Spending for the Better: A Regression Analysis on how Mental Health Expenditures Can Improve GDP per capita

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Abstract

This research will identify whether government intervention through expenditure on mental health resources is a potential solution to improving labor productivity. By running a multiple linear regression, this study will investigate the relationship between federal mental health expenditures worldwide and subsequent countries' GDP per capita as a proxy for productivity. We expect as mental health expenditure increases, individual productivity, and labor output will increase.

Background

According to the World Health Organization, one in every five people in the U.S. live with a mental disorder, yet more than half of this group feels they have unmet needs. The American Psychiatric Association reported that unresolved depression accounts for a 35% reduction in productivity, costing the economy $210.5 billion annually. It is also clear that the government is knowledgeable about these negative costs, "Given the costs to those suffering from mental health disorders with unmet needs and the costs that spillover to society as a whole, it is important to consider ways that public investments can be made most effectively to improve overall outcomes." While the government may be willing to take steps to close the gap of unmet needs, a true relationship between investment and benefits must be established. This paper delves into the process by which a solution emerges through this vital relationship. Continuing to neglect these conditions will have a devastating impact on these individuals' quality of life.

Data Merging and Cleaning

In developing a multiple linear regression model, we need a cleaned and sufficient dataset including both main variables. We use mental health expenditure data from the World Health Organization as a proxy for government intervention and World Bank GDP per capita data as a proxy for productivity. Because there is no numerical value of both productivity and government intervention in mental health investment, assigning GDP per capita and government expenditures is the most accurate. Further, mental health intervention is difficult to substantiate without the application of expenditure value. The World Health dataset covers 78 countries in 2011 and uses unadjusted survey measurements. Specifically, this value is the percentage of mental health expenditures out of total health expenditures calculated using local currency. The World Bank 2011 GDP per capita data is calculated in current United States dollars. In this study, it is important to realize that complete datasets with similar variables could not be found in more recent years.

Omitted Variables

We did not want to have omitted variables in our statistical model, so we worked to eliminate that possibility. We added Government Indicator data from the World Bank to our dataset to offset potential overestimations of mental health expenditure effects. All Government Indicators are measured from -2.5 to 2.5 smaller numbers indicating a weaker public perception of the government. We chose to include Voice and Accountability as it measures the extent to which citizens can participate in selecting their government and acting on liberties. Government Effectiveness is the perception of government service quality and implementation. Regulatory Quality regards a government's ability to develop and maintain a private sector. We feel that if individuals perceive their governments to be productive and responsive, these governments will be more likely to spend on mental health. We did not want to have omitted variables in our statistical model, so we worked to eliminate that possibility.

Preliminary Analysis

Before analysis, we identify any patterns or outliers in our data. We summarize our combined dataset to find measures that will help identify abnormalities in the data. The mean of our GDP per capita variable includes data from a wide range of countries which results in outliers and is misleading. We notice similar patterns between indicators as we expect a country with a high effectiveness indicator to have a high-quality indicator. The mean of global mental health expenditures as a percentage of health expenditures is a mere 3.44% highlighting the need for increases. A reference point in Canada showed that to satisfy the minimum unmet mental health care needs, the country would have to raise its mental health care investment percentage to at least 9% out of total healthcare spending. We have a median GDP per capita of $6590.01 excluding outliers from various countries.

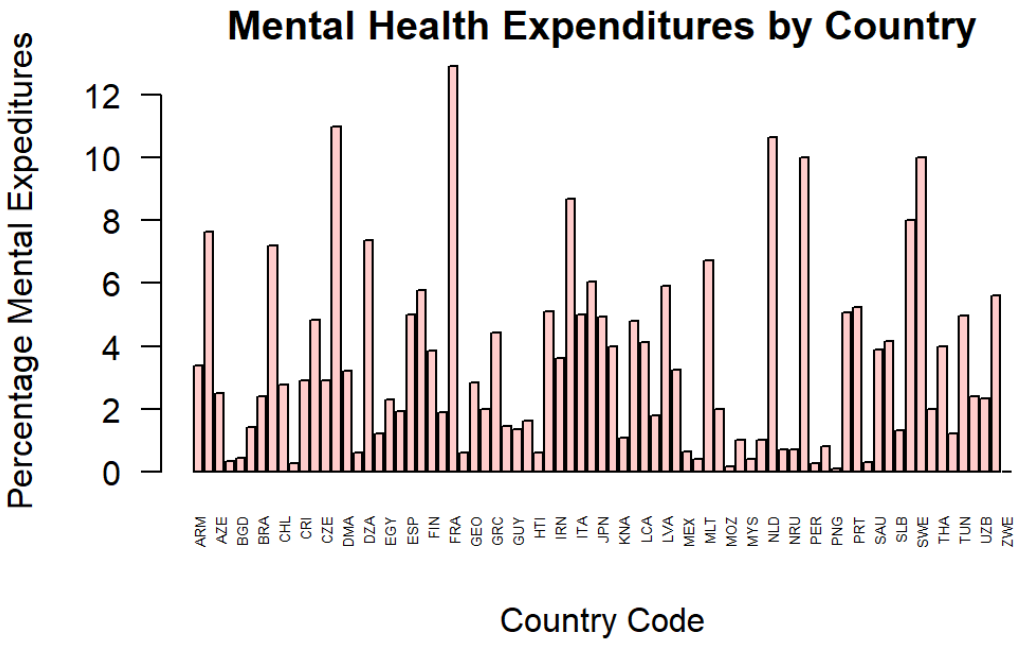
Table 1: Summary Statistics

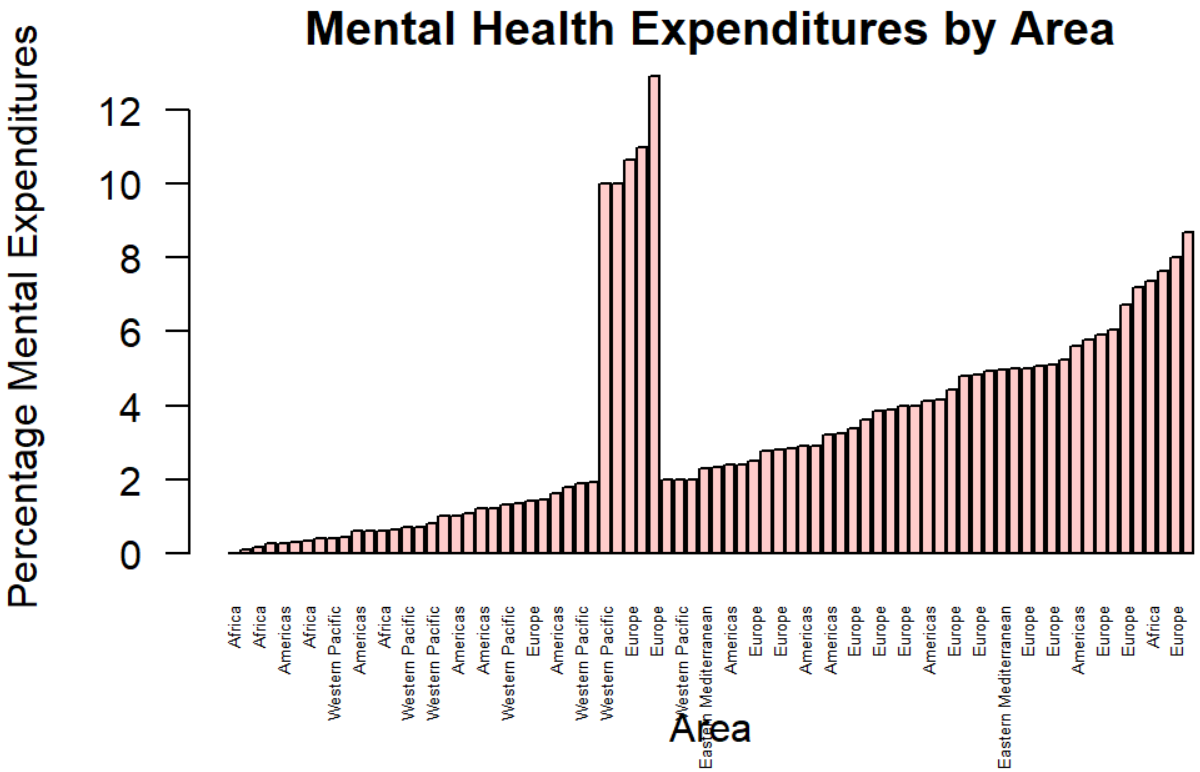
Statistic	N	Mean	St. Dev.	Min	Max
vars	3	2.000	1.000	1	3
n	3	77.000	0.000	77	77
mean	3	4,864.739	8,422.867	0.144	14,590.630
sd	3	5,740.611	9,939.605	1.004	17,217.880
min	3	82.453	144.739	-2.230	249.578
max	3	20,862.890	36,123.010	1.610	62,574.150
range	3	20,780.440	35,978.270	3.840	62,324.570
se	3	654.203	1,132.723	0.114	1,962.159

All following tables are formatted using Hlavac, Marek (2022). stargazer: Well-Formatted Regression and Summary Statistics Tables.
R package version 5.2.3. https://CRAN.R-project.org/package=stargazer

Plotting

We illustrate our plots to pinpoint spread and draw basic conclusions. In a barplot of mental health expenditure frequencies, we see that the spread of values ranges from 0.01% to 12.91%. There is variance throughout the data without noticeable shape. From a Cureus paper, Rajkumar observed that “MH% was below 1% of the total health budget on mental health in 19 out of the 78 (24.36%). All these countries belonged to the low- and middle-income category; MH% below 1% was not observed in any high-income country.” These findings match the geographical differences we see throughout the graphs. Lower-income countries located in Africa and South America have significantly lower ratios of mental health care investment to overall spending.

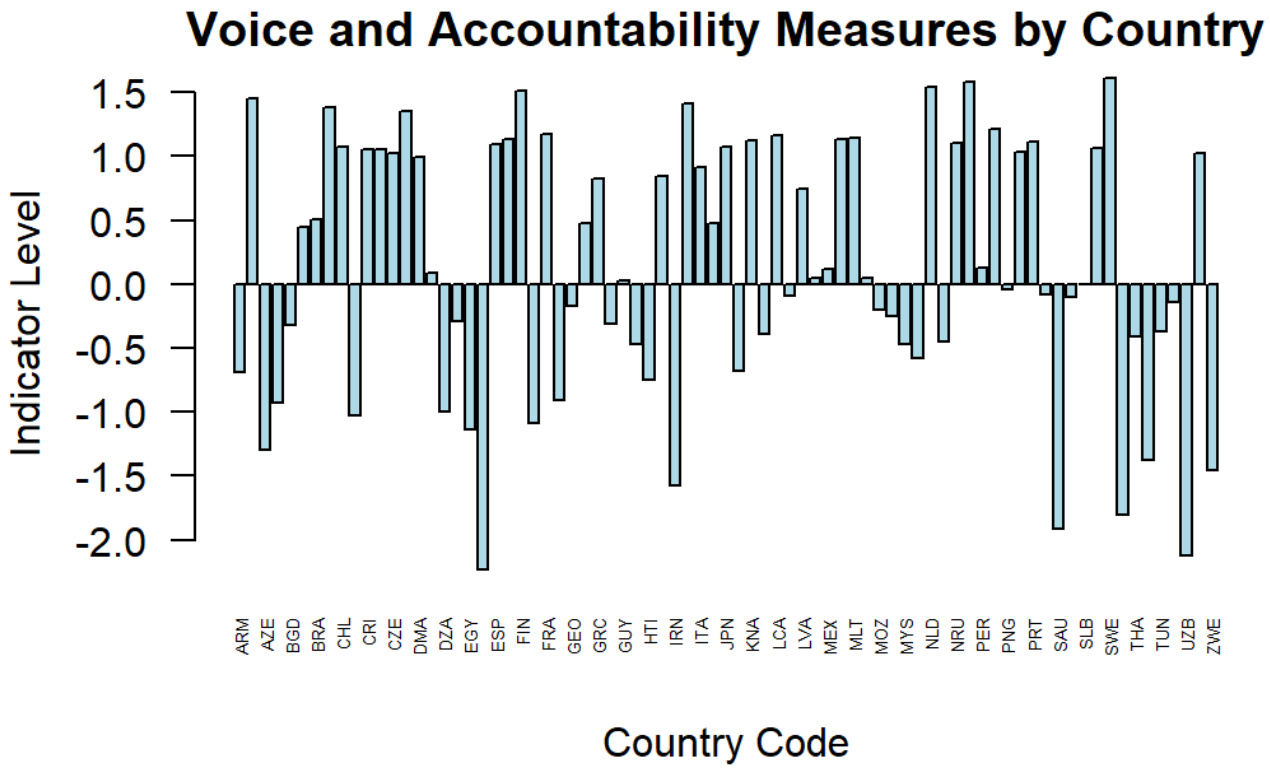

Mental Health Expenditures by Country
Percentage Mental Expeditures
0
2
4
6
8
10
12
ARM AZE BGD BRA CHL CRI CZE DMA DZA EGY ESP FIN FRA GEO GRC GUY HTI IRN ITA JPN KNA LCA LVA MEX MLT MOZ MYS NLD NRU PER PNG PRT SAU SLB SWE THA TUN UZB ZWE
Country Code


Mental Health Expenditures by Area
Percentage Mental Expenditures
0
2
4
6
8
10
12
Africa Africa Americas Africa Western Pacific Americas Africa Western Pacific Western Pacific Americas Americas Western Pacific Europe Americas Western Pacific Western Pacific Europe Europe Western Pacific Eastern Mediterranean Americas Europe Europe Americas Americas Europe Europe Europe Americas Europe Europe Eastern Mediterranean Europe Europe Europe Americas Europe Europe Africa Europe
Area

Geographical Differences

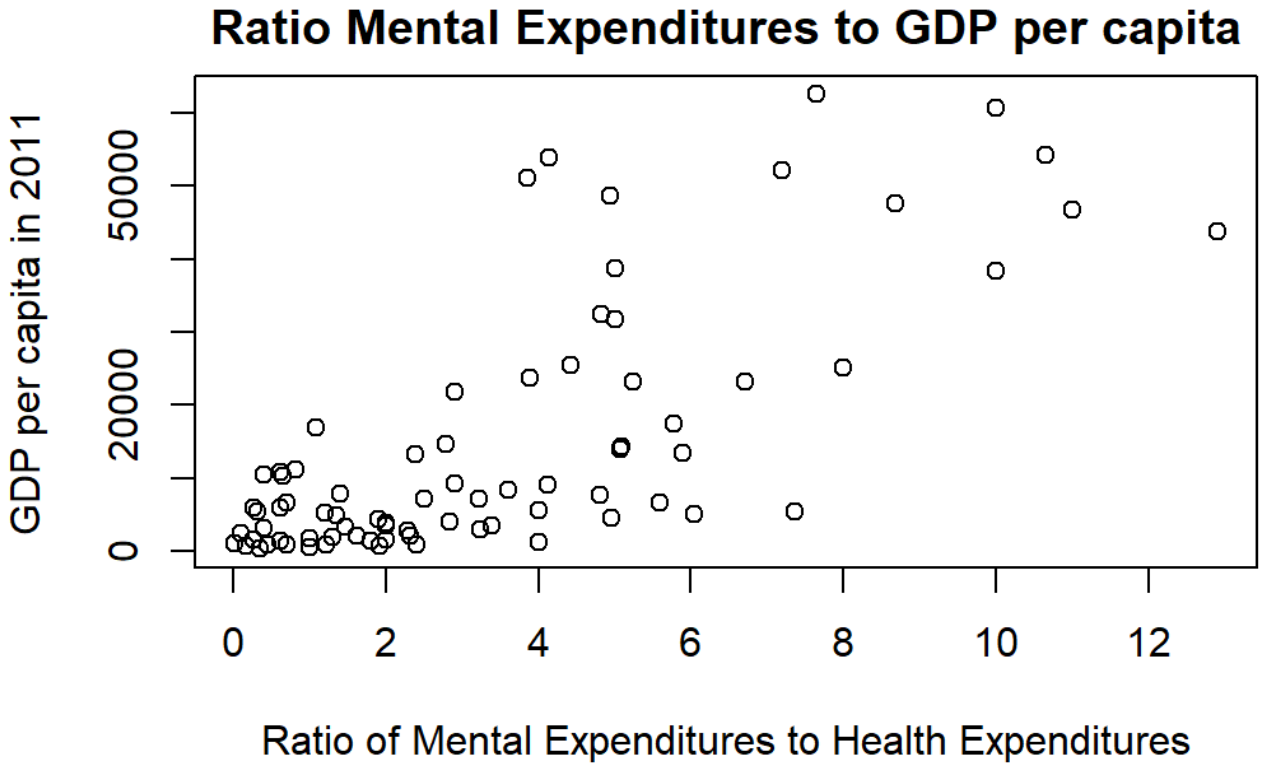
By separating our dataset by geographical region, we quickly notice that European areas continuously have higher ratios than their African counterparts. While no causal relationship can be drawn, this may indicate that geographical differences influence government mental health expenditures.

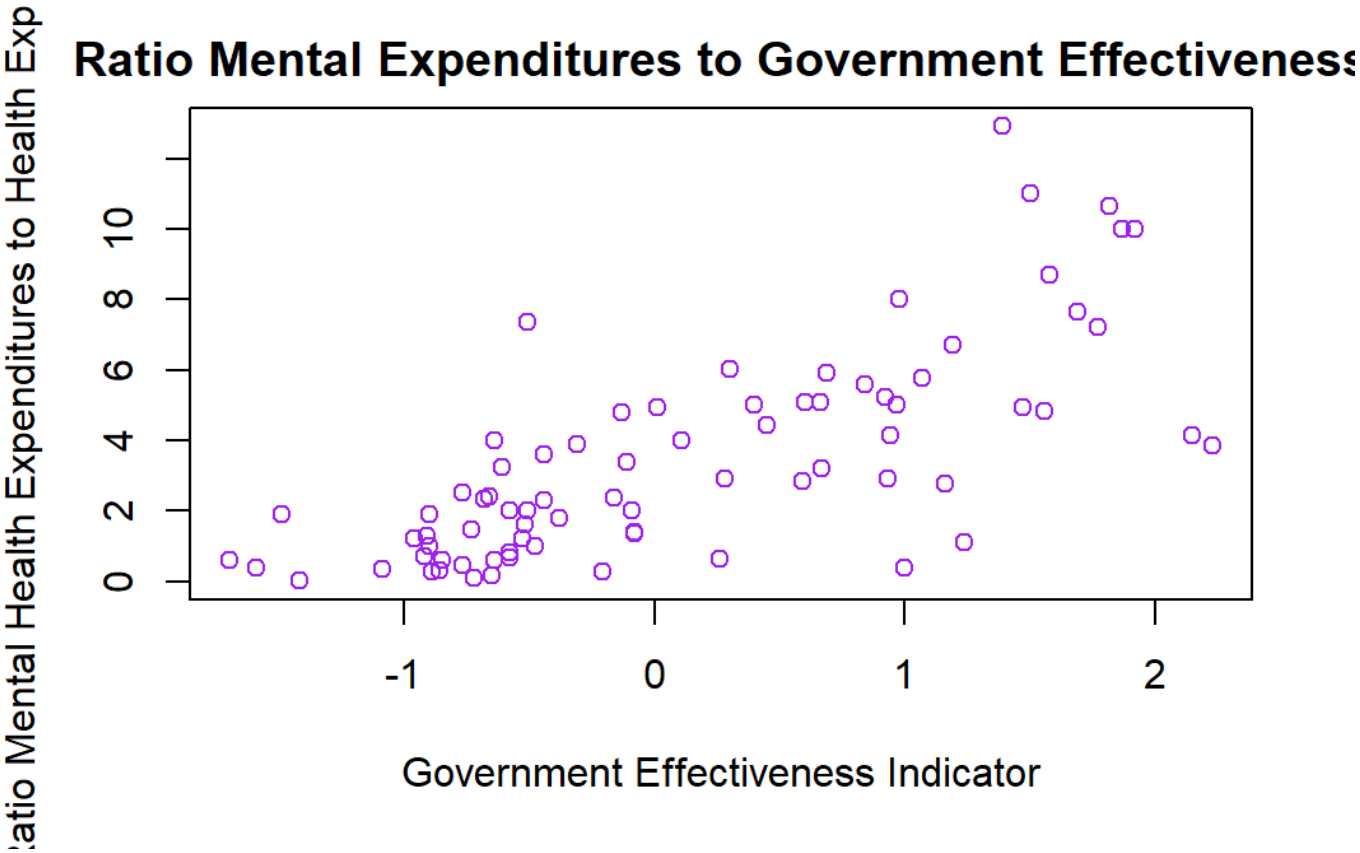
As expected, our independent variables correlate highly with our control variable, especially across geographical regions. Europe maintains extremely high indicator values while Africa and the Americas maintain lower indicator values. We can only comment on geographical variations at a descriptive level, but hypothesis testing could deepen this analysis.



Correlation Testing

Before testing, we need to make sure both main variables have a relatively strong correlation. We used a scatterplot between mental health expenditure ratios and GDP per capita to see the relationship between individual points. There is a clear cluster with low expenditure ratios and low GDP per capita becoming more spread moving rightwards. Overall, there is a weak positive correlation between these two variables. We also decided to test Government Effectiveness and mental health expenditure to avoid an overly correlated variable. We see a strong positive correlation between the Government Effectiveness indicator and mental health expenditure ratios.





Scatterplot Summary

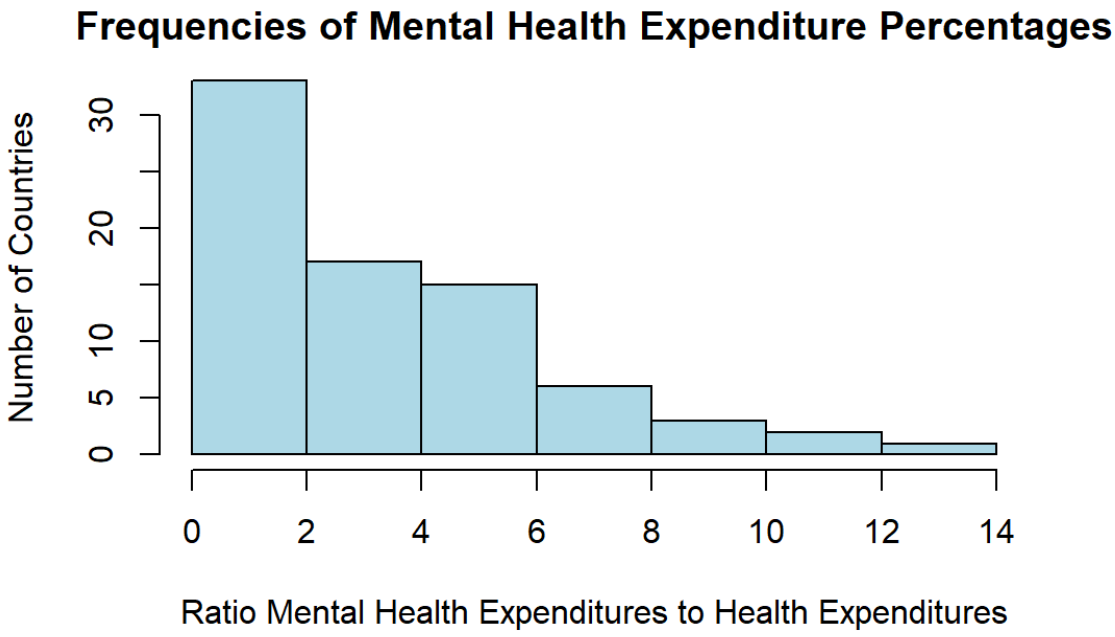
Clearly, in the scatterplot, there is a strong positive correlation between Government Effectiveness and Mental Health Expenditure Ratios. A cluster of data around smaller indicator values and lower expenditure ratios occurs.

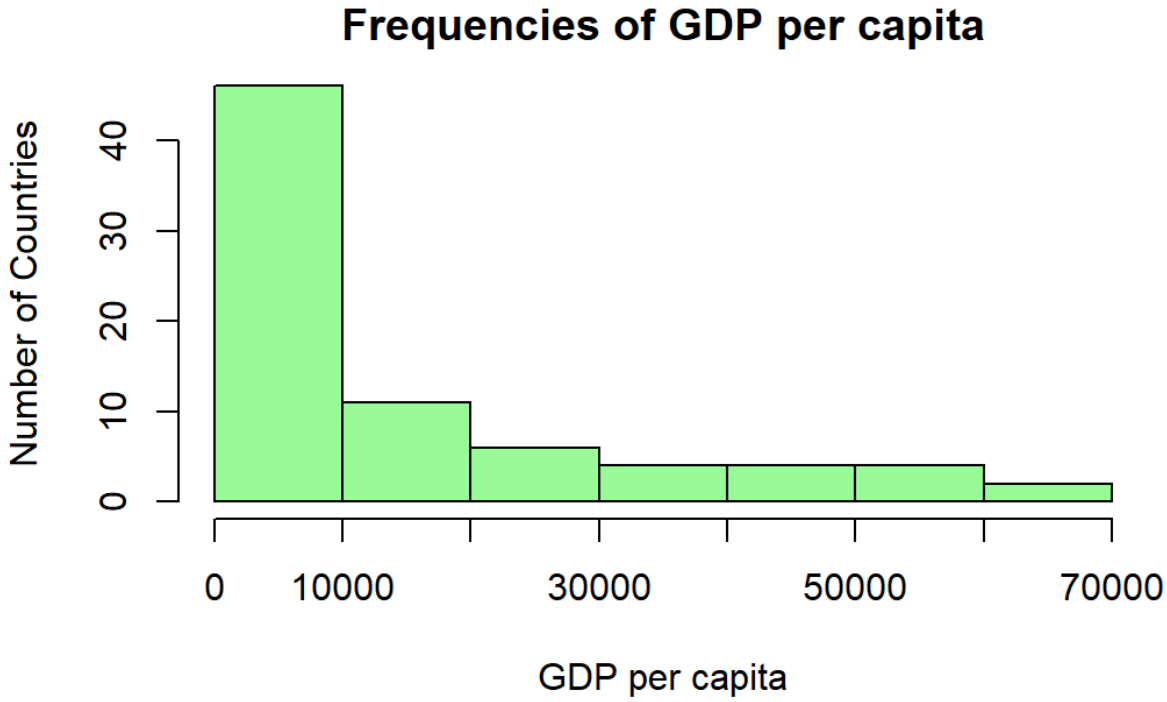
Pearson's Correlation Testing

```
95 percent confidence interval:
 0.6193183 0.8273194
sample estimates:
      cor
0.7405696
```

Limitations to Central Limit Theorem

We found it crucial to note that because statistical analysis requires data to follow normality, our tests must be used with caution. The central limit theorem establishes that for a large number of samples in a population, the sample means will follow normal distribution even if the population isn't. We graphed the frequencies of both main variables following a right-skewed pattern. If we were to complete more analysis, we would adjust our data for linearity.


Frequencies of Mental Health Expenditure Percentages
Number of Countries
0
5
10
20
30
0
2
4
6
8
10
12
14
Ratio Mental Health Expenditures to Health Expenditures


Frequencies of GDP per capita
Number of Countries
0
10
20
30
40
0
10000
30000
50000
70000
GDP per capita

Simple Linear Regression

To start our basic linear regression test between mental health expenditures and GDP per capita, we set the former as an independent variable x and the latter as dependent y. With a p-value less than zero, we know that the conclusions drawn are very significant. Based on our test, we can set up the linear equation y = $4320.70(x)- $293.30. For every 1% increase in the mental health expenditures ratio, we can expect a $4320.70 increase in GDP per capita. We are 95% confident that our slope falls inside the interval ($3433.41, $5208.00). Based on our Multiple R-squared values, mental health expenditure ratios explain about 54.84% of the variation within our dependent variable, GDP per capita. Thus, our model fits relatively well with our data.

Table 2: Linear Regression Analysis

	Dependent variable:
	gdp_per_capita
mental_expenditures	4,320.697***
	(452.703)
Constant	-293.331
	(2,047.844)
Observations	77
R2	0.548
Adjusted R2	0.542
Residual Std. Error	11,646.940 (df = 75)
F Statistic	91.092*** (df = 1; 75)
Note:	*p<0.1; **p<0.05; ***p<0.01

Multiple Linear Regression

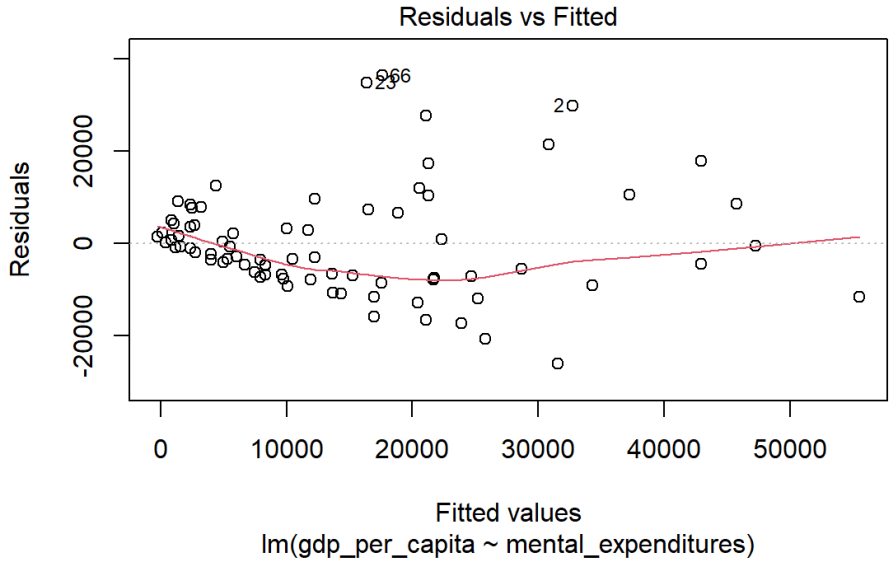
We performed a multiple linear regression with our omitted variables to come to more accurate conclusions. Our analysis has a p-value less than 0.01 meaning that the findings are significant. Note that all else is held constant through this regression analysis. Based on the test, we set up a new linear equation, y = $1639.20(x) + $7620.20. For every 1% increase in the mental health expenditure ratio, we can expect a $1639.20 increase in GDP per capita. We are 95% confident that our slope falls inside the interval ($630.98, $2647.42). Based on our Multiple R-squared values, mental health expenditure ratios explain about 73.81% of the variation within our dependent variable, GDP per capita. Thus, our model is a strong fit for our data.

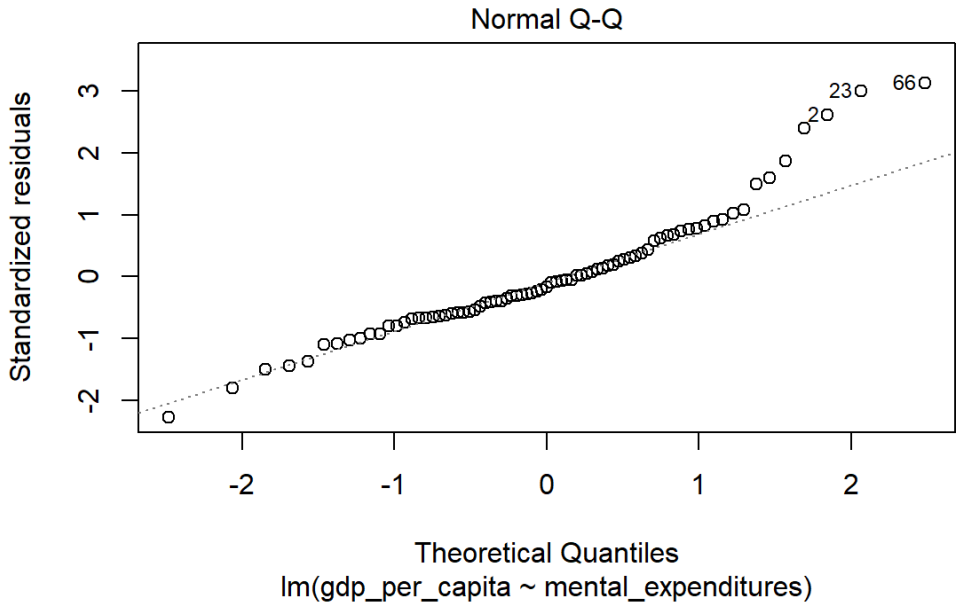
Table 3: Multiple Linear Regression

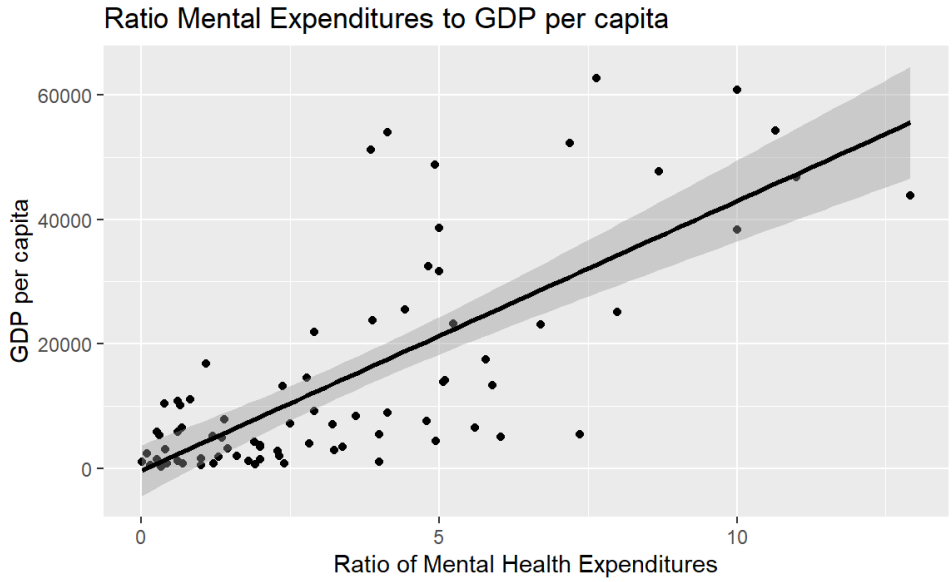
	Dependent variable:
	gdp_per_capita
mental_expenditures	1,639.158***
	(514.358)
`VA Estimate`	-166.453
	(1,612.697)
`GE Estimate`	8,984.794***
	(2,944.123)
`RQ Estimate`	2,217.821
	(2,890.017)
Constant	7,620.152***
	(1,945.063)
Observations	77
R2	0.738
Adjusted R2	0.724
Residual Std. Error	9,053.114 (df = 72)
F Statistic	50.725*** (df = 4; 72)
Note:	*p<0.1; **p<0.05; ***p<0.01

Normality Graphs

Our Residuals vs Fitted graph does have a slight curvature pattern which indicates the nonlinearity of data. As noted in previous sections, our data did not follow normality but could be adjusted. Our Normal Q-Q graph emphasizes the deviation from the normal path.







Conclusion

By looking across 77 countries, we see a high variance of mental health expenditures across samples. To discern whether this variation of government spending in mental health produces varying productivity, we run a multiple linear regression between mental health expenditures and GDP per capita. We establish that there is a strong positive correlation between the variables. For every one-unit increase in the mental health expenditure ratio, we expect a $1639.20 increase in GDP per capita. For comparison, the global average GDP per capita in 2011 was $10,471.

This suggests an increase in government expenditures on mental health does increase GDP per capita and productivity. Through the data collection process, we realize that because our sample is from self-reporting countries, their values are inherently biased. Thus, we cannot make casual comparisons and must focus on individual country measurements. During preliminary analysis, we found our data did not follow a normal distribution, potentially causing skewed conclusions. To resolve this issue, we could transform our data using logarithmic methods or run a non-parametric test. Despite a relationship between these variables established, there is a lack of evidence for the association through time and allocation of funds to be secured.

Further research can be taken in two trajectories, analysis through time and specific intervention methods for effectiveness. Namely, to analyze the relationship between mental health spending and productivity across time. This will allow for trends in countries to be identified over time which can change the specifics of government spending. Moreover, we can find certain mental health programs that could increase the effectiveness and sustainability of the identified relationship. Through additional studies on the effect of mental health and the benefits of such spending, the government can make more well-informed decisions in its resource allocation.

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