Impact of Economic Development on the Labor Market

Sejal Mogalgiddi, Tony Tran, Ryan Jones, Gabriel Alvarado

Motivation

- Analyzing Inflation, GDP, and Economic Growth reveals insights into labor market dynamics and government policies, beyond just economic performance.

- Our research aims to investigate how GDP, inflation, and economic growth relate to unemployment across both developing and developed countries.

- Can overall contribute to economic knowledge by assisting in the creation of strategies for job growth and economic stability.
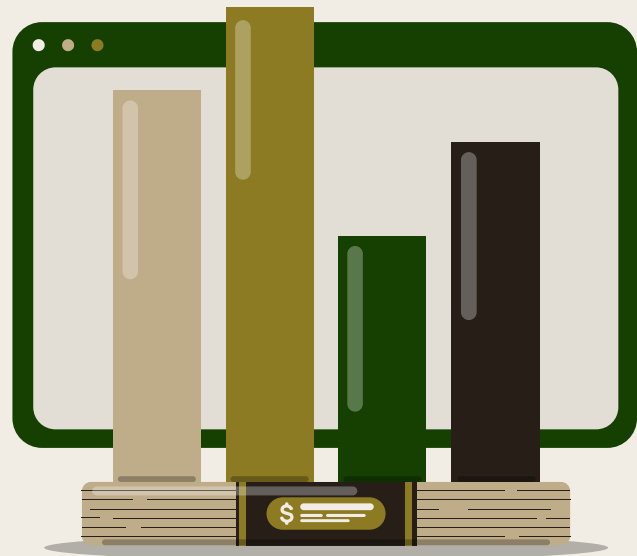
Our dataset

We worked with the following variables:

- **Inflation Rate (%)**

- **Unemployment Rate (%)**

- **Economic growth (%)**
- **GDP (in billion USD)**

Our dataset is from kaggle and was created by Adil Shamim. The dataset covers 19 countries from 2010 to 2023, we removed 2024, and 2025 as they were predictions.

Proposed Full Model

$$\hat{y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 (X_1 \cdot X_2) + \beta_5 (X_2 \cdot X_3) + \beta_6 (X_1 \cdot X_3)$$

Where:

X_1: GDP

X_2: Inflation

X_3: Economic Growth

$(X_1 \cdot X_2)$: GDP and Inflation

$(X_2 \cdot X_3)$: Inflation and Economic Growth

$(X_1 \cdot X_3)$: GDP and Economic Growth

```
Residuals:
    Min      1Q  Median      3Q     Max
 -9.984  -2.633  -0.919   1.280  72.300

Coefficients:
                                        Estimate Std. Error t value Pr(>|t|)
(Intercept)                            6.335e+00  7.378e-01   8.586 8.53e-16 ***
GDP..in.billion.USD.                  -4.644e-06  1.666e-04  -0.028   0.9778
Inflation.Rate....                    -1.231e-02  1.594e-02  -0.772   0.4407
Economic.Growth....                    1.933e-01  1.494e-01   1.294   0.1967
GDP..in.billion.USD.:Inflation.Rate....  2.749e-05  3.787e-05   0.726   0.4686
Inflation.Rate....:Economic.Growth....   2.207e-03  1.547e-03   1.426   0.1550
GDP..in.billion.USD.:Economic.Growth.... -6.511e-05  3.769e-05  -1.727   0.0853 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 6.662 on 259 degrees of freedom
Multiple R-squared:  0.08401,   Adjusted R-squared:  0.06279
F-statistic: 3.959 on 6 and 259 DF,  p-value: 0.0008303

> |
```
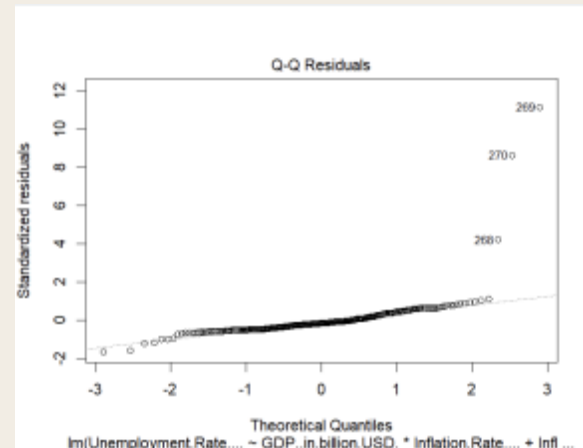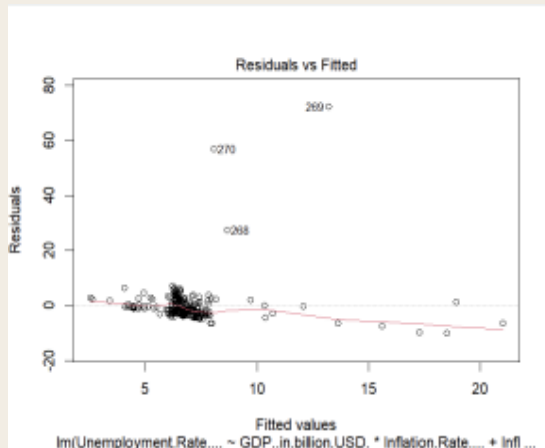
Exploratory Data Analysis

Violations occurred:

- **Slight Linearity**

- **Homoscedasticity**

- **Normality**

No issues with collinearity.

```
                        Unemployment.Rate....  GDP..in.billion.USD.  Inflation.Rate....  Economic.Growth....
Unemployment.Rate....           1.0000000            -0.1141088           0.2430853           0.1206309
GDP..in.billion.USD.           -0.1141088             1.0000000          -0.1751804          -0.1334499
Inflation.Rate....              0.2430853            -0.1751804           1.0000000           0.3724251
Economic.Growth....             0.1206309            -0.1334499           0.3724251           1.0000000
>
```

Model Diagnostics

```
> head(sort(stud_res), 20)
       263         262         267         261         252         260         251          43
-1.6604356  -1.5707116  -1.2193207  -1.1850532  -0.9725301  -0.9690106  -0.9365599  -0.7151508
       277         273         275         276         259         274         249         278
-0.6931035  -0.6688930  -0.6514988  -0.6411419  -0.6408036  -0.6248603  -0.6224619  -0.6196346
       280         247          41         281
-0.6157146  -0.5900836  -0.5848040  -0.5765363
> tail(sort(stud_res), 20)
       189         190         149         217         211         216           1         199
 0.6236972   0.6236972   0.6256858   0.6396538   0.6691961   0.7097027   0.7192381   0.7882651
       215         202         214         201         212         200         213         182
 0.7975106   0.8018883   0.8298390   0.8622897   0.9007759   0.9268221   0.9660808   1.0334567
       203         268         270         269
 1.1041371   4.3575209  10.2255738  15.4326880
```

```
> print(high_leverage)
         4          5          6          7          8          9         10         11
0.05668282 0.05430639 0.11233630 0.07016577 0.05742372 0.05866820 0.07077138 0.45283631
        12         13         14         17         28         43         91        182
0.22691552 0.49904791 0.11509602 0.05506535 0.10249895 0.05367417 0.05687120 0.12935622
       219        244        245        253        254        260        261        262
0.05396083 0.12177619 0.26964663 0.10339892 0.20601771 0.07436808 0.12344463 0.15700208
       263        265        266        267        269
0.17985346 0.19423368 0.05588176 0.37733056 0.05264444
```

```
> cooks_d[cooks_d > 1]
named numeric(0)
```

We see that through these tests, we can pinpoint rows 43, 182, 260, 261, 262, 263, 267, 269, 268 and 270 as **potential outliers**, so we will further assess these rows.

Further Analysis

```
         Country Year GDP..in.billion.USD. Inflation.Rate.... Unemployment.Rate....
43          Japan 2020                 6500               0.2                  2.8
182  Saudi Arabia 2015                  646               5.4                 10.5
260        Turkey 2013                    1             592.0                  7.4
261        Turkey 2014                    1             767.0                  8.2
262        Turkey 2015                    1             857.0                  7.7
263        Turkey 2016                    1             853.0                  8.5
267        Turkey 2020                    3             717.0                 14.6
269        Turkey 2022                    4             500.0                 85.5
268        Turkey 2021                    4               0.0                 36.1
270        Turkey 2023                    5               0.0                 65.0
     Economic.Growth....
43                  -4.8
182                -14.0
260                  9.7
261                  9.9
262                 10.3
263                 10.9
267                 13.2
269                 10.0
268                 12.0
270                  9.0
> |
```

From this analysis, we can see that rows 269, 270, 268, 182, and **must be removed** since the unemployment rate is absurdly high (85.5%, 65.0%, 36.1%, and 10.5%).
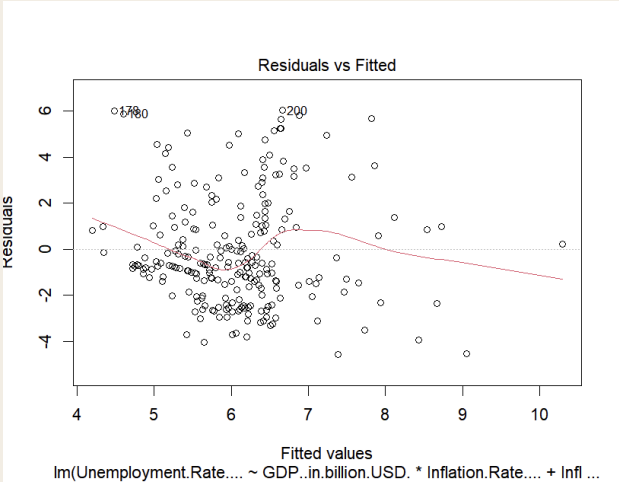
Turkey's unemployment rates

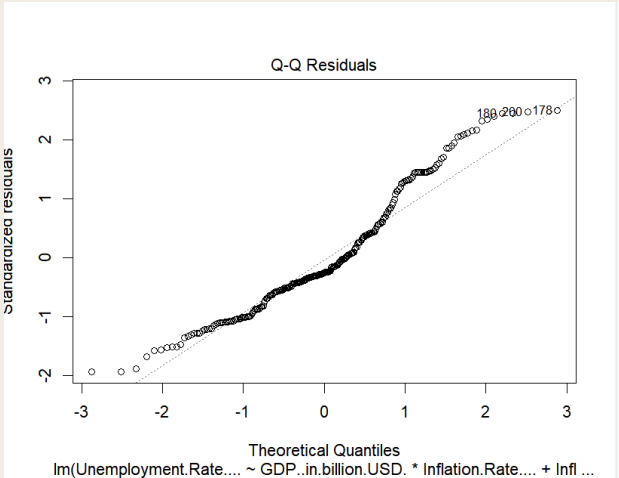| Turkey Unemployment Rate Unemployment Rate	
2023	9.41%
2022	10.43%
2021	11.97%
2020	13.15%
2019	13.73%
2018	10.96%
2017	10.92%
2016	10.90%
2015	10.30%
2014	9.90%
2013	9.71%
2012	9.21%
2011	9.79%
2010	11.88%

- Turkey's unemployment rates skews our dataset causing **high outliers,** for example:
  - In 2021 the actual unemployment rate was around 11%, our data said it was 36%
  - In 2022 the actual unemployment rate was around 10%, our data said it was 85%
  - In 2023 the actual unemployment rate was around 9%, our data said it was 65%
- ➤ So we **removed** Turkey from our dataset
- Saudi Arabia 2015 was an outlier as well.

Saudi Arabia Unemployment rates

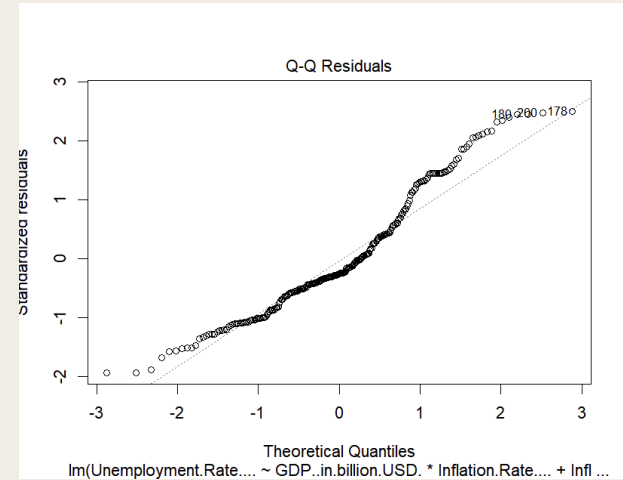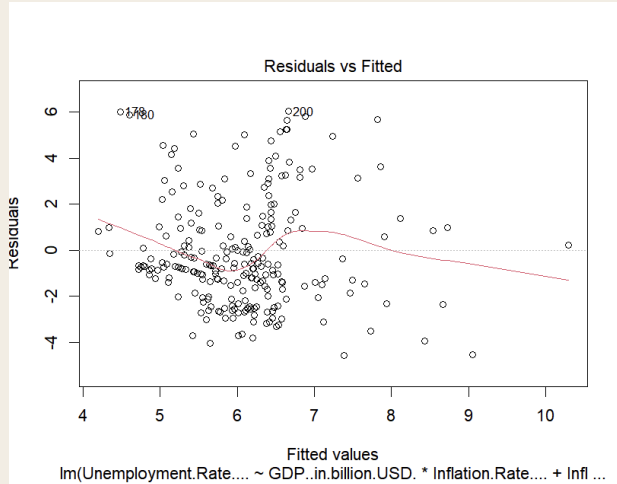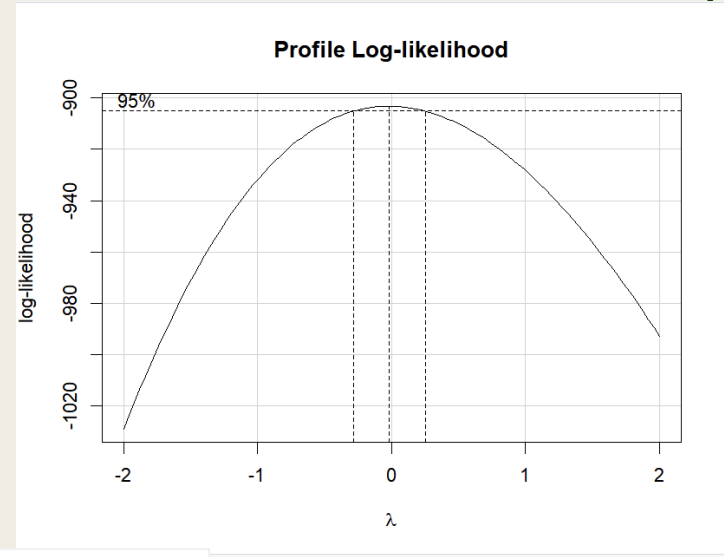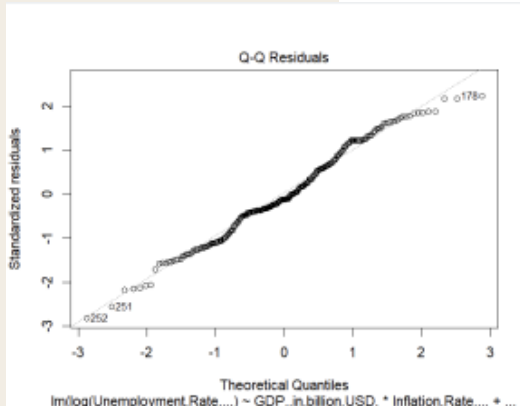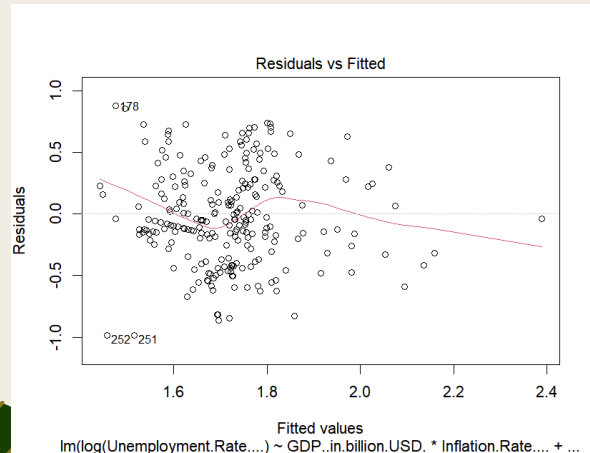| Saudi Arabia Unemployment Rate Unemployment Rate	
2023	4.88%
2022	5.59%
2021	6.62%
2020	7.45%
2019	5.64%
2018	6.03%
2017	5.89%
2016	5.60%
2015	5.60%
2014	5.88%

After Removal

- Normality is slightly violated

- Still has plausible outliers

- Linearity is violated

- We will use Box Cox to address these violations

After doing a Box-Cox test, we see that it **strongly suggests a log transformation**. However, we also conducted a square root and inverse square root transformation just to see if it gives us any other improvements.

While **all three transformations seemed to yield worse results for Linearity/Constant variance**, log made the normal plot slightly better while keeping Linearity as it was before rather than make it worse like the other two transformations. So we decided to transform our variables to log.

Profile Log-likelihood

Residuals vs Fitted

lm(log(Unemployment.Rate....) ~ GDP..in.billion.USD. * Inflation.Rate.... + ...

Q-Q Residuals

lm(log(Unemployment.Rate....) ~ GDP..in.billion.USD. * Inflation.Rate.... + ...

➜ The log transformation made our normal plot look slightly better while keeping linearity very similar.

Model Selection

For the model selection we used Backward selection, in this process, we decided to **remove**:

- GDP and Economic Growth
- Inflation
- Inflation and Economic growth

Our **final** model now looks like:

$$\hat{y} = \beta_0 + \beta_1 X_1 + \beta_3 X_3 + \beta_4 (X_1 \cdot X_2)$$

```
Residuals:
     Min       1Q   Median       3Q      Max
-1.15282 -0.21403 -0.04662  0.27114  0.86663

Coefficients:
                                     Estimate Std. Error t value Pr(>|t|)
(Intercept)                         1.849e+00  3.889e-02  47.554  < 2e-16 ***
GDP..in.billion.USD.               -1.922e-05  8.186e-06  -2.348   0.0197 *
Economic.Growth....                -3.495e-02  7.249e-03  -4.822 2.49e-06 ***
GDP..in.billion.USD.:Inflation.Rate....  4.470e-06  2.204e-06   2.028   0.0437 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3962 on 247 degrees of freedom
Multiple R-squared:  0.09724,   Adjusted R-squared:  0.08627
F-statistic: 8.868 on 3 and 247 DF,  p-value: 1.325e-05
```

Difficulties Encountered

Some difficulties we encountered were:

★ Deciding what outliers we should remove.

-> For example, choosing between removing only the highest outliers from Turkey's dataset or remove it as a whole.

★ Deciding which transformation to pick between log, square root, and inverse square root.

Conclusion

- Objective: Investigate how GDP, Inflation, and Economic Growth impact Unemployment.

- Approach:

  - Conducted exploratory data analysis

  - Performed model diagnostics for:

    - Linearity
    - Homoscedasticity
    - Normality

  - Applied a log transformation to improve model performance

- Key Findings:

  - GDP, Economic Growth, and the interaction between GDP and Inflation are significant predictors of Unemployment

  - These relationships offer valuable insights for policy decisions and economic planning

Sources:

The World Bank. *Unemployment, Total (% of Total Labor Force) (Modeled ILO Estimate) – Turkey*. The World Bank Group, 2024,

https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS?end=2024&locations=TR&start=2009&view=chart. Accessed 15 Apr. 2025.

Macrotrends. *Turkey Unemployment Rate 1991–2024*. Macrotrends LLC, 2024, https://www.macrotrends.net/global-

metrics/countries/tur/turkey/unemployment-rate. Accessed 15 Apr. 2025.

The World Bank. *Unemployment, Total (% of Total Labor Force) (Modeled ILO Estimate) – Saudi Arabia*. World Bank,

https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS?locations=SA. Accessed 20 Apr. 2025.

Macrotrends. *Saudi Arabia Unemployment Rate 1991-2024*. Macrotrends LLC, https://www.macrotrends.net/global-

metrics/countries/SAU/saudi-arabia/unemployment-rate. Accessed 20 Apr. 2025.