

Okun's Law

Summary and Demonstration in R

Robert Schnitman

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1 Introduction

The purpose of this document is to summarize and demonstrate Okun's Law in the R programming language.

2 Definition

Named after Arthur Melvin Okun, Okun's Law states that there is an inverse relationship between the unemployment rate and an economy's productivity.¹

3 Demonstration

3.1 Loading Libraries

First, we'll load two libraries that will be used to display our data and plot the unemployment rate (UR) against Real GDP, Percent Change from Last Year (RGDP).

```
library(knitr)      # For tables.
library(kableExtra) # For extending tables.
library(ggplot2)    # For graphing.
library(stargazer)  # For regression tables.
library(magrittr)   # For chaining functions.
```

3.2 Importing Data

Second, we'll import our data downloaded from Federal Reserve's FRED (Federal Reserve Economic Data) database.²

```
# 1. Import the unemployment rate.
ur <- read.csv('UR.csv', stringsAsFactors = FALSE)

# 2. Import the GDP LY (last year) percent change data.
gdp <- read.csv('GDP_DELTA.csv', stringsAsFactors = FALSE)

# 3. Merge our data.
ur_gdp <- merge(ur, gdp, by = 'DATE')
```

¹Prachowny 1993. <https://ideas.repec.org/a/tpu/restat/v75y1993i2p331-36.html>

²<https://fred.stlouisfed.org/series/UNRATE> and <https://fred.stlouisfed.org/series/GDPC1>

```
# 4. Preview our data.
kable(head(ur_gdp, 5), booktabs = TRUE, caption = 'FRED Data Preview',
      col.names = c('Date', 'Unemployment Rate', 'Real GDP LY Percent Change')) %>%
  kable_styling(full_width = TRUE, latex_options = "hold_position") %>%
  footnote(general = 'Data are end-of-period and seasonally adjusted. Only the first few years are shown',
          footnote_as_chunk = TRUE)
```

Table 1: FRED Data Preview

Date	Unemployment Rate	Real GDP LY Percent Change
1948-01-01	4.0	3.88681
1949-01-01	6.6	-1.53303
1950-01-01	4.3	13.36853
1951-01-01	3.1	5.47138
1952-01-01	2.7	5.36785

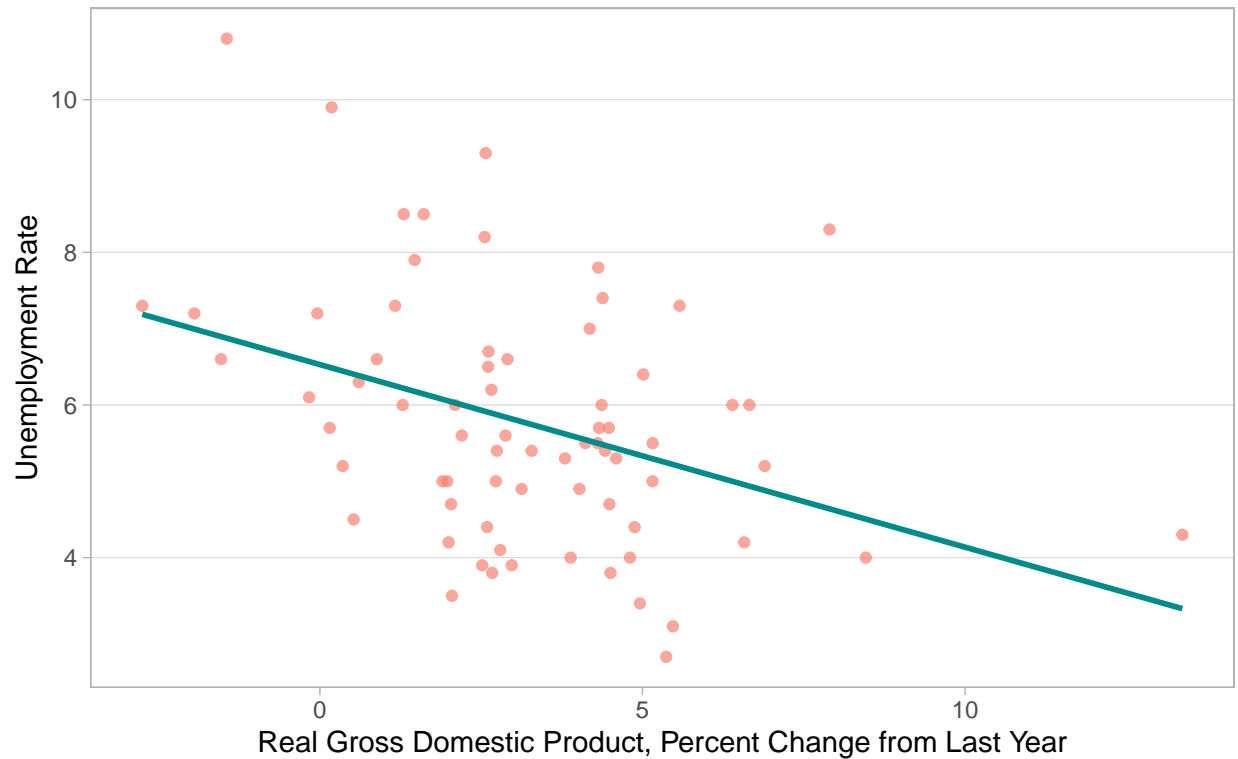
Note: Data are end-of-period and seasonally adjusted. Only the first few years are shown.

Table 1 presents the first few years of UR and RGDP data. We will use this dataset to plot the latter against the former to showcase Okun's Law.

3.3 Plotting the Data

```
### Figure 1.
ggplot(ur_gdp) +
  aes(y = UNRATE, x = GDPC1_PC1) +
  geom_point(col = 'salmon', alpha = 0.7) +
  geom_smooth(method = 'lm', col = 'cyan4', se = FALSE, alpha = 0.7) +
  labs(y = 'Unemployment Rate',
       x = 'Real Gross Domestic Product, Percent Change from Last Year',
       title = 'Fig. 1 - Okun's Law Demonstration, 1948-2018',
       caption = 'Note. Data are end-of-period, seasonally adjusted values.') +
  theme_light() +
  theme(panel.grid.minor = element_blank(),
        panel.grid.major.x = element_blank())
```

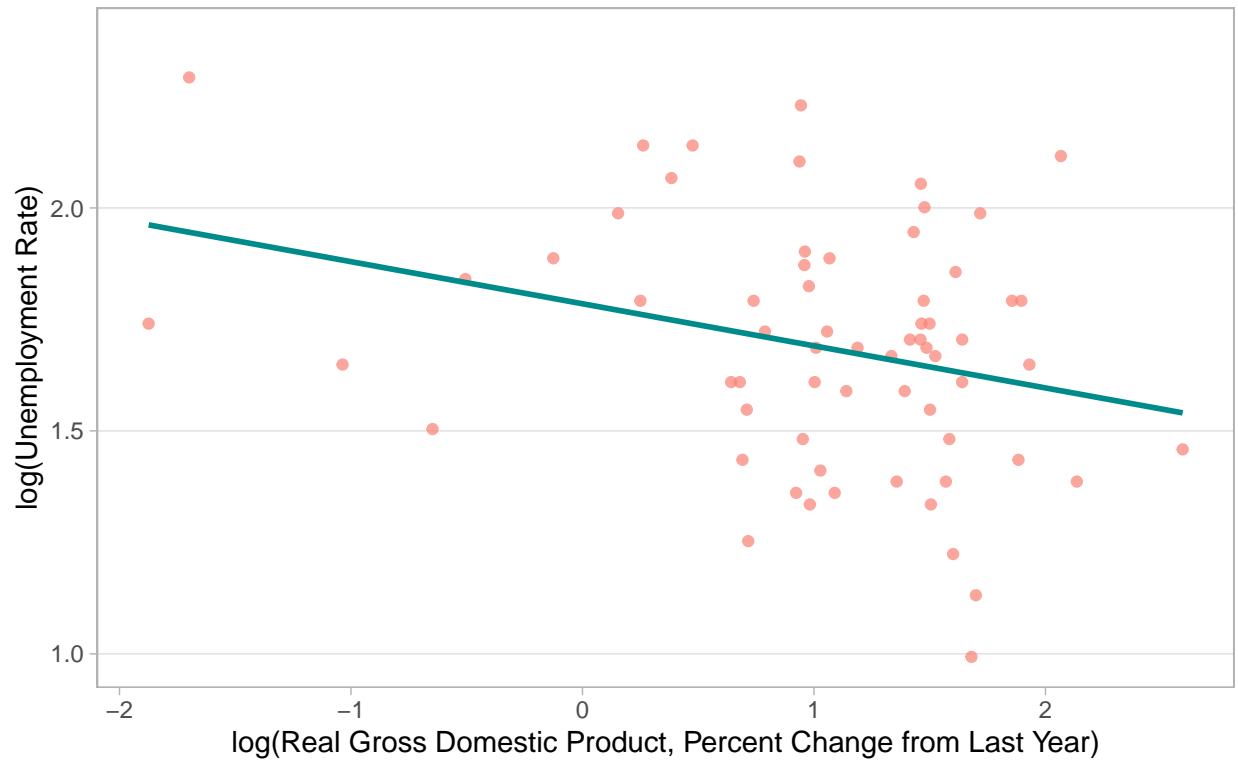
Fig. 1 – Okun's Law Demonstration, 1948–2018



Note. Data are end-of-period, seasonally adjusted values.

```
### Figure 2.
ggplot(ur_gdp) +
  aes(y = log(UNRATE), x = log(GDPC1_PC1)) +
  geom_point(col = 'salmon', alpha = 0.7) +
  geom_smooth(method = 'lm', col = 'cyan4', se = FALSE, alpha = 0.7) +
  labs(y = 'log(Unemployment Rate)',
       x = 'log(Real Gross Domestic Product, Percent Change from Last Year)',
       title = 'Fig. 2 - Okun\'s Law Demonstration, 1948-2018, Log-transformed',
       caption = 'Note. Data are end-of-period, seasonally adjusted values.') +
  theme_light() +
  theme(panel.grid.minor = element_blank(),
        panel.grid.major.x = element_blank())
```

Fig. 2 – Okun's Law Demonstration, 1948–2018, Log-transformed



Note. Data are end-of-period, seasonally adjusted values.

3.4 Regression Results

Let's estimate regressions for more details on how UR relates to RGDP.

```
m1 <- lm(UNRATE ~ GDPC1_PC1, ur_gdp)           # Levels
m2 <- lm(log(UNRATE) ~ log(GDPC1_PC1), ur_gdp) # Log-transformations

stargazer(m1, m2,
  type = 'latex',
  dep.var.labels = c('Unemployment Rate', 'log(Unemployment Rate)'),
  covariate.labels = c('Real GDP LY \\% Change', 'log(Real GDP LY \\% Change)'),
  title = 'Unemployment Rate vs. Real GDP')
```

% Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
 % Date and time: Fri, Jan 10, 2020 - 3:38:01 PM

Based on Table 2, the untransformed model performed better than the log-transformed counterpart (Adjusted R^2 of 12.9% vs. 6.8%, respectively). Both show a negative, linear relationship between the unemployment rate and GDP.

Table 2: Unemployment Rate vs. Real GDP

	<i>Dependent variable:</i>	
	Unemployment Rate	log(Unemployment Rate)
	(1)	(2)
Real GDP LY % Change	-0.239*** (0.071)	
log(Real GDP LY % Change)		-0.094** (0.040)
Constant	6.529*** (0.290)	1.785*** (0.053)
Observations	71	65
R ²	0.141	0.083
Adjusted R ²	0.129	0.068
Residual Std. Error	1.519 (df = 69)	0.263 (df = 63)
F Statistic	11.344*** (df = 1; 69)	5.672** (df = 1; 63)
<i>Note:</i>		*p<0.1; **p<0.05; ***p<0.01

3.5 Diagnostics

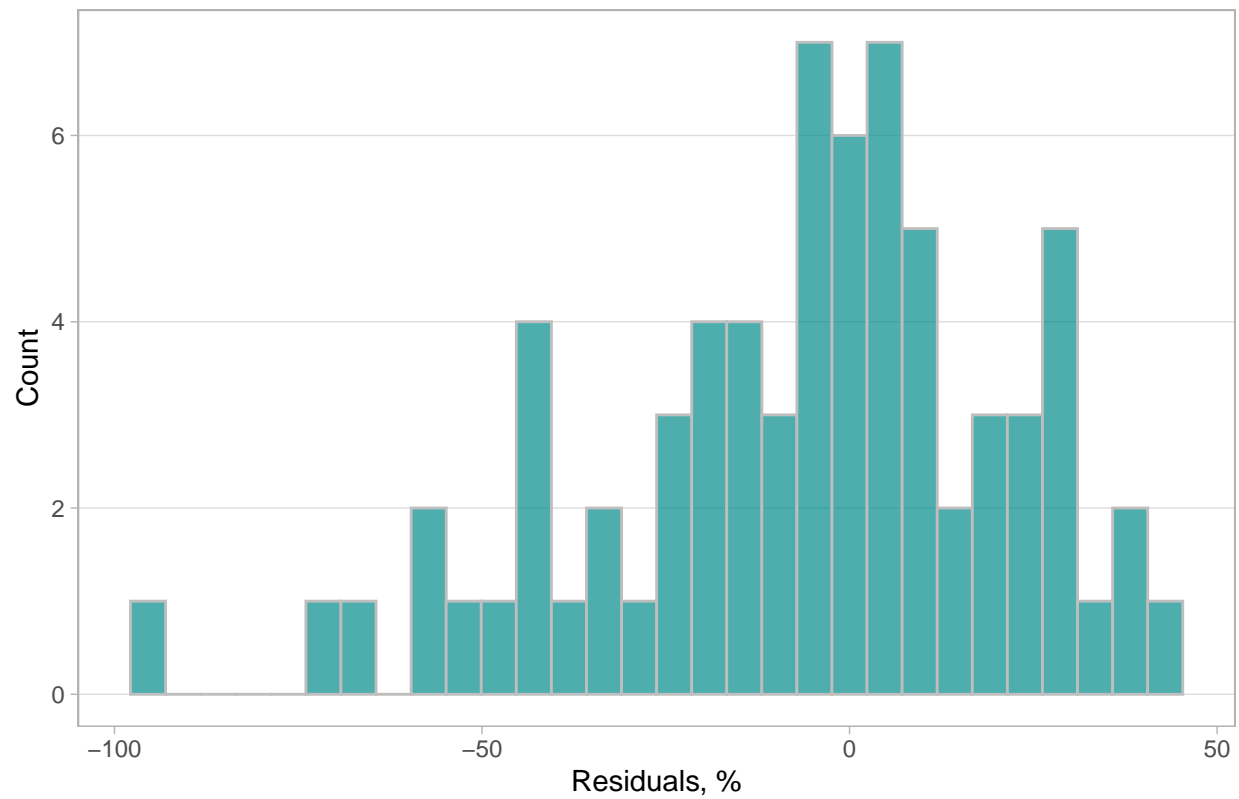
To further check the performance of our models, let us examine the residuals from both models.

```
### Create fitted/predicted values and residuals
fitres1 <- data.frame(fit1 = predict(m1), res1 = resid(m1)) %>%
  transform(res_pct1 = res1/(fit1 + res1)) # Residuals %

fitres2 <- data.frame(fit2 = predict(m2), res2 = resid(m2)) %>%
  transform(res_pct2 = res2/(fit2 + res2)) # Residuals %
```

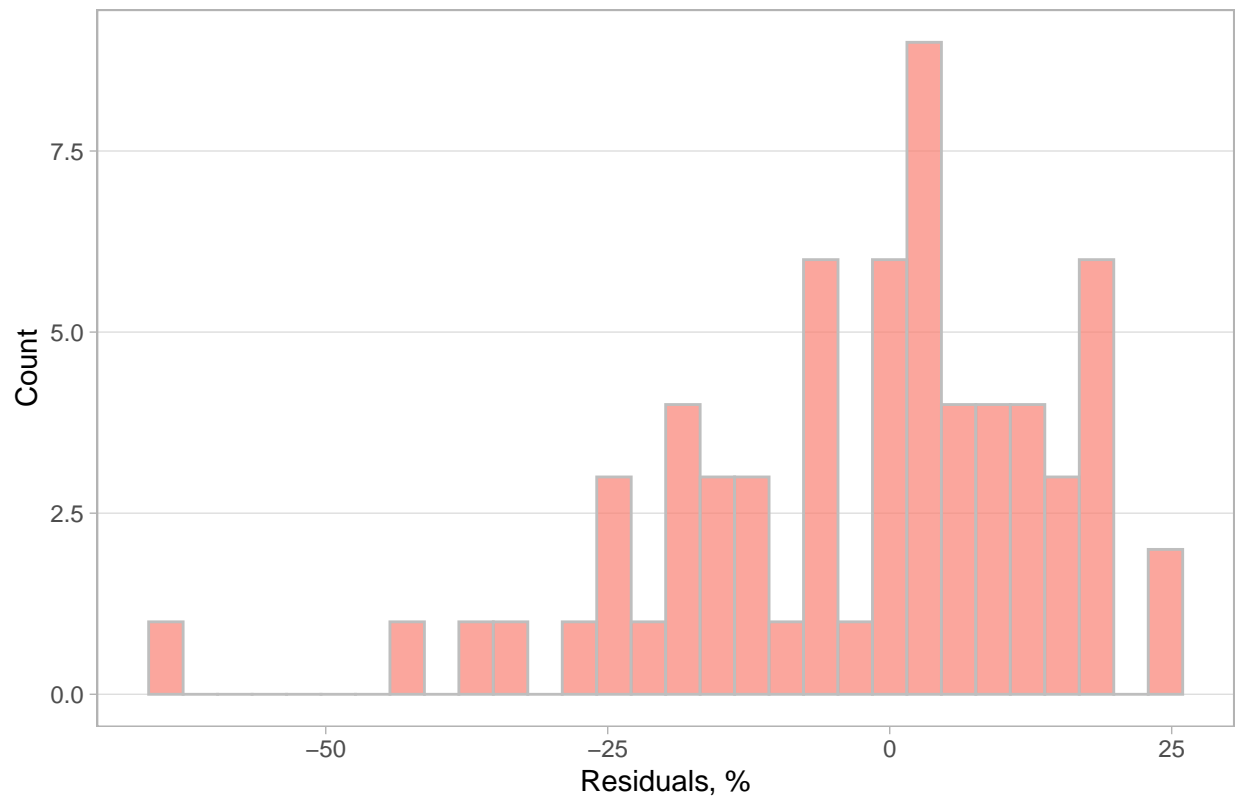
```
### Residual Distributions
ggplot(fitres1) +
  aes(x = res_pct1*100) +
  geom_histogram(fill = 'cyan4', col = 'grey', alpha = 0.7) +
  labs(y = 'Count',
       x = 'Residuals, %',
       title = 'Fig. 3 - Model 1 Residuals') +
  theme_light() +
  theme(panel.grid.minor = element_blank(),
        panel.grid.major.x = element_blank())
```

Fig. 3 – Model 1 Residuals



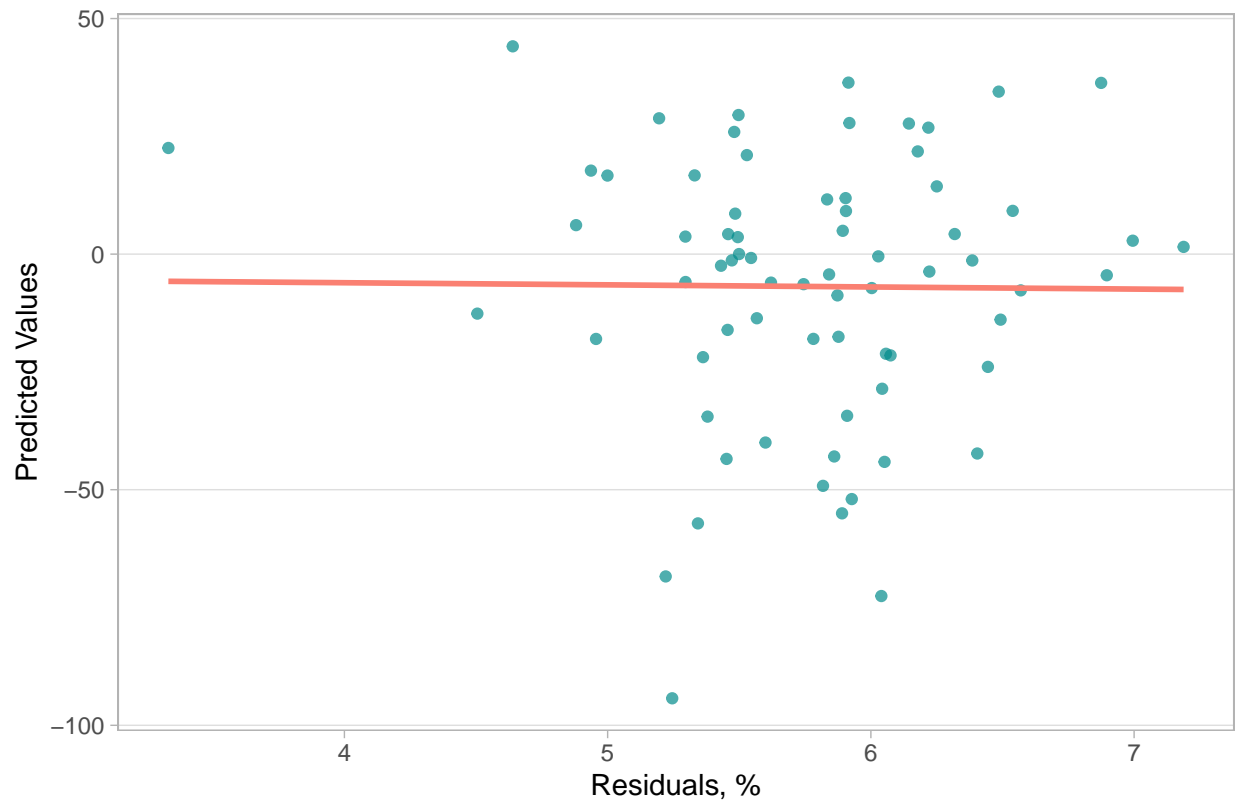
```
ggplot(fitres2) +  
  aes(x = res_pct2*100) +  
  geom_histogram(fill = 'salmon', col = 'grey', alpha = 0.7) +  
  labs(y = 'Count',  
       x = 'Residuals, %',  
       title = 'Fig. 4 - Model 2 Residuals') +  
  theme_light() +  
  theme(panel.grid.minor = element_blank(),  
        panel.grid.major.x = element_blank())
```


Fig. 4 – Model 2 Residuals



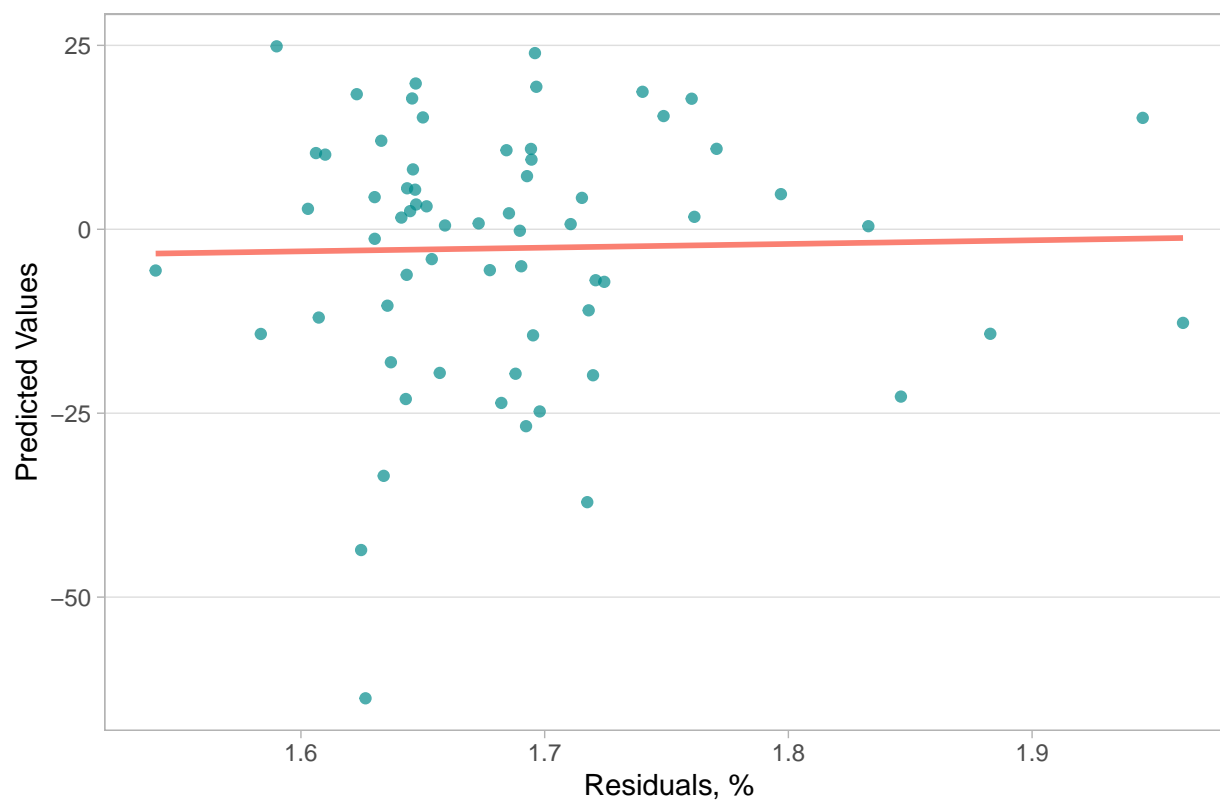
```
### Predicted Values vs. Residuals
ggplot(fitres1) +
  aes(x = fit1, y = res_pct1*100) +
  geom_point(col = 'cyan4', alpha = 0.7) +
  geom_smooth(method = 'lm', col = 'salmon', alpha = 0.7, se = FALSE) +
  labs(y = 'Predicted Values',
       x = 'Residuals, %',
       title = 'Fig. 5 - Model 1 Predicted Values vs. Residuals') +
  theme_light() +
  theme(panel.grid.minor = element_blank(),
        panel.grid.major.x = element_blank())
```

Fig. 5 – Model 1 Predicted Values vs. Residuals



```
ggplot(fitres2) +
  aes(x = fit2, y = res_pct2*100) +
  geom_point(col = 'cyan4', alpha = 0.7) +
  geom_smooth(method = 'lm', col = 'salmon', alpha = 0.7, se = FALSE) +
  labs(y = 'Predicted Values',
       x = 'Residuals, %',
       title = 'Fig. 6 - Model 2 Predicted Values vs. Residuals') +
  theme_light() +
  theme(panel.grid.minor = element_blank(),
        panel.grid.major.x = element_blank())
```

Fig. 6 – Model 2 Predicted Values vs. Residuals



4 Conclusion

Based on Figures 1 and 2, as well as the regression results in Table 2, Okun's Law generally still holds to this day: one should note the overall declining trend despite the relatively low Adjusted R^2 values.

5 References

Prachowny, Martin F J, 1993. "Okun's Law: Theoretical Foundations and Revised Estimates," The Review of Economics and Statistics, MIT Press, vol. 75(2), pages 331-336, May.

U.S. Bureau of Economic Analysis, Real Gross Domestic Product [GDPC1], retrieved from FRED, Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org/series/GDPC1>, January 10, 2020.

U.S. Bureau of Labor Statistics, Unemployment Rate [UNRATE], retrieved from FRED, Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org/series/UNRATE>, January 10, 2020.