Economic and Climatic Determinants of U.S. Farmer Suicide

Qi Wu, Pierre Mérel, and Richard J. Sexton

Farmers around the world commit suicide at high rates relative to the general population, but factors causing farmers to commit suicide are not well understood. We study the role of economic and climatic factors in farmer suicide in the United States from 1999–2017 based on a panel of county-level data. We find that extreme heat is positively associated with farmer suicide. Chronic unfavorable economic conditions are also associated with an increase in farmer suicide.

Suicide is a perplexing societal issue. As in many other countries, in the United States, farmers commit suicide at exceptionally high rates compared to the general population. Statistics compiled by the Centers for Disease Control and Prevention (CDC) indicate that suicide rates in the United States among male, working-age farmers, ranchers, and other agricultural managers were the highest at 44.9 per 100,000 population of any occupational group in 2012 and the fourth highest at 32.2 per 100,000 population in 2015, the most recent results available.

Despite being at an increased risk of violent death, suicide in particular, farmers are significantly understudied in the area of violent workplace fatalities. Our research was designed to address the void in understanding on this critical topic by studying the role that climatic and economic factors may play in causing farmer suicides in the United States. We combined nonpublic vital statistics from the CDC, PRISM daily weather data from Oregon State University, and U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS) economic data into a county-year panel to estimate the effects of weather variables and economic factors on farmer suicides.

Summary Statistics

The CDC data do not identify suicide victims by occupation, so we use suicides committed at a farming site as a proxy. We report briefly on socio-demographic characteristics of these suicide victims during 1999–2017 based on the CDC statistics. Table 1 shows that the majority of farmers who committed suicide were white males. In 2017, 64% of U.S. farmers were males. However, about 90% of the farmers who died by suicide were males. The racial composition of farmer suicide victims in the United States is consistent with the racial composition of the farming population, with over 96% of farmer suicide victims being white. Table 2 summarizes the occurrence of farmer suicides by age. More than half of the farmers who committed suicide were 45 or older.

Table 3 shows that nearly 60% of U.S. farmers committing suicide utilized firearms, compared to 50.4% of the general population. The second most common manner of suicide for farmers was hanging, strangulation, and suffocation.

Farmer suicide has been a significant problem in California. From 1999–2017, 231 California farmers committed suicide, 5.6% of the U.S. total. California had the second-highest U.S. farmer suicide total during this period, following Texas, with 495 farmer suicides. Mirroring the national statistics, 91% of California suicide victims were male, and 93% were white. California suicide victims were somewhat younger than the national average, with 46.8% being 45 or older.

Analysis

We formulated an econometric model to analyze farmer suicides at the county level in the United States from 1999–2017, with 57,095 county-year observations in total. The variable we seek to explain is the number of farmer suicides in a county in a given year, a variable that ranges from zero to five. Explanatory variables in the model include precipitation during the growing season (defined as March 1–September 30), temperature during the growing season measured in terms of degree-days aggregated over the

Table 1. U.S. Farmer Demographics and Suicide Occurrence

	U.S. Farmers	Farmer Suicide	
Sex	**Percent**	**Number**	**Percent**
Female	36	334	10.16
Male	64	2,952	89.84
Total	**100**	**3,286**	**100**
Race	**Percent**	**Number**	**Percent**
White	95.4	4,009	96.28
Black	1.3	69	1.66
American Indian	1.7	48	1.15
Others	1.6	38	0.91
Total	**100**	**4,164**	**100**

Source: Farmer demographics: USDA NASS, 2017; Farmer suicide by sex (2003–2017) and race (1999–2017): CDC, 2019.

Table 2. Farmer Suicide Occurrence by Age Group

Age	Number	Percent
Under 24 Years	567	13.62
25–34 Years	619	14.87
35–44 Years	787	18.90
45–54 Years	925	22.21
55–64 Years	664	15.95
65 Years and Over	601	14.43
Age Not Stated	1	0.02
Total	**4,164**	**100**

Source: CDC, 2019.

growing season, and proxies for the strength of the agricultural economy in the county in each year.

Degree-days (DD) is an agronomic concept that measures the amount of exposure to temperatures conducive to crop production. In some cases, researchers separate DD into growing degree-days (GDD), intended to represent temperatures suited to crop growth, and harmful degree-days (HDD), which represent the hottest temperatures that may damage crops or harm livestock.

We chose 10 C (50 F) as the base value to compute DD. The PRISM weather data contain daily minimum, T_{min}, and maximum, T_{max}, temperatures on a 2.5 x 2.5 mile grid for the contiguous United States. We used formulas from the scientific literature to convert T_{min} and T_{max} to DD, with the basic idea being that warmer temperatures contribute greater DD and better crop growing conditions over a range of DD values, but that eventually the hottest temperatures (highest values of DD) are harmful to crops and livestock and may also have adverse psychological impacts on people. We computed DD on a daily basis for each U.S. county by aggregating across the PRISM grids within the county using cropland area weights. The daily DD were then summed across the March 1–September 30 growing season. We also estimated specifications using 8 C (46.4 F) as the base value for computing DD and also separating DD into GDD and HDD.

Precipitation levels were also available for each day at each grid cell from the PRISM database. They were then aggregated for the whole growing season and to the county level using cropland area weights.

To study the impacts of conditions in the agricultural economy on farmer suicides, we constructed indexes of economic conditions at the county-year level based upon the ten leading U.S. agricultural products according to the USDA cash value ranking: corn, soybean, wheat, hay, grapes, cattle and calves, milk, broilers, hogs, and chicken eggs. The historical national prices of the ten products from 1999 to 2017 were retrieved from USDA NASS. These prices were converted to real values (2017 dollars), and the 19-year average real price was computed for each crop, *c*. The deviation of the real price in any year *t* from the historical average measures the relative economic conditions for crop *c* in year *t*. Specifying the difference ($D_{c,t}$) in logs yields the measure in percentage terms. The index of economic conditions in a county was then constructed as the weighted sum of the $D_{c,t}$, with the weights representing the relative importance of each commodity, based upon sales value in that county.

Agriculture in some counties is animal-based, while in others, crop production dominates. Crops like corn, hay, and soybeans are significant feed inputs for animal production, meaning that high prices ($D_{c,t} > 0$), while good news for the crop producers, are bad news for livestock producers. To address this problem, we created separate indexes for crops, $I_{C,t}$, consisting of corn, soybeans, wheat, hay, and grapes, and animal products, $I_{A,t}$, consisting of cattle and calves, milk, broilers, hogs, and chicken eggs. Finally, we separated U.S. counties into those with animal-dominant agriculture, crop-dominant agriculture, and agriculture that was relatively balanced between crop and animal production.

Table 3. Farmer Suicide Occurrence by the Manner of Suicide

Manner of Death (1999–2017)	Count	Percent
Intentional Self-Poisoning	281	6.75
Hanging, Strangulation, and Suffocation	1,304	31.32
Discharge of Firearms	2,424	58.21
Jumping From a High Place	23	0.55
All Other Unspecified Means and Their Sequelae	132	3.17
Total	**4,164**	**100**

Source: CDC, 2019.

Results

We found that precipitation during the growing season was positively and statistically significantly associated with farmer suicide. However, when we decomposed counties into those that relied primarily upon rainfall for agriculture and those that relied primarily upon irrigation, we found no statistically significant effect of precipitation in the rainfed counties, where one would logically expect to find the most significant impact of precipitation, given agriculture's reliance upon it. It may be that the positive and significant effect of precipitation on farmer suicide across all counties reflects the psychological impact on farmers of cloudy, rainy, and gloomy days, an effect that has been studied considerably in the general literature on suicide, albeit without reaching a definitive conclusion.

To understand the effects of temperature (measured as DD) on farmer suicide, we chose to specify the relationship as a flexible polynomial, given the ex-ante expectation that moderate heat is beneficial for crop production and animal health but that extreme heat is harmful to both crops and animals and may be a precipitating factor in farmer suicide. We thus modeled the relationship between farmer suicide count in a county and year and DD in that county and year as a cubic function, i.e., we created variables for DD, DD^2, DD^3. The hypothesis is that moderate heat is inversely related to farmer suicide, but extreme heat, manifested primarily in

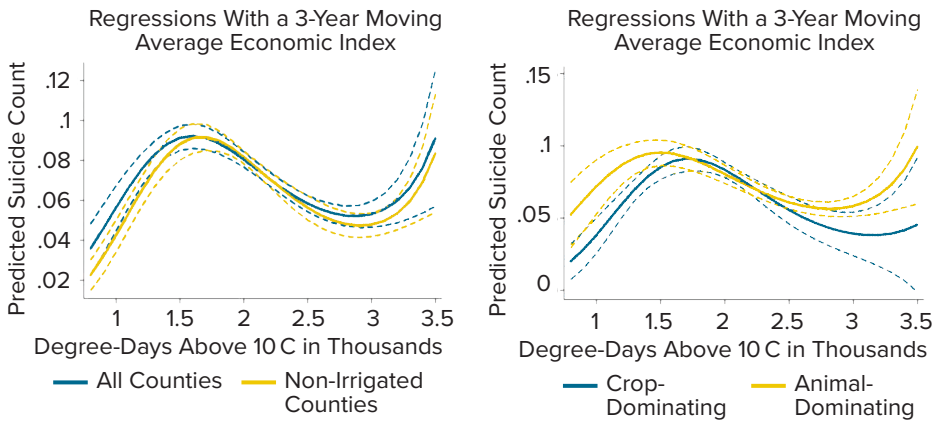
the effect of DD^3, is positively associated with farmer suicide.

Results are illustrated in Figure 1, where the left-side panel shows the cubic relationship for all counties and for non-irrigated counties only. The results are very similar. Farmer suicide is decreasing in DD over a considerable range, reflecting favorable growing conditions, but is increasing in DD for the highest temperatures. About 10% of the DD observations in the sample fall into the extreme heat category where farmer suicide is increasing in DD. Notably, the robustness of this finding was confirmed by models which separated DD into GDD and HDD, where we found that HDD, measured in terms of temperatures of 34 C (93.2 F) and higher was associated with higher farmer suicide counts.

The right-side panel compares the effect of DD for crop- and animal-dominant counties. Notably, the positive effect of high DD on farmer suicide is only present in animal-dominant counties. The hottest U.S. counties typically rely upon irrigated agriculture for crop production, and thus farmers have some ability to modulate irrigation in response to temperatures. Farmers with animal operations have less opportunity to control the impacts of extreme heat, and, moreover, may experience severe psychological impacts from seeing animals under their care and stewardship suffer, and possibly die, due to extreme heat.

Finally, we turn to the impacts of our economic indexes. A first key finding was that a model relating farmer suicide in a given year to only the economic conditions in that year produced insignificant results for the effect of economic conditions—a single bad year for the agricultural economy is not associated with higher farmer suicide counts. However, when we constructed the economic index as a three-year moving average—the average of the current year's index and the indexes from the past two years—we found a negative and statistically significant effect. Good, prolonged economic conditions in a county were associated with a reduced farmer suicide count. This effect was present for the crop index in crop-dominating counties and for the animal index in animal-dominating counties and was robust to alternative specifications of the model. For instance, a one standard deviation increase in the three-year moving average crop (animal) index is associated with a 4.67% (10.76%) decrease in farmer suicide count.

Figure 1. Relationship Between Farmer Suicide and Degree-Days



Note: Dotted lines are 95% confidence intervals.

The results, thus, suggest that it is prolonged, multi-year unfavorable economic conditions that increase farmer suicide rates. U.S. farms are often passed down through multiple generations. Multi-generational farm owners bear the pressure of preserving the family business. Loss or threat of loss of the business due to successive years of poor income is likely to exacerbate stress and self-blame emotions, which could lead to suicide.

Conclusion

Our study finds that extreme heat and chronic poor economic conditions are positively associated with farmer suicide in the United States. The effect of precipitation appears primarily due to the psychological impact of gloomy weather, not to precipitation's effects on farming operations. The high rates of both suicidal ideation and actual suicide among farmers create an imperative to understand suicide's causal factors in order to support appropriate and timely interventions by mental health professionals and agricultural service providers. We hope that our findings can support such efforts.

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Authors' Bios

Qi Wu is a 2022 UC Davis ARE department Ph.D. graduate. She is currently Xingnong Young Fellow Assistant Professor at China Agricultural University in Beijing. Pierre Mérel is a professor and Richard J. Sexton is a Distinguished Professor, both in the ARE department at UC Davis. They can be reached at qiiwu@ucdavis.edu, prmerel@ucdavis.edu, and rjsexton@ucdavis.edu, respectively.

For additional information, the authors recommend:

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