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Increases in Gross Domestic Product Decrease Working Age Population Deaths in US Counties: 2015-2019

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ABSTRACT

In this paper I investigate the link between GDP growth and deaths among the working age population. I gather economic data at the U.S. County level from the Bureau of Economic Analysis and the Bureau of Labor Statistics, and premature deaths data from Center for Disease Control. Using regression analysis, I find a strong and statistically significant negative relationship between GDP growth and premature deaths, especially once I control for other economic and religious factors. My results indicate that a 10-percentage point increase in the GDP results in 1 percentage point fewer premature deaths in the county. My literature review suggests that more active leisure time, better diet, and more health care expenditure are potential mechanisms through which GDP growth impacts premature deaths. My results suggest that it is possible to save lives through economic stimulation in low GDP areas.

Introduction

One of the most important economic indicators is Gross Domestic Product (GDP). According to the Organization for Economic Co-operation and Development, GDP is defined as the "the standard measure of the value added created through the production of goods and services in a country during a certain period" ("GDP and Spending", 2021). GDP can be calculated through two primary methods: the expenditure approach and the income approach. The expenditure approach relies on the expenditures of a party for a certain period, while the income approach relies on payments to the factors of production involved for a set period ("Calculating GDP", 2006).

While there is abundant research connecting GDP to economic indicators, there is less research on how it relates to important social and health-related outcomes. The working age population is defined as "those aged 15 to 64" ("Working Age Population", 2021) which consists of the share of the population most likely to be working. Premature deaths in this category are especially devastating from both an economic and humanitarian perspective. When considering the income approach to GDP, each premature death results in fewer workers and thus fewer people earning an income and therefore a lower GDP. More significantly, each premature death is a person who dies earlier than necessary and results in a tragic loss for their friends, families, and communities. The humanitarian effect is quantified in a study by Carter *et al.* (2007) which documents that in South Africa the death of an adult family member has a larger economic effect on poorer families.

Some prior research has examined the link between economic growth and certain subsets of premature death rate, such as suicide. A study from Europe conducted by Fountoulakis *et al.* (2014) found that there was a strong correlation between the number of suicides and economic metrics. Other studies by Chang *et al.* (2009) and Chang *et al.* (2010) corroborate this trend regarding suicide in Asia during the economic crisis of the 1990s. More broadly, Chetty *et al.* (2016) observed that wealthier individuals in the US have higher life expectancies. As a result, it would be expected that as an area economically develops, its life expectancy would increase, and as a result its premature

death rate would decrease. There is also a study by Knapp *et al.* (2019) that measures economic insecurity and the death rates at the US county level from 2000-2015. However, this study does not analyze the impacts of specific individual economic variables.

In this paper, I use econometric techniques to relate changes in GDP to changes in the premature death rate at the US county level. The data primarily come from the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the Center for Disease Control. In my analysis, I examine how the percentage change in the premature death rate amongst the working age population from 2015 to 2019 is related to changes in GDP, income per capita, the unemployment rate, and religious characteristics of the local population. I control for religion because it is social factor that has an impact on the premature death rate. Durkheim (2013) first proposed the connection between religious affiliation and suicide rates in 1897 and the connection has been ostensibly studied ever since. A review of literature conducted by Lawrence, Oquendo, and Stanley (2020) found that religious attendance helps protect an individual from suicide attempts. More generally, Sullivan (2010) found that the mortality differentials vary by religious factors. All these studies suggest that religion may play a role in the premature death rate.

My results indicate a strong and statistically significant negative relationship between GDP growth and premature deaths. Across a variety of specifications, my results indicate that an increase in GDP decreases the premature death rate. This is especially true when I control for other economic variables (GDP, income per capita, and the unemployment rate) and social variables (the number of religious adherents per congregation). The results indicate that the variables other than GDP are poor predictors of the death rate. When controlling for these other social and economic variables, a 10-percentage point increase in the GDP results in 1 percentage point fewer deaths. To put this result in another way, moving from the 10th to the 90th percentile of the GDP distribution would result in around 430 fewer premature deaths in a county.

In addition to these results, I examined several plausible mechanisms through which an increase in GDP would lead to a decrease in the premature death rate. These include a better diet, more active leisure time, and more health care expenditure. Broadly, my literature review suggests these are all possible mechanisms through which GDP impacts the premature death rate.

The paper proceeds as follows. In section two, I describe the data I collected for this analysis. I display my overall results and analysis of potential mechanisms in section three. Section four contains my conclusion and includes a discussion of study limitations and ideas for future avenues of work on this topic.

Data

The data on the deaths and population from each county come from the Center for Disease Controls. The unemployment data is from the Bureau of Labor Statistics which defines the unemployment rate as "the number of unemployed as a percentage of the labor force" ("Labor Force Statistics", 2015). Data regarding income per capita and real gross domestic product come from the Bureau of Economic Analysis. The real gross domestic product is defined as "the inflation adjusted value of the goods and services produced by labor and property located in the United States." ("Real Gross Domestic Product", 2021). The religious data comes from the Association of Religion Data Archives, which contains a survey of the number of congregations and followers of five major religions and denominations from 2010. This includes Methodists, Baptists, Catholics, Non-Denominational Adherents, and Mormons.

I calculate the following variables to assist in my data analysis. The average adherents per congregation is the total number of congregants divided by the number of congregations. The percent increase is $\frac{new\ value - old\ value}{old\ value}$ and the death rate is $\frac{deaths}{population} \times 100$.

Summary

Table 1. This table summarizes of all the key data. It shows the average, standard deviation, minimum, median, and maximum for the death rate, unemployment rate, income per capita, and GDP in 2015 to 2019. It also displays these statistics for the percent change of the same variables.

	Avg	Std	Min	Median	Max
Death Rate 2015	0.42	0.14	0.10	0.41	1.43
Death Rate 2016	0.43	0.14	0.09	0.42	1.12
Death Rate 2017	0.44	0.15	0.10	0.42	1.27
Death Rate 2018	0.44	0.15	0.07	0.42	1.21
Death Rate 2019	0.44	0.15	0.10	0.42	1.18
Unemployment Rate 2015	5.70	1.92	2.00	5.40	24.60
Unemployment Rate 2016	5.37	1.84	2.00	5.10	24.20
Unemployment Rate 2017	4.70	1.60	1.50	4.40	19.70
Unemployment Rate 2018	4.20	1.43	1.50	4.00	18.80
Unemployment Rate 2019	4.02	1.44	1.40	3.70	20.90
IPC 2015	40,095	10,945	18,162	37,947	196,854
IPC 2016	40,400	11,107	18,183	38,397	205,843
IPC 2017	41,853	11,761	18,854	39,716	227,436
IPC 2018	43,653	12,618	18,916	41,379	230,141
IPC 2019	45,190	12,984	19,472	42,785	229,825
GDP 2015	6,223,780	25,400,884	49,283	1,152,640	658,688,546
GDP 2016	6,328,114	26,002,500	48,787	1,163,771	674,110,134
GDP 2017	6,478,469	26,767,463	47,728	1,156,139	697,593,991
GDP 2018	6,671,296	27,557,319	48,196	1,179,169	708,846,321
GDP 2019	6,819,955	28,195,728	50,767	1,192,910	726,943,301
%Change Death Rate	4.99	20.72	-62.20	3.20	145.95
%Change Unemployment Rate	-28.36	12.37	-68.67	-28.57	59.09
%Change IPC	11.52	5.06	-17.24	11.21	71.41
%Change GDP	6.98	14.37	-51.94	5.87	259.73

The average GDP in 2015 is 6,223,780 and in 2019 it is 6,819,955. The average percent increase in GDP is 6.98%. The largest increase in the death rate was 145.95% in Tucker County, WV and the largest decrease was -62.20% in Matthews County, VA. The largest increase in GDP was 259.73% in Reeves County, TX while the largest decrease was 51.94% in Adams County, OH.

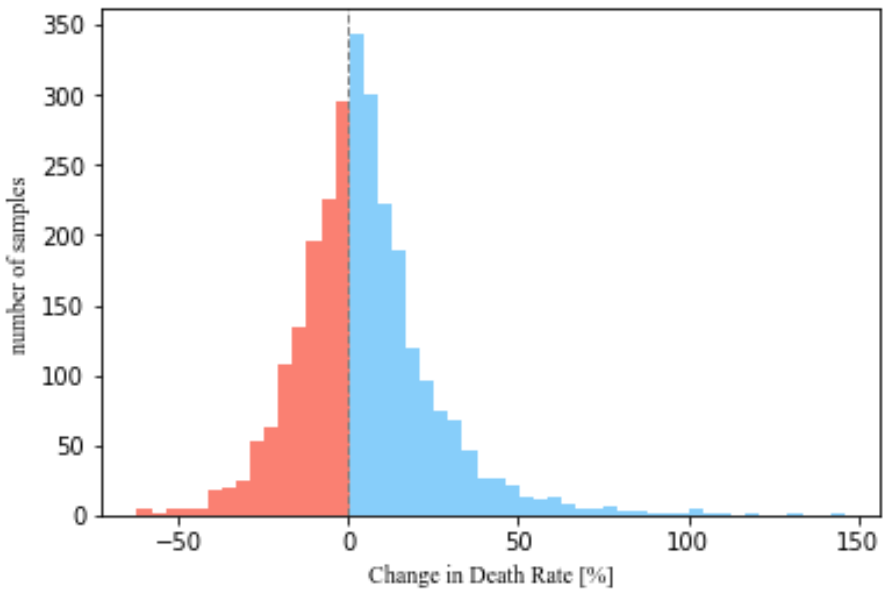

Figure 1. This histogram displays the percent change in the premature death rate from 2015 to 2019. The percent change is seen on the x axis and the number of samples is seen on the y-axis.

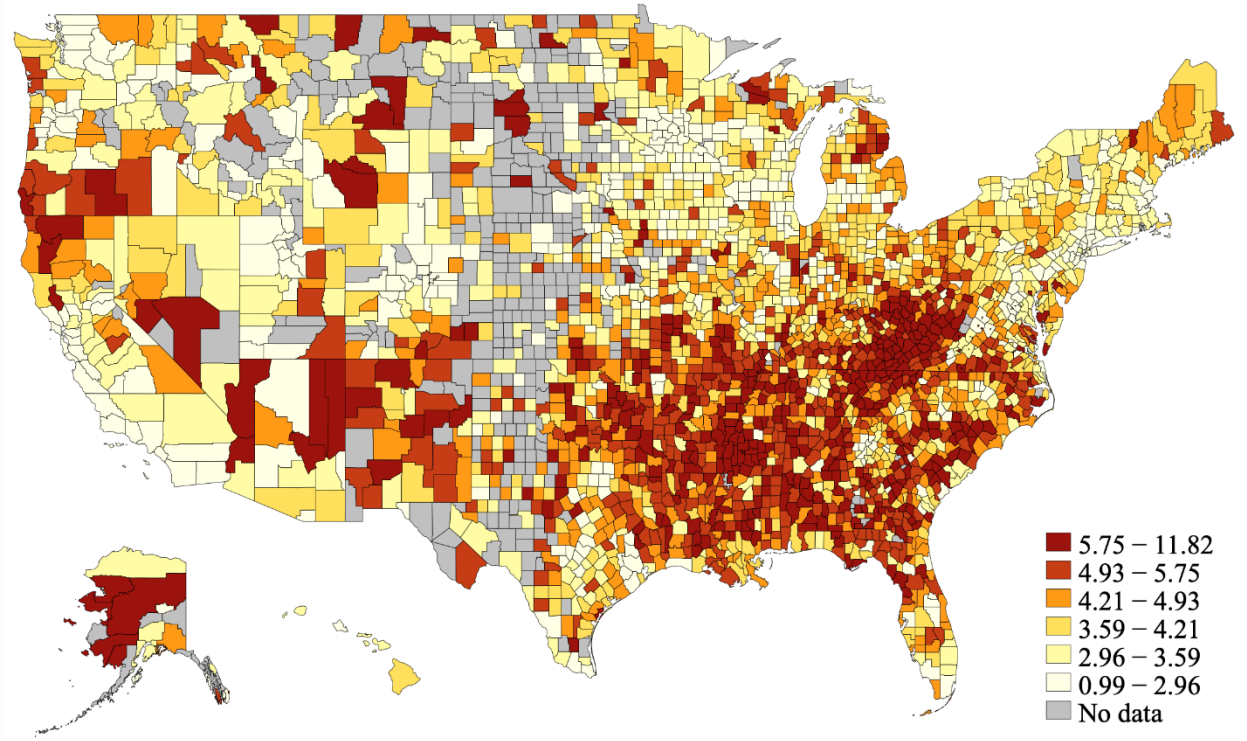

Fig 2. This map displays the death rates per thousand residents in all the counties across the US in 2019. The range varies from a high death rate to a low death rate. This corresponds to red to yellow respectively. Gray indicates there is no data for that county.

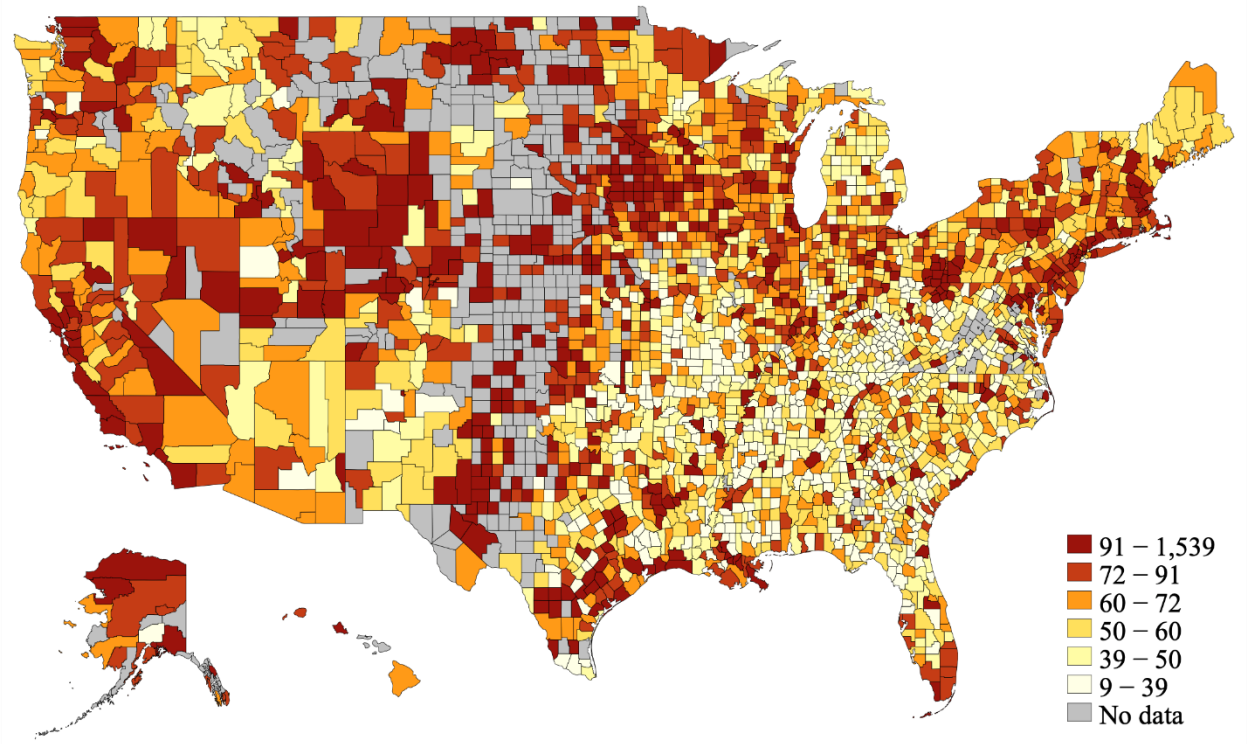

Fig 3. This map displays the GDP per capita among all the counties in the US in 2019. The range varies from a high GDP per capita to a GDP per capita. This corresponds to red to yellow respectively. Gray indicates there is no data for that county.

Fig. 1 demonstrates that increase in premature death rate is relatively normal. There are certain counties where the pre-mature death rate increased drastically (for example, 145.95% in Tucker County, WV) while there are others that experienced a large decline (-62.20% in Matthews County, VA). Investigating whether these changes are related to changes in GDP is the focus of this paper.

Fig. 2 and Fig. 3 support the idea that there is a correlation between economic situation and premature deaths. In areas of high GDP per capita, there tends to be a correlation with that same area having a low death rate. Conversely, in areas with low GDP per capita, there seems to be a high death rate. For example, the northeast has a high GDP per capita and a low death rate, while the south has a low GDP per capita and a high death rate.

Regressions

For my analysis, I will be using ordinary least squares regression. My dataset is at the county level, and I will run the following three regressions:

$$\Delta Death\ Rate_i = \beta_0 + \beta_1 * \Delta GDP_i + \epsilon_i \quad (1)$$

$$\Delta Death\ Rate_i = \beta_0 + \beta_1 * \Delta GDP_i + \beta_2 * \Delta Unemployment\ Rate_i + \epsilon_i \quad (2)$$

$$\Delta Death\ Rate_i = \beta_0 + \beta_1 * \Delta GDP_i + \beta_2 * \Delta Unemployment\ Rate_i + \delta * R_i + \epsilon_i \quad (3)$$

In these equations, i indicates each US county, $Death\ Rate_i$ measures the change in premature deaths from 2015 to 2019 in county i, and GDP_i measures the change in real GDP in county i from 2015 to 2019. Equation 1 is a univariate regression that estimates the relationship between changes in GDP and changes in the death rate. Equation 2 is a multivariate regression that includes additional controls for changes in the unemployment rate and in income

per capita. Equation 3 adds religious controls, where R_i is a vector of average number of adherents per congregation for the following religious groups: Methodists, Baptists, Catholics, Non-Denominational Adherents, and Mormons.

Results

I display the results of these regressions in Table 2.

Table 2. This table displays the results of the regressions. Colum 1 corresponds with equation 1. Column 2 corresponds with equation 2. Column 3 corresponds with equation 3.

	Change in premature deaths, %		
	(1)	(2)	(3)
Change in GDP, %	-0.05	-0.07	-0.10
	[0.03]*	[0.03]**	[0.03]***
Change in Unemployment Rate, %		-0.01	-0.02
		[0.03]	[0.04]
Change in Income Per Capita, %		0.12	0.05
		[0.09]	[0.10]
Baptists Per Congregation			0.00
			[0.00]*
Catholics per Congregation			0.00
			[0.00]
Mormons per Congregation			0.00
			[0.00]
Methodists per Congregation			0.00
			[0.00]
Nondenominational per Congregation			0.00
			[0.00]
Constant	5.33	3.94	7.91
	[0.44]***	[1.37]***	[1.72]***
Observations	2726	2726	1554
R^2	0.001	0.002	0.021

Note: *p<0.1; **p<0.05; ***p<0.01

Column 1 uses a simple linear regression to calculate and predict the percent increase in death rate from 2015 to 2019 based on the percent increase in GDP from 2015 to 2019 at the county level. A marginally significant regression equation was found (F (1,2724) = 2.972, p < .085), with an R^2 of 0.001. The county's predicted percent increase in the death rate is equal to 5.33 - 0.05(percentage points increase in death rate) when percent increase in GDP is measured in percentage points. The county's death rate decreased by .05 percentage points for each percentage point of increase in GDP.

Column 2 displays the regression when controlling for other economic factors. A simple linear regression was calculated to predict percent increase in death rate based on percent increase in GDP, percent increase in income per capita, and percent increase in unemployment rate. A significant regression equation was found (F (3,2722) = 1.61, p < .185), with an R^2 of .002. Participants' predicted weight is equal to 3.94 -.01 (percent increase in

unemployment rate) + .12 (percent increase in the income per capita) - .07 (percent increase in the GDP) (percentage points increase in death rate) when all three variables are measured in measured in percentage points The death rate decreased .01 for each percentage point of increase in unemployment rate, .12 for each percentage point of increase in income per capita, and decreased .07 for each percentage point increase in increased GDP.

When considering religious data, the model improves drastically. The percent increase in death rate based on economic data (percent increase in GDP, percent increase in income per capita, and percent increase in unemployment rate) and the religions data (average number of congregants per congregation for Baptists, Catholics, Mormons (LDS), Methodists, and Non-denominational). A significant regression equation was found ($F(8,1545) = 4.05$, $p < .001$), with an R^2 of .021. The death rate for the county was predicted to equal 7.91 -.02 (percent increase in the unemployment rate) + .05 (percent increase in the Income per Capita) - .10 (percent increase in the GDP) - 0 (number of Baptists per congregation) - 0 (number of Catholics per congregation) - 0 (number of Mormons per congregation) - 0 (number of Methodists per conjugation) - 0 (number of non-denominational per congregation) when death rate is measured in percentage points.

The death rate decreased by .02 for each additional percentage point of increase in the unemployment rate, increased by .05 for each additional percentage point of increase in the income per capita, decreased .10 for each additional percentage point of increase in the GDP. There was a negligible impact for the religious controls. While percent change in GDP alone is not significant in affecting the change in death rate, when controlling for other economic and religious factors it becomes highly significant with a p-value of .002.

Mechanisms

In the previous section, I documented that an increase in GDP is correlated with a lower death rate. In this section, I examine several possible mechanisms through which an increase in GDP would result in a lower death rate. Understanding how GDP affects the death rate has important implications for leaders trying to increase economic growth while also improving citizen's life expectancy. I will be investing in three potential mechanisms: (i) more active leisure time, (ii) better diet, and (iii) larger health care expenditures.

Active leisure time

More active leisure time is a possible explanation for why an increase in the GDP may decrease the premature death rate. The income approach to GDP defines GDP as the sum of labor income, rental income, interest income, and profits. Labor income is the largest contributor, as it comprises around 60 percent of total GDP ("Share of Labour Compensation", 2021). If labor income and active leisure time are complements, then an increase in labor income can lead to an increase in active leisure time. Meanwhile, being physically active has been linked to longer life expectancies. For these reasons, an increase in GDP can decrease premature deaths by increasing active leisure time in a population.

Various studies offer support for more active leisure time as a mechanism explaining the relationship between GDP growth and the death rate documented in this paper. In Europe, a study by Cameron *et al.* (2013) found that there was a strong correlation between countries with higher GDP per capita and the prevalence of active leisure time among adults. This idea of more wealth correlating to more exercise could correlate to the US counties. A study by the Blackwell and Clark (2016) found that adults working in managerial, professional, and teaching or social service occupations were most likely to meet the 2008 federal guidelines for physical activity while adults employed in production were the least likely to meet the guideline. Production jobs have the lowest annual wage of this group, which supports the claim that lower income results in less active leisure. As GDP increases, it would follow that more exercise would occur, and overall health would increase resulting in fewer premature deaths. Also, among the nine indicators I analyzed, the biggest predictor of weekly physical activity at the state level was money: according to Ingraham

(2018) residents of states with larger median incomes were more likely to be physically active than residents of low-income states.

Diet

Another mechanism is diet. Afshin *et al.* (2019) found that diet plays an important role in living a long and healthy life. A series of academic articles provide support for diet as a potential mechanism. One study by Minet Kinge *et al.* (2015) found from 70 countries that obesity decreases as GDP and education increases. This is corroborated with another study of 49 western countries by Nguyen Thanh Binh *et al.* (2010), that found wealthier countries had higher amounts of and compositions of polyamines in their diets. As GDP increases in these counties, there would be an expected increase in healthy eating which would decrease diet related illness that could prematurely kill someone. These illnesses include obesity, heart disease, strokes, type two diabetes, and certain types of cancers ("Poor Nutrition",2021). It would logically follow that as a US county increased its GDP, the diet of its residents would improve. When the residents eat healthier, they are less susceptible to these illnesses and less residents would therefore die prematurely.

Increased health care expenditure

A final proposed mechanism explaining the link between GDP and death rates is an increasing health care expenditure. As there is more money in the economy, more of that money can be spent on healthcare expenditures. More money spent on healthcare expenditures allows for newer

A study by Fuchs (2013) found that there is a positive correlation between the rate of growth of GDP and the rate of growth of national healthcare expenditure. As the county becomes wealthier and increases its GDP, it would be reasonably to assume that it increases its healthcare expenditure. As health care expenditure increases over time, so does life expectancy ("Life expectancy", 2017). Additionally, Alkire *et al.* (2018) observed that inadequate access to health care increases the number of unnecessary deaths as well as creates economic loss. As the economy grows, the amount of health care expenditures increases, creating more access to adequate health care and thus saving lives.

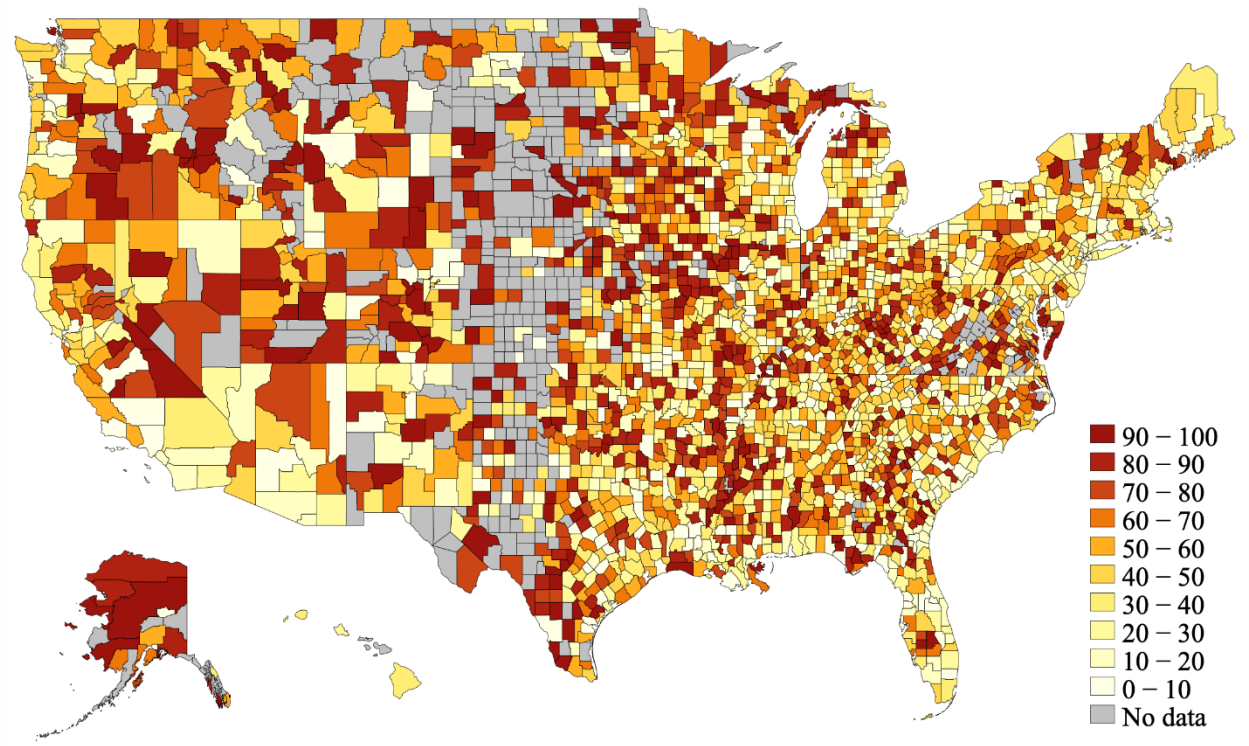

Fig 4. This map demonstrates the percent error of the expected percent increase in death rate and the actual percent increase in death rate when controlling for the economic factors. The colors range from red to yellow. Red is a higher error while yellow is a lower error. Gray counties indicate there is no data. The high error counties appear in clusters.

Conclusion

In this paper, I examine the link between GDP growth and premature deaths of the working age population. My results indicate that GDP increases result in a decrease in the premature death rate of the working age population, especially once I control for other economic and social factors. These results are significant because they highlight a key relationship between economic growth and standards of living and suggest that improved economic performance may be a way to save lives in high death rate areas. According to my results, policymakers should try to stimulate the economy by increasing the GDP in low GDP areas in order to save lives. Economic stimulation should be prioritized in the Southeast where the GDP is the lowest and the death rate is the highest (see Figures 2 and 3). The impact on communities that saving these lives would bring is enormous.

My study has a few possible limitations that are worth commenting on. The first is unaccounted social factors that may impact the premature death rate. Religion is not the only plausible social factor that could influence suicide and pre-mature deaths. For example, areas that are high in non-religious community support groups may have lower death rates. Because my analysis was conducted at a very fine-grained level, this precludes me from collecting additional social data since it is rarely collected at the county level. Also, when it becomes accessible, more comprehensive religious data can be used to increase the sample size of counties when running the regression with religion.

Another limitation is that premature deaths are not separated by cause of death. In my analysis, natural disasters, homicides, suicides, and disease deaths are all categorized the same. However, it is likely that the relationship between GDP and premature deaths is stronger for some types of deaths compared to others. Future research could try to combat this by controlling deaths for those which are a direct result of the economic condition as well as preventable versus non-preventable deaths.

Future research can head in a few additional directions besides the two previously mentioned points. It can try to explain the impact of the mechanisms on the death rate. In my analysis, I only examine potential mechanisms through a literature review of other research, but future work can seek to directly collect county-level data on these mechanisms. An additional direction for future is to explain the geographical correlation in my regression errors. In Figure 4, I plot the distribution of errors from my model. The figure suggests that counties with the greatest error between the predicted death rate and the actual death rate seem to be adjacent to other counties with high error. Understanding this relationship would increase our understanding of the relationship between economic growth and population health.

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