006 and 2017. This dataset contains information about 13 characteristics for each observation: *suicides* – number of deaths from intentional self-harm, *suicides (firearm)* – number of deaths from intentional self-harm with use of firearms, *interpersonal violence* – deaths from interpersonal violence rate (per 100k population), *suicide rate* – deaths from intentional self-harm rate (per 100k population), *suicide rate (fa)* – deaths from intentional self-harm with use of firearms rate (per 100k population), *firearms* – estimates for number of civilian firearms holdings, *firearms per capita* – same per capita, *population* – estimates of population in country, *unemployment* – the share of the total labor force that is without work but available for and seeking employment (ILO estimates or national estimates if available), *GDP* – gross domestic product of country (thousands of constant 2010 US\$), *GDP per capita* – same per capita, *gross domestic savings* – gross domestic savings as a percentage of GDP, *population density* – midyear population divided by land area in square kilometers, *upper secondary education* – people enrolled in upper secondary education as a percentage of population of appropriate age, *region* – geographical region where country is located.

The data on deaths by causes estimates is represented by Institute for Health Metrics and Evaluation. [4] Actual reported suicide statistics by county is published by World Health Organisation. [19] Economic and education data is taken from World Bank Data Bank. [17] Estimates for civilian firearms holdings are represented by Graduate Institute of International and Development Studies in Geneva, Switzerland [8, 16].

In Appendix [A] I represent several figures. Box plots on suicide rates and GDP per capita by region, scatter plots for suicide rates in connection with GDP per capita and unemployment rates [Figures (1) – (4)] correspond to data for part of work without firearms. I show figures for only two years (2000 and 2013) for convenience (in 2014 there are several missing, Canada in particular). I also show densities for suicide rates and civilian firearms [Figures (5) – (6)], and scatter plots for suicide rates regarding to civil firearms holdings [Figure (7)].

II Academic literature findings at individual level

Academic literature on individual approach to suicidal behavior, suicide attempts and completed suicide highlights two major aspects of suicidal behavior: neurobiological and psychological. In this paper I don't intend to dwell on the neurobiological and psychological literature which is devoted to suicide since they are focused on individual level to improve medical practice and power of suicide attempts prediction. Nevertheless, I constitute that several basic concepts and findings worth mentioning.

Stress-Diathesis Models are significant in study of suicidal behavior. Particularly, a focus on Mann and Arango (1992) [10] model which combines neurobiology and psychopathology findings, this model is basic for research in suicidology. [13] "Stress" component of this model refers to state-dependent factors also called "proximal risk factors". It includes life events and stress, that lead to psychosocial crises, and psychiatric disorders. [11] Such factors can be triggers for suicidal behavior. [15] "Diathesis" component refers to genetic, epigenetic, developmental factors (e.g. family history of suicide, childhood abuse, personality traits).

The interpersonal theory of suicide [18] distinguishes the effects of thwarted belongingness and perceived burdensomeness on suicidal desire. Desire to engage in suicidal behavior that occurs in the presence of these two factors is considered to be the most dangerous. The capability to engage in suicidal behavior separates from the desire of suicide.

There also exist an economic theory of suicide [6] which is based on comparison of discounted expected utility of staying alive with some threshold.

In this paper I mostly refer to Stress-Diathesis Models and Interpersonal Theory of Suicide.

III Macro analysis in literature

Macro analysis of individual tragedies, suicide in particular, is the topic of social sciences. Most research is devoted to small groups of countries or even one county.

Antonio Rodríguez Andrés (2006) [1] conducted a research based on 15 European countries panel data, the author found that economic growth have a significant impact on suicide rates, while unemployment and income level don't.

There is also an example of cluster analysis on sample of BRICS countries. [5] The authors point that growth in suicide and homicide rates may occur during economic crises, and emphasize that suicide and homicide rates significantly lower in more developed regions and financial centers.

There are a few studies on interdependence between gun availability and violence or suicides. [2, 12, 14] These studies focus mostly on effect of firearm legislation changes on violence level and suicides.

IV GDP per capita and unemployment

From theoretical findings on individual level of suicidal behavior it is reasonable to assume that unemployment and GDP dynamics may affect suicide rates dynamics. Main channel of influence here is psychological component, stress in particular. In this sense GDP dynamics refers to phases of business cycles, during this phases social/individual states of mind changes. Unemployment is also this kind of staff, but also reflects spells that can deepen the depressive state of some individuals. These both facts refer to "state-dependent" factors of suicidal behavior.

Nevertheless, just one sight at graphic expression of pair relationships between dependent variable and variables is not enough in this case. If we take a look at these graphs, we cannot observe obvious interdependence between suicide rates and unemployment, suicide rates and GDP per capita.

Through estimations I found that despite suicide rates in countries are significantly correlated with GDP per capita and unemployment rates¹, fixing other important factors that affect psychological and social states of individuals leads to dramatic loss in significance of interdependence between suicide rates and GDP per capita but not between suicide rates and unemployment rates. See Table [1].

Table 1: Estimates for fixed effects model

	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI
<i>const***</i>	23.276	1.6473	14.130	0.0000	20.042	26.509
<i>unemployment**</i>	0.0680	0.0393	2.2472	0.0249	0.0886	0.1274
<i>GDP per cap</i>	0.0170	0.0512	0.3330	0.7392	-0.0834	0.1174
<i>fertility***</i>	-4.1103	0.5313	-7.7360	0.0000	-5.1533	-3.0673
<i>internet***</i>	-0.0458	0.0048	-9.6311	0.0000	-0.0551	-0.0364
<i>secondary edu.***</i>	-0.0340	0.0095	-3.5649	0.0004	-0.0528	-0.0153
<i>assaults per cap***</i>	0.0704	0.0238	2.9560	0.0032	0.0237	0.1172

Notes: Dependent variable: suicide rates. Number of observations: 861. Fixed effects model. Entity effects included. Robust standard errors. *** Indicates the significance at the 1 percent level. ** Indicates the significance at the 5 percent level. * Indicates the significance at the 10 percent level.

One possible way to cope with that is using lags for *GDP per capita* and *unemployment*. This approach may be chosen to include an effects of previous "state-dependent" factors changes on individuals further disorders and suicidal behavior. It turns out that model with first order lags is the most adequate. Using more distant lags eliminates the effect on already very few (in comparison with population size) cases of completed suicide in current period which individuals' critical pathology stage reveals in more distant previous periods. See Table [2]

¹See Appendix B

Table 2: Estimates for model with unemployment and GDP lags

	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI
<i>const</i> ***	23.394	1.7498	13.318	0.0000	19.869	26.739
<i>unemployment</i> ***	0.1686	0.0532	3.1714	0.0016	0.0642	0.2730
<i>unemployment</i> ₋₁ **	-0.1284	0.0531	-2.4181	0.0158	-0.2326	-0.0242
<i>GDP per cap</i>	0.0942	0.0844	1.1160	0.2648	-0.0715	0.2600
<i>GDP per cap</i> ₋₁	-0.0802	0.0750	-1.0691	0.2854	-0.2274	0.0671
<i>fertility</i> ***	-4.2157	0.5665	-7.4415	0.0000	-5.3279	-3.1035
<i>internet</i> ***	-0.0444	0.0052	-8.5345	0.0000	-0.0546	-0.0342
<i>secondary edu.</i> ***	-0.0303	0.0099	-3.0566	0.0023	-0.0498	-0.0108
<i>assaults per cap</i> ***	0.0759	0.0269	2.8218	0.0049	0.0231	0.1287

Notes: Dependent variable: suicide rates. Number of observations: 805. Fixed effects model. Entity effects included. Robust standard errors. *** Indicates the significance at the 1 percent level. ** Indicates the significance at the 5 percent level. * Indicates the significance at the 10 percent level.

Despite *GDP per capita* and *GDP per capita*₋₁ are still not significant even at 10% level, their p-values got greater a lot. But still the signs of these variables do not fit the theory. That's why we should carefully treat these results. The effect of unemployment on suicide rates is significant and matches the theory. The results on unemployment rates significance are equivalent to the statement that *current* unemployment rate and *difference* in unemployment rate influence current suicide rates.

The main problems here are following ones: a lot of missing values in reports of actual completed suicide cases; an excessively large number of time periods that are located very densely on a time interval (this problem occurs because of dependent variable specific features); unbalanced sample; few number of countries (entities) in sample; different suicide rates sensitivity to economic indexes for different countries/clusters of countries; GDP is a "massive" macro-indicator and may track and signal other important factors, that's why the set of regressors must be collected in a more precise way.

Including time effects helps to increase the reliability of GDP per capita one period lag but it is negotiable. See Appendix [B].

V Civilian firearms holdings

This part is based on two assumptions. First, greater civilian firearms holdings number may increase a probability of suicide attempt by giving more opportunities for that. Second, the level of violence in country negatively affects individual's development and social interactions. There may exist fascinating two-way interdependence between civilian-held firearms and a level of violence: growing number of civilian guns leads to increase in level of violence; population

assess level of violence in country as high and, thus, tends to buy more guns to secure themselves.

Table 3: Suicide and firearm models comparison

Model	1	2	3	4
Dep. Var.	Suicide rate (fa)	Suicide rate (fa)	Suicide rate	Suicide rate
No. Observations	292	215	292	215
<i>const</i>	0.8115*** (5.4921)	0.9113*** (3.1380)	13.342*** (8.0307)	16.975*** (5.0036)
<i>firearms per cap</i>	1.4600** (2.3518)	2.2026*** (2.7852)	5.7996* (1.9605)	5.0142 (1.0355)
<i>violence</i>	0.0260*** (3.5406)	0.0212*** (2.8184)	0.4329*** (3.2476)	0.3944** (2.5799)
<i>fertility</i>	-0.0006 (-0.0202)	0.0195 (0.3364)	-1.3298*** (-3.0500)	-1.9164** (-2.2896)
<i>internet</i>	-0.0019*** (-2.9642)	-0.0020* (-1.7219)	-0.0232*** (-2.7489)	-0.0245* (-1.7850)
<i>unemployment</i>	0.0077 (1.3548)	0.0131 (1.2759)	0.0674 (1.3271)	0.0523 (0.6760)
<i>GDP per cap</i>	-0.0161*** (-2.9399)	-0.0117 (-1.2578)	-0.1519*** (-3.7107)	-0.1368 (-1.6343)
<i>upper secondary</i>		-0.0022 (-1.0661)		-0.0176 (-1.1828)

Notes: Fixed effects models. Entity effects included. Robust standard errors. *** Indicates the significance at the 1 percent level. ** Indicates the significance at the 5 percent level. * Indicates the significance at the 10 percent level.

Models 1, 2, 3 support the above hypothesis, while 4 doesn't. (see Table [3]) These results must be treated carefully because of several reasons. The dependent variables are estimates, many regressors are estimates. Thus, the real covariance matrix is of more complex nature, it is better to transform standard errors in order to control over this feature. Global estimates for civilian firearms holdings are available for only 2 years: 2006 and 2017. Actual reports of suicide rates by country contain many missing values and ends in 2016². The most valuable model here is Model 3 because coefficients of all other significant variables are of signs that do not contradict the theory.

VI Conclusion

Macro analysis of suicide statistics by country should be done carefully to derive reliable results. Suicide rates may significantly vary even within country. [5] In average suicide rates are not sensitive to GDP pre capita and its lags, the most powerful result is with actual value

²WHO Mortality Database

and one period lag. The necessity of time effects is negotiable and depends on data and set of regressors quality. In this paper I found significant effect of unemployment on suicide rates. The effect gets more reliable if lags in unemployment are added, and it makes sense.

It turns out that civilian-held firearms per capita volume is positively correlated not only with suicide with use of firearm rate but also with overall suicide rate. This result is reasonable but should be treated carefully because of rough data on firearms and suicide rates. So there is a potential for further research.

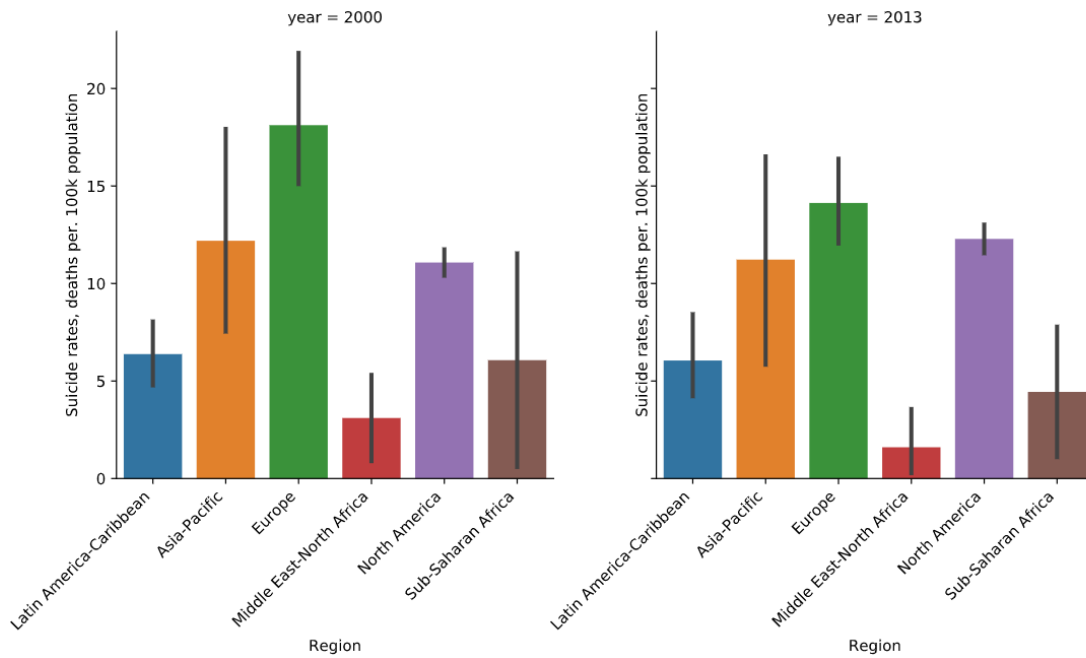
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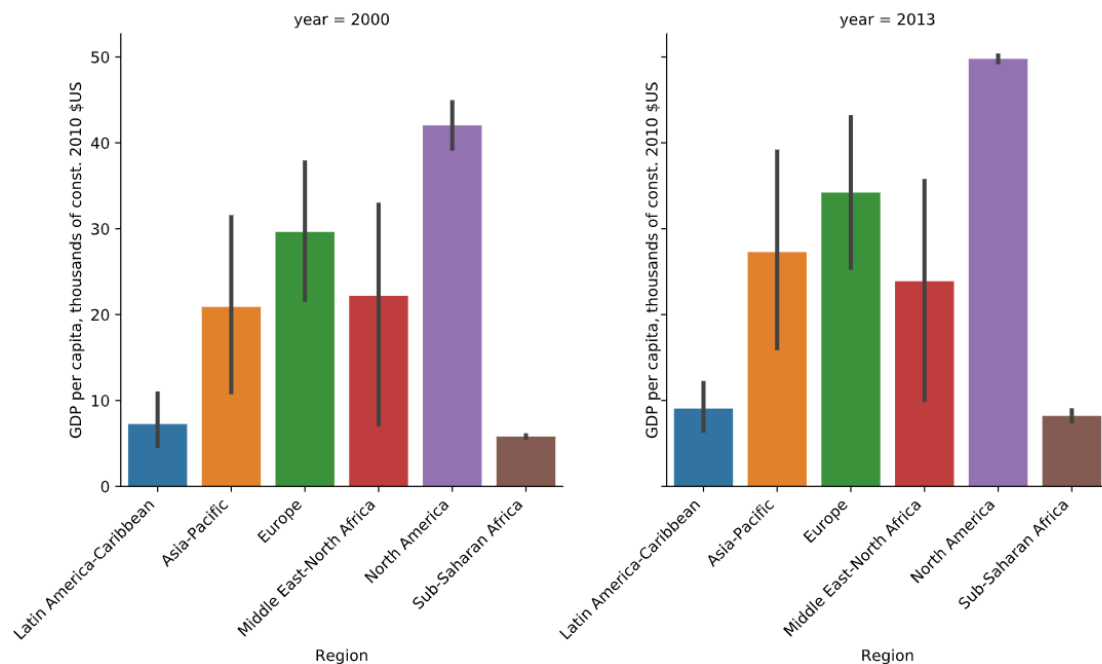
A Graph Appendix

Figure 1: Suicide rates by region (2000 and 2013)



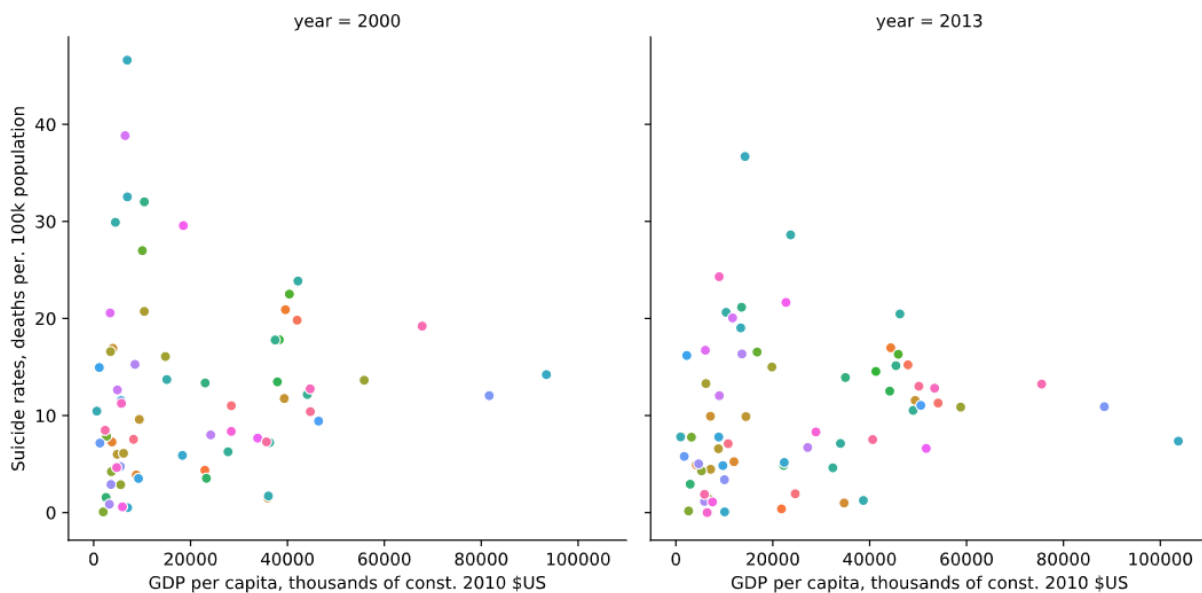
Notes: Every bar represents the average value for particular region. 95% confidence intervals.

Figure 2: GDP per capita by region (2000 and 2013)



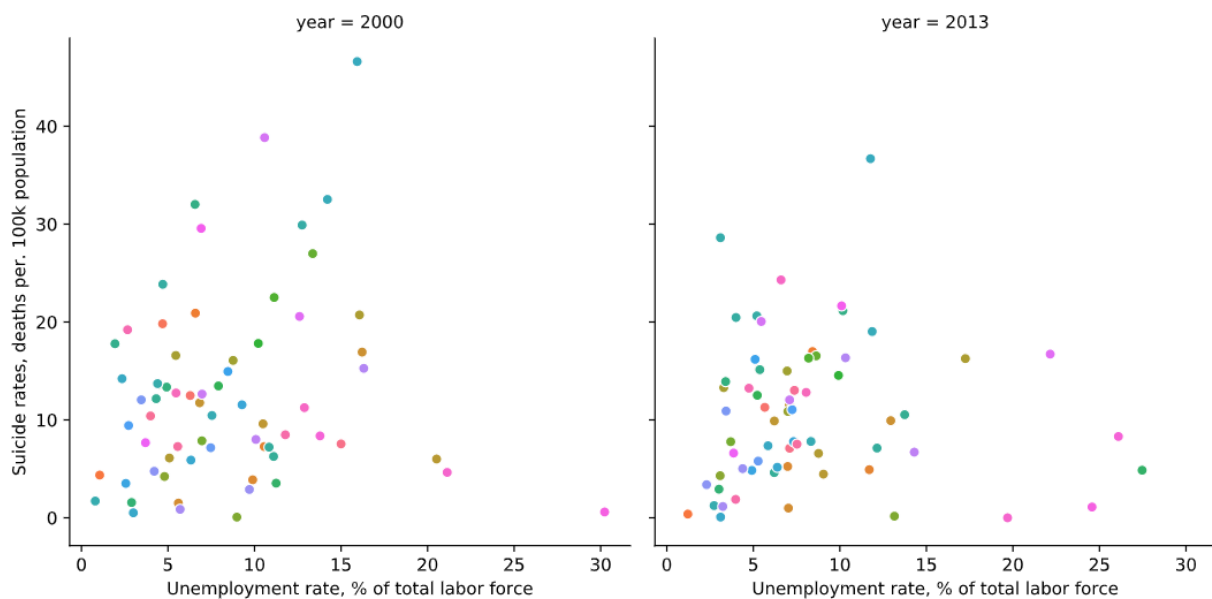
Notes: Every bar represents the average value for particular region. 95% confidence intervals.

Figure 3: Scatter plot on suicide rates regarding GDP per capita (2000 and 2013)



Notes: Every point is a particular country from the sample. Colors do not refer to any characteristic.

Figure 4: Scatter plot on suicide rates regarding unemployment (2000 and 2013)



Notes: Every point is a particular country from the sample. Colors do not refer to any characteristic.

Figure 5: Suicide rates density (2006 and 2017)

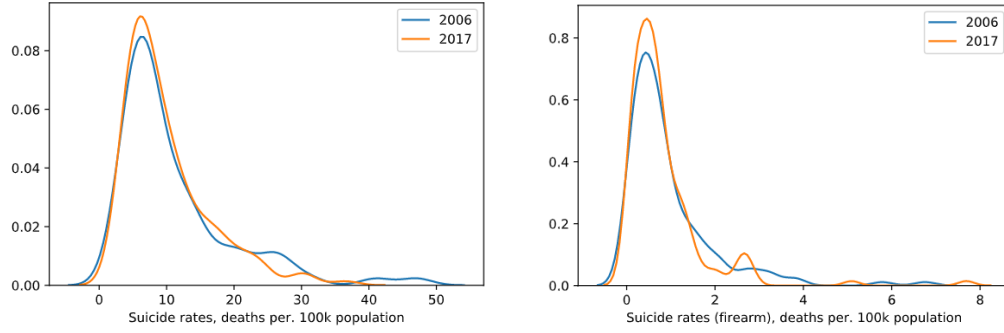


Figure 6: Civilian firearms holdings density (2006 and 2017)

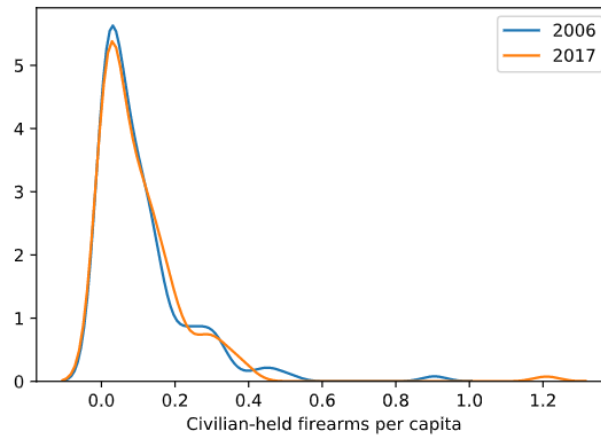
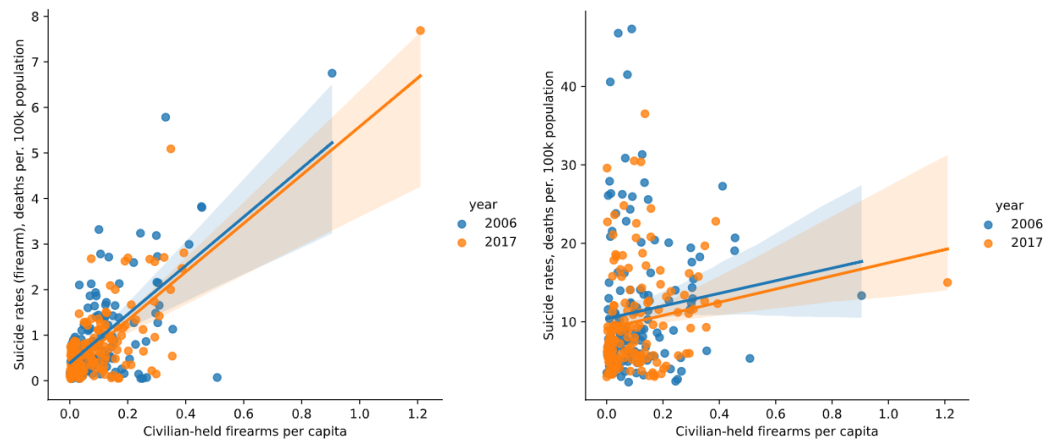


Figure 7: Scatter plots on suicide rates regarding amount of civilian firearms holdings (2000 and 2013)



Notes: Every point is a particular country from the sample. Rough linear regressions. 95% confidence intervals.

B Appendix

Tables 4 and 5 reflect correlation (fixing entity effects) between suicide rates and GDP per capita, suicide rates and unemployment rates.

Table 4: Pair regression of suicide rate on GDP per capita

	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI
<i>const***</i>	17.788	0.9936	17.992	0.0000	15.838	19.738
<i>GDP per cap***</i>	-0.2742	0.0415	-6.6081	0.0000	-0.3556	-0.1928

Notes: Dependent variable: suicide rates. Number of observations: 1033. Fixed effects model. Entity effects. Robust standard errors. *** Indicates the significance at the 1 percent level. ** Indicates the significance at the 5 percent level. * Indicates the significance at the 10 percent level.

Table 5: Pair regression of suicide rate on GDP per capita

	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI
<i>const***</i>	10.623	0.2464	43.113	0.0000	10.139	11.106
<i>unemployment***</i>	0.1117	0.0314	3.5526	0.0004	0.0500	0.1734

Notes: Dependent variable: suicide rates. Number of observations: 1003. Fixed effects model. Entity effects. Robust standard errors. *** Indicates the significance at the 1 percent level. ** Indicates the significance at the 5 percent level. * Indicates the significance at the 10 percent level.

In further table significance of time effects is negotiable.

Table 6: Estimates for model with unemployment and GDP lags

	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI
<i>const***</i>	26.213	2.0939	12.519	0.0000	22.103	30.324
<i>unemployment**</i>	0.1413	0.0568	2.4872	0.0131	0.0298	0.2528
<i>unemployment₋₁*</i>	-0.1086	0.0588	-1.8480	0.0656	-0.2239	0.0068
<i>GDP per cap</i>	0.1517	0.0971	1.5620	0.1187	-0.0390	0.3425
<i>GDP per cap₋₁**</i>	-0.1946	0.0887	-2.1946	0.0285	-0.3688	-0.0205
<i>fertility***</i>	-3.8118	0.5344	-7.1332	0.0000	-4.8610	-2.7627
<i>internet***</i>	-0.0761	0.0106	-7.1780	0.0000	-0.0969	-0.0553
<i>secondary edu.***</i>	-0.0384	0.0167	-3.5923	0.0004	-0.0594	-0.0174
<i>assaults per cap***</i>	0.0638	0.0272	2.3427	0.0194	0.0103	0.1172

Notes: Dependent variable: suicide rates. Fixed effects model. Entity effects and Time effects included. Robust standard errors. *** Indicates the significance at the 1 percent level. ** Indicates the significance at the 5 percent level. * Indicates the significance at the 10 percent level.