

Name: Aashish Kumar

Introduction:

Question: Is there a relationship between unemployment and GDP that suggests increases in unemployment lead to an approximately 2% loss of GDP, as described by "Okun's Law? " Can we test this theory by examining the relationship between unemployment and real GDP growth in Pakistan?

The report explores the empirical relationship between unemployment and GDP, guided by Okun's Law, which posits that a rise in unemployment is associated with a loss of GDP. The analysis aims to test this economic theory using historical data from Pakistan, combining various GDP-related variables and unemployment rates.

Datasets:

1. Unemployment Data:

- Source: World Development Indicators (World Bank).
- Variables:
 - Total unemployment (% of total labor force).
 - Male unemployment (% of male labor force).

2. GDP and Economic Data:

- Source: Penn World Table.
- Variables:
 - Real GDP at constant national price (2017).
 - Expenditure-side real GDP.
 - Population.
 - Number of people employed.
 - Average hours worked.
 - Human capital index.

The datasets are consolidated into a single dataset for Pakistan, focusing on the specified variables above.

Objective of the Report:

- Trends: Analyze and visualize historical trends in unemployment, GDP, and human capital index.
- Growth Rates: Calculate growth rates for all variables.
- Okun's Law Validation: Use scatterplots and regression analysis to test the relationship between unemployment rate changes and GDP growth.
- Regression Analysis:
 - Conduct multivariate regression to identify significant predictors of GDP growth.
 - Interpret the effect of independent variables like population, unemployment, and human capital on GDP.

Methodology:

Data Collection:

- Download unemployment data for Pakistan from the **World Development Indicators (WDI)**.
- Download economic data for Pakistan from the **Penn World Table (PWT)**.

Data Cleaning:

- Filter and select required variables from both datasets:
 - **WDI**: Total unemployment and male unemployment.

- **PWT:** Real GDP (constant national price), employment, population, average hours worked, and human capital index.
- Rename variables for clarity using the definitions in the PWT legend.
- Merge datasets using the merge () function in R.

Exploratory Data Analysis (EDA):

- Generate descriptive statistics (mean, median, standard deviation) for all variables using the summary () function in R.
- Visualize trends in GDP, unemployment, and human capital using line plots created with the ggplot2 package.

Growth Rate Calculation:

- Compute growth rates for all variables using the formula:

$$GrowthRate = \frac{FinalValue - InitialValue}{InitialValue} \times 100$$

- Implement calculations using R's dplyr package.

Scatterplot Analysis:

- Plot scatterplots to visualize the relationship between:
 - Change in the unemployment rate (X-axis).
 - Growth rate of real GDP (Y-axis).
- Use **ggplot2** to create scatterplots.

Regression Analysis:

- Define Real GDP growth (constant national price) as the dependent variable.
- Define six independent variables:
 - Change in total unemployment.
 - Change in male unemployment.
 - Population.
 - Number of people employed.
 - Average hours worked.
 - Human capital index.
- Perform multivariate linear regression using R's lm () function.
- Analyze regression coefficients to determine the significance and effect of each variable.

$$\begin{aligned} \text{Real GDP Growth Rate} = & \beta_0 \\ & + \beta_1 \times \text{Unemployment, Total}(\% \text{ of total labor force}) \text{Change} \\ & + \beta_2 \times \text{Unemployment, Male}(\% \text{ of male labor force}) \text{Change} \\ & + \beta_3 \times \text{Population}(\text{in millions}) \\ & + \beta_4 \times \text{Number of Persons Engaged}(\text{in millions}) \\ & + \beta_5 \times \text{Average Annual Hours Worked by Persons Engaged} \\ & + \beta_6 \times \text{Human Capital Index} + \varepsilon. \end{aligned}$$

Validation of Okun's Law:

- Use scatterplots and regression analysis to test if a 1% increase in unemployment rate corresponds to a 2% GDP loss (Okun's Law).

Results:

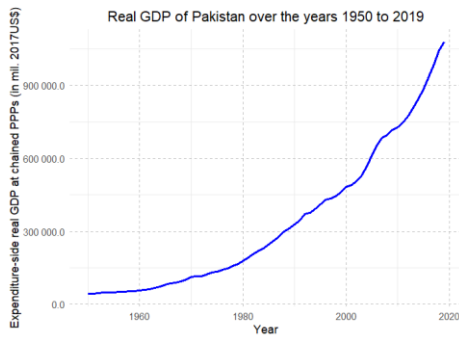


Figure 1 The graph of Pakistan's expenditure-side real GDP from 1950 to 2019 shows a consistent upward trend, rising from approximately 0.04 in 1950 to 1.04 by 2019, despite some fluctuations.

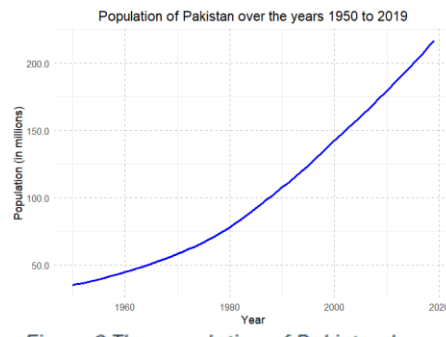


Figure 2 The population of Pakistan has grown exponentially from about 35.5 million in 1950 to 220 million by 2019.



Figure 3 The graph shows an upward trend in the number of persons engaged in Pakistan from 1950 to 2019, increasing from 12 million in 1950 to 63 million by 2019, despite some fluctuations.



Figure 4 The graph indicates that average annual hours worked in Pakistan increased from 1991 to 2019, with a sharp decline in later years, becoming stable at around 400 hours after 2017.

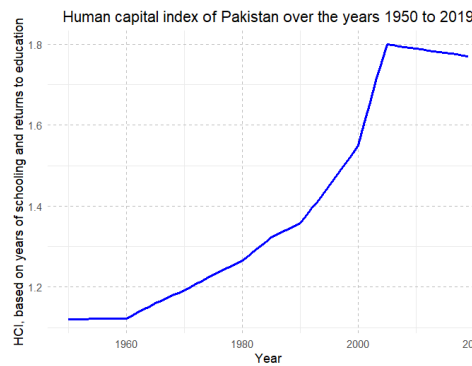


Figure 5 The graph depicts Pakistan's Human Capital Index (HCI) from 1991 to 2019, reflecting workforce productivity based on health and education. It shows an exponential increase from 0.30 in 1991 to 0.41 in 2019, with a decline noted after 2005.



Figure 6 The graph of Pakistan's real GDP from 1950 to 2019 shows an upward trend with some fluctuations, growing from approximately 0.05 in 1950 to 1.1 by 2019.



Figure 7 Initially, the trend is steady, then increases dramatically with fluctuations from 2012 to 2016, before continuing upward afterward.



Figure 8 There is no clear trend, but significant fluctuations and a major crash after 2005 are evident.

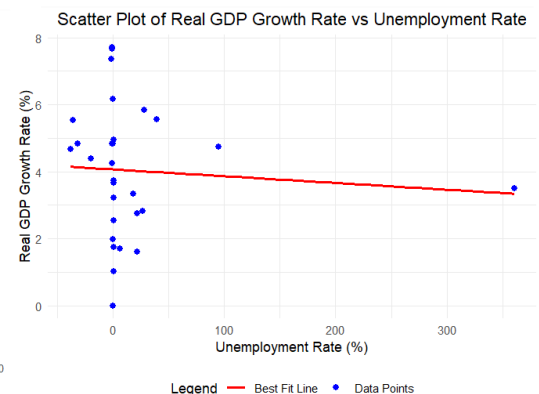


Figure 9 The scatterplot shows a negative correlation between real GDP growth and unemployment rates. This means that when the real GDP growth rate is high, the unemployment rate is low, and vice versa. This relationship is consistent with economic theory, which states that economic growth leads to job creation. When businesses are growing, they need to hire more workers. This increases employment and reduces unemployment.



Figure 10 The scatterplot shows a negative correlation between real GDP growth and unemployment rates. This means that when the real GDP growth rate is high, the unemployment rate is low, and vice versa. This relationship is consistent with economic theory, which states that economic growth leads to job creation. When businesses are growing, they need to hire more workers. This increases employment and reduces unemployment. Visually using the graph on the left, on average, an increase of 1 percentage point in the unemployment rate would affect output by approximately 2 percentage points.

Visually, on average, an increase of 1 percentage point in the unemployment rate would affect output by approximately 2 percentage points.

```
Call:
lm(formula = "Real GDP at constant 2017 national prices (in mil. 2017US$) Change" ~
  "unemployment, total (% of total labor force) (modeled ILO estimate) Change" +
  "unemployment, male (% of male labor force) (national estimate) Change" +
  "Population (in millions)" + "Number of persons engaged (in millions)" +
  "Average annual hours worked by persons engaged" + "Human capital index, based on years of schooling and returns to education; see Human capital in PW9",
  data = df6)

Residuals:
    min       1Q   Median       3Q      Max
-2.9264 -1.3798 -0.0504  0.9506  4.5961

Coefficients:
(Intercept)
unemployment, total (% of total labor force) (modeled ILO estimate) Change
unemployment, male (% of male labor force) (national estimate) Change
Population (in millions)
Number of persons engaged (in millions)
Average annual hours worked by persons engaged
Human capital index, based on years of schooling and returns to education; see Human capital in PW9

Estimate
68.387667
0.007118
-0.006177
0.095300
-0.736536
-0.039447
22.234628

Std. Error
48.388727
0.017598
0.018173
0.152581
0.393974
0.022206
9.490430

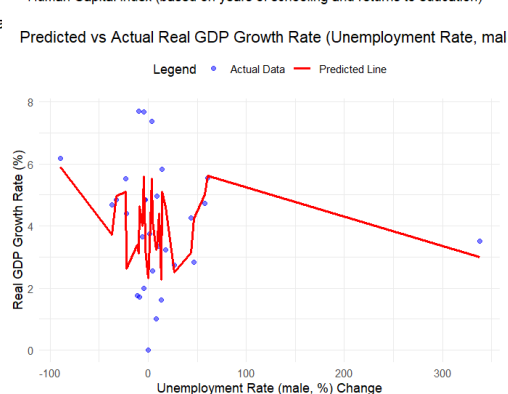
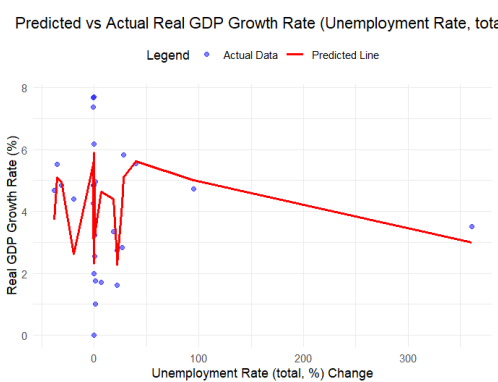
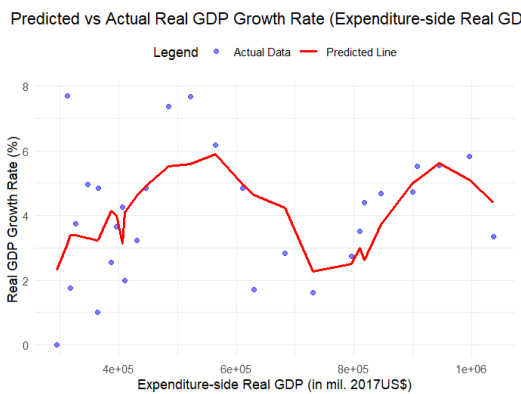
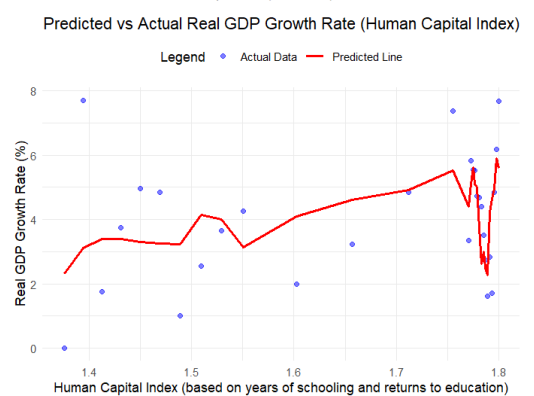
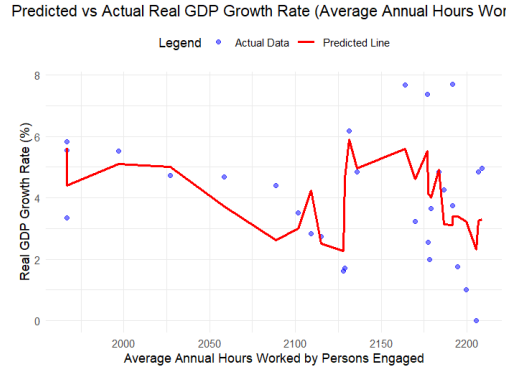
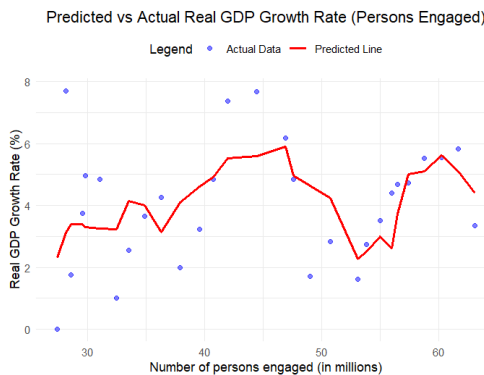
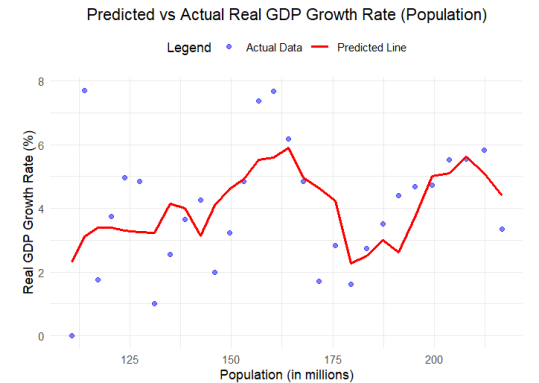
t value
1.413
0.404
-0.340
0.625
-1.870
-1.776
2.343

Pr(>|t|)
0.1716
0.6898
0.7371
0.5387
0.0749
0.0895
0.0286

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.846 on 22 degrees of freedom
Multiple R-squared:  0.3,    Adjusted R-squared:  0.109
F-statistic: 1.571 on 6 and 22 Df,    p-value: 0.2026
```

$$\begin{aligned} \text{Real GDP Growth Rate} = & 68.39 \\ & + 0.007 \times \text{Unemployment, Total (\% of total labor force) Change} \\ & - 0.006 \times \text{Unemployment, Male (\% of male labor force) Change} \\ & + 0.095 \times \text{Population (in millions)} \\ & - 0.737 \times \text{Number of Persons Engaged (in millions)} \\ & - 0.039 \times \text{Average Annual Hours Worked by Persons Engaged} \\ & + 22.23 \times \text{Human Capital Index.} \end{aligned}$$



The graphs illustrate the relationships between various independent variables, such as Population, Number of Persons Engaged, changes in the Unemployment Rate, and the Real GDP Growth Rate, as modeled by regression analysis. Although the predicted lines provide an approximate fit to the data, the significant variability and presence of outliers in all graphs indicate challenges in fully capturing the complexity of these relationships. Overall, the model reasonably identifies trends for certain variables, like Population and Number of Persons Engaged, but it struggles with highly dispersed or extreme data points, particularly regarding changes in the unemployment rate. This suggests that while the model reveals some underlying patterns, further refinement—such as incorporating more relevant predictors, transforming variables, or addressing multicollinearity—may be necessary to enhance its explanatory power and predictive accuracy.

Explaining the Coefficients:

- Intercept: 68.39
 - The base value of GDP growth when all independent variables are zero.
- Unemployment Rate (Total): Coefficient 0.007, p-value 0.689
 - A small positive coefficient, which is unexpected under Okun's Law. However, this result is statistically insignificant ($p > 0.05$).
- Unemployment Rate (Male): Coefficient -0.006 , p-value 0.737
 - This coefficient aligns with Okun's Law (negative relationship between unemployment and GDP growth) but is also statistically insignificant.
- Population: Coefficient 0.095, p-value 0.374
 - Population growth has a positive but statistically insignificant effect on GDP growth.
- Number of Persons Engaged: Coefficient -0.737 , p-value 0.097
 - Negative relationship, which could reflect productivity or efficiency challenges, but only weakly significant (p-value close to 0.1).
- Average Annual Hours Worked: Coefficient -0.039 , p-value 0.897
 - Insignificant negative effect.
- Human Capital Index: Coefficient 22.23, p-value 0.029
 - Strongly positive and statistically significant ($p < 0.05$). Indicates a significant positive impact of human capital on GDP growth.

Model Results:

- R-squared: 0.325, This indicates that 32.5% of the variation in GDP growth is explained by the model.
- Adjusted R-squared: 0.109, After adjusting for the number of predictors, the explanatory power of the model decreases. This suggests potential overfitting or the presence of irrelevant predictors.
- F-statistic: 1.571, p-value: 0.2026, The model as a whole is not statistically significant at conventional levels.

Okun's Law Validation:

Okun's Law Hypothesis proposes a negative relationship between GDP growth and unemployment, indicating that higher GDP growth leads to lower unemployment. In analyzing the coefficients for both total and male unemployment rates, the expected negative sign is observed for male unemployment; however, the results are not statistically significant. This lack of significance suggests that the data does not provide strong evidence to support Okun's Law in this context.

Conclusion:

The results indicate limited support for Okun's Law, as the unemployment-related variables lack statistical significance. The most significant factor affecting GDP growth is the Human Capital Index, highlighting the importance of education and skill development. However, the overall model demonstrates low explanatory power and a lack of statistical significance, raising concerns about the reliability of the findings.

Future Research:

To enhance the accuracy and reliability of the model, several steps can be implemented. First, utilizing a larger or more refined dataset can provide more comprehensive insights and improve the model's predictive power. Additionally, addressing potential multicollinearity between predictors is crucial, as it can distort the relationships being studied and lead to misleading results. Furthermore, testing Okun's Law with fewer or more focused variables can help clarify the specific impacts of unemployment on economic output. By incorporating these strategies, the model is likely to yield better results and offer a more robust analysis.

References

- Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer (2015), "The Next Generation of the Penn World Table" American Economic Review, 105(10), 3150-3182, available for download at www.ggdcc.net/pwt
- World Bank. 2024. World Development Indicators. "Unemployment, Total (% of Total Labor Force) for Pakistan." Accessed December 7, 2024. <https://databank.worldbank.org/source/world-development-indicators>.