# Analyzing Economic Growth by Country

## Using R

Presentation By:
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# The dataset

Source:
Journal of Applied Econometrics Data Archive

Content:
121 countries and 10 variables
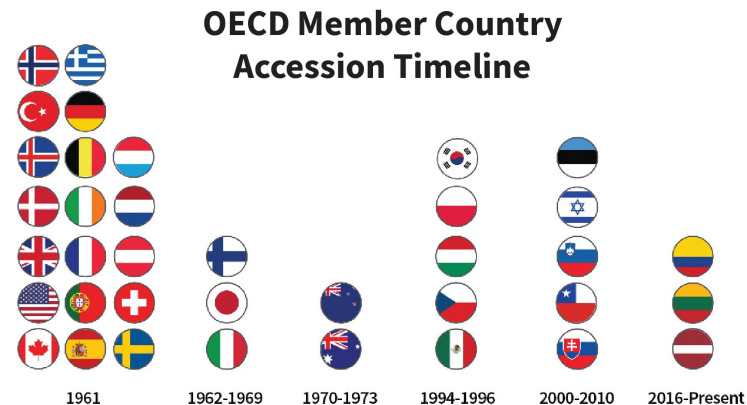From 1960 to 1985

**Additional definitions:**

**GDP** - Gross Domestic Product, the total goods and services produced within a country

**GDP per capita**- GDP per person: GDP/Population

| Variable | Definition |
|---|---|
| **Oil-Producing Country** | Factor: Is the country oil-producing? |
| **OECD** | Factor: Is the country member of OECD? |
| **Inter \*** | Factor: does country have quality data |
| **GDP 60** | Per Capita GDP in 1960 |
| **GDP 85** | Per Capita GDP in 1985 |
| **GDP Growth** | Average GDP growth rate of GDP per Capita from 1960 to 1985 |
| **Invest** | Average ratio of investment (including Government Investment) to GDP from 1960 to 1985 |
| **Literary 60** | Fraction of the population over 15 years old that is able to read and write in 1960 |
| **School** | Average fraction of working age population enrolled in secondary school from 1960 to 1985 |
| **Population Growth** | Average growth rate in working age population from 1960 to 1985 |

# OECD Countries

- OECD- Organization of Economic Co-operation and Development

- An international organisation that works to build better policies for better lives.

- Mostly made up of more developed and western countries

- Countries with similar governments and economies

**OECD Member Country Accession Timeline**

| 1961 | 1962-1969 | 1970-1973 | 1994-1996 | 2000-2010 | 2016-Present |

*Source: "List of OECD Member Countries – Ratification of the Convention on the OECD, OECD, https://www.oecd.org/about/document/list-oecd-member-countries.htm.*

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# Background

What is Economic Output & Growth? - GDP, the total amount of goods and services produced within a country, with the given inputs

One theory that attempts to model and explain Economic Growth is the Solow Growth Model. Solow Growth Model helps explain why poor countries are growing faster than rich, and which factors of economic output drive economic growth at all stages of development.

- Super simple Solow Growth Model-
  - Economic Output (GDP) = Labor Population * Education + Physical Capital + Ideas/Technology
  - Economic Growth (ΔGDP) = ΔLabour Population *  Δ Education + ΔInvestment + ΔTechnology +  ΔPhysical Capital
- Convergence
  - Solow's Growth Model states that all inputs of economic output and growth experience diminishing returns
    - As inputs increase, their impact decreases

# Background: More Solow Growth Model Assumptions

Some more important Solow Growth model assumptions:

- Developed Countries approach zero growth
    - Developed countries have higher levels of diminishing returns
    - Countries with higher GDP have lower growth rates
    - Depreciation of physical and human capital
        - More developed countries have to devote more investment to maintaining accumulated capital

- Institutions
    - Countries with similar institutions follow similar paths of economic output
        - Institutions effect how inputs are managed and used; impacting input and output efficiency
    - OECD countries are an example of similar institutions

# Objectives & Methodology

- Model Economic Growth

  - Using basic variable selection techniques and linear regression

- Apply Solow Growth Model assumptions to our Economic Growth Model
  - Convergence
    - Model variable's diminishing returns using log-transformation
  - Countries with similar institutions
    - Use subset regression to model economic growth of countries with similar institutions

- Compare Models
  - Compare previous models using basic model selection techniques
  - Analyze difference among the coefficients and levels of significance for each model

  - See if solow growth model assumptions improve our estimations

# Modeling Economic Growth

1. Prepping the Dataset
2. Linear Modeling
   - Backwards selection
   - Forwards selection
   - Stepwise Regression
3. Modeling Convergence
   - Log transformation equation
4. Model Selection
   - Original versus log transformation
5. Subset regression
   - Countries with similar institutions OECD, Non-OECD

# Prepping the Data

- Removed rows with missing values

- Removed all rows where inter = "no"

  - Initial regression trials identified all outliers to be inter = no.

  - All oil-producing countries had weak data

- Translated all data +1

  - One method to prepare the data for box-cox transformation

  - Ensures all variables are >0

**Original dataset:**

|          | non-Oil | Oil |
|----------|---------|-----|
| non-OECD | 76      | 23  |
| OECD     | 22      | 0   |

**Dataset after cleaning the data:**

|          | non-Oil | Oil |
|----------|---------|-----|
| non-OECD | 74      | 4   |
| OECD     | 22      | 0   |

**After removing rows where inter = no:**

|          | non-Oil | Oil |
|----------|---------|-----|
| non-OECD | 52      | 0   |
| OECD     | 22      | 0   |

# Forward, Stepwise, and Backwards Selection

- Categorical variables were omitted from the variable selection process; OECD will be used as a proxy for similar institutions in subset regression

- Each selection method yields the same result

**Equation:**

GDP Growth = Invest + POP Growth + GDP 60 + School

| Variable | Coefficients |
| --- | --- |
| Intercept | 1.029e+00 |
| GDP 60 | -3.112e-04 *** |
| Pop Growth | 7.078e-01 *** |
| Invest | 9.593e-02 *** |
| School | 1.698e-01 * |

- Results in an equation similar to the Solow Growth Model

- Solow Growth assumptions will be applied to improve our model

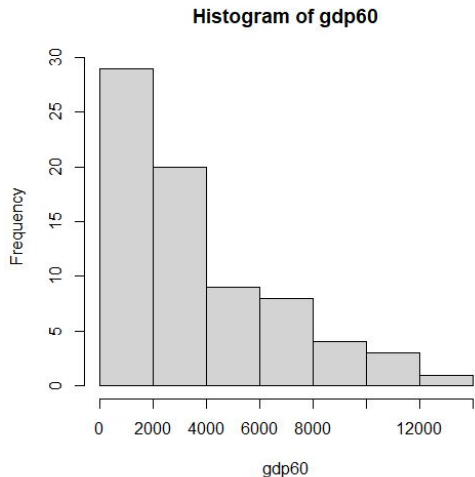| | |
| --- | --- |
| **R-Square Adjusted** | 0.432 |
| **Residual Standard Error** | 1.263 |

# Econometric Technique: Log Transformations

- Log Transformations are an econometric technique used to:

  - Model convergence and other nonlinear functions

  - Create normally distributed variables from skewed variables
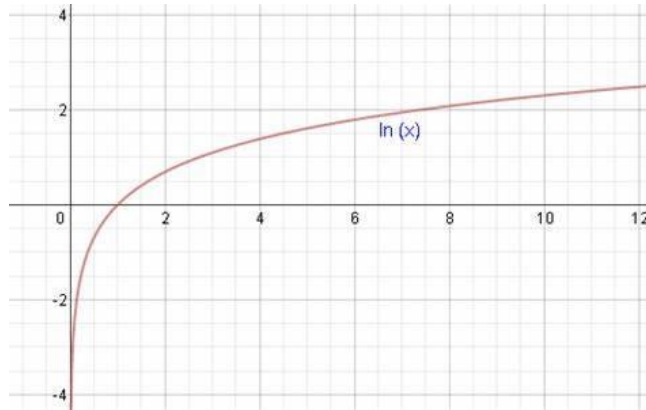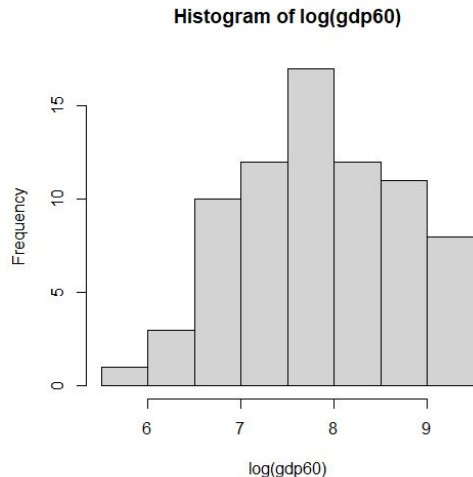
# Log Transformation: GDP60

Before:                                        After:



- Log transformation of GDP60 successfully normalized the distribution, visually

- Log transformation applied to invest, gdpgrowth, school, and popgrowth to model diminishing returns; following Solow Model Growth Model assumption

# Log-Log Transformation Equation

**Equation:**

log(gdpgrowth)=log(gdp60)+log(invest)+log(school)+log(popgrowth)

| Variable | Estimate |
|---|---|
| Intercept | 1.6125 *** |
| Log(GDP 60) | -.2645*** |
| Log(Pop Growth) | .34045*** |
| Log(Invest) | .40493*** |
| Log(School) | .298193 ** |

| | |
|---|---|
| **R-Square Adjusted** | 0.4633 |
| **Residual Standard Error** | .239 |

- **The log-transformations increased R-square Adjusted by 3%**
- **School has increased significance**
- **More analysis is needed to determine if the model is a better fit**

# Model Selection critea

- Residual Analysis

  - Residual plots and standard residual error

- Model Selection Criteria
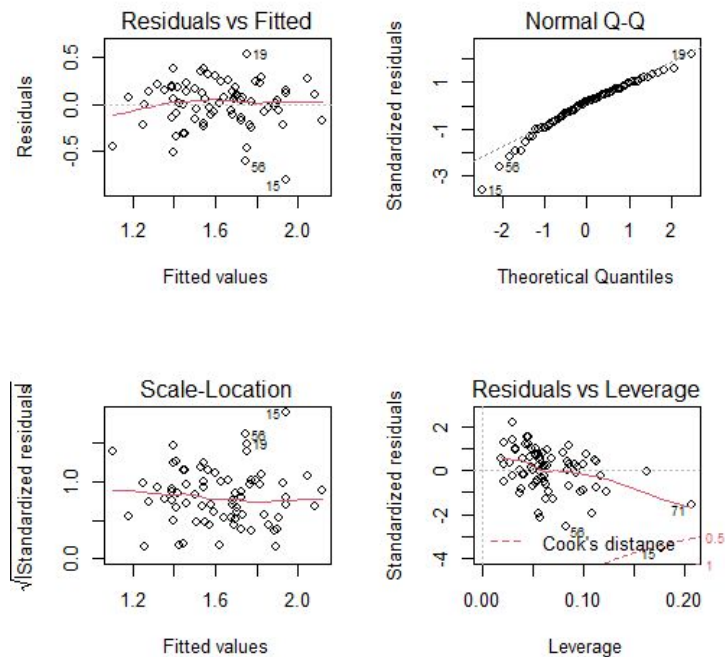
  - AIC, BIC, PRESS statistics

# Residual Analysis

## Graph with the GDP Growth Model
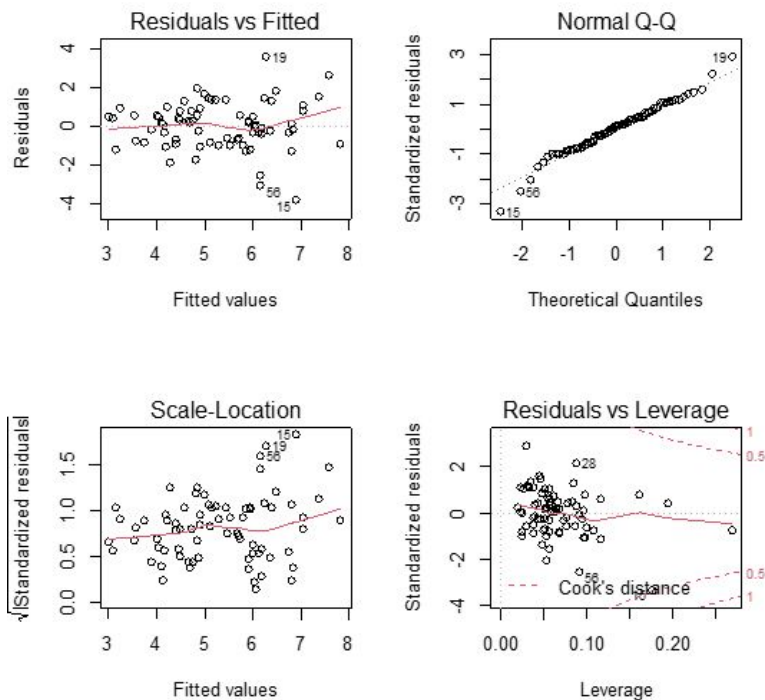


| Residual Standard Error | 1.263 |
| --- | --- |

## Graph with the Log(GDP Growth) Model



| Residual Standard Error | .239 |
| --- | --- |

# Model selection criteria

**List of criteria and a brief description of what it is:**

AIC- based on maximum likelihood and a penalty for each parameter

BIC- Similar to AIC but penalizes additional parameters more

Press - Formed by predicting each observation based on a model developed by using the other observations

**Model Selection Criteria table:**

| Model | AIC | BIC | PRESS |
|---|---|---|---|
| Original Equation | 251.3923 | 265.2167 | 130.3756 |
| Log-Log Transformation | 4.991 | 18.815 | 4.63029 |

- **Based on the AIC, BIC, and PRESS statistics, log-log transformation equation yields best results**

# Subset Regression

Subsets:

- OECD & Non- OECD

Motivation:

- Solow Growth Model assumption: Country's level of productivity and efficiency is dependent on the institutions
  - OECD countries all have arguably the same institution and become the perfect subgroup of analysis

# Subset Modeling: By Institution

## OECD Country Model:

| Variable | Coefficients |
|---|---|
| Intercept | 2.97735 *** |
| GDP 60 | -0.31702 *** |
| Pop Growth | 0.19182 * |
| Invest | 0.23437 |
| School | 0.19868 |
| **R-Square Adjusted** | 0.6608 |
| **Residual Standard Error** | 0.1122 |
| **Sample Size:** | 22 |

## Non-OECD Country Model:

| Variable | Coefficients |
|---|---|
| Intercept | 1.35746** |
| GDP 60 | -0.30506 *** |
| Pop Growth | 0.92123 ***. |
| Invest | 0.31811 ** |
| School | 0.30206 ** |
| **R-Square Adjusted** | .5607 |
| **Residual Standard Error** | 0.2435 |
| **Sample Size** | 52 |

- **OECD Improved Adjusted R-square by %20**
- **Invest and School are no longer significant**
  - **Assumption: developed countries' diminishing returns & depreciation**

- **Improved adjusted R-square by 10%**
- **Coefficients larger compared to OECD**
  - **Assumption: Less developed countries have less diminishing returns**

# Conclusion:

- Modeling Economic Growth
  - Backwards, Forwards, and Stepwise yield same results
  - Applying log transformations to our variables slightly improved our model
- Subset Modeling
  - OECD Versus Non-OECD; to simulate countries of similar institutions
    - Successfully improved the model in both cases
    - OECD Model found investment and school insignificant, Pop growth less significant as well.
- Solow Growth Model assumptions
  - By controlling for assumptions described in the Solow Growth Model Theory, our model was improved

# Questions?

# Citations and resources

Journal that reference the same dataset:

1. Durlauf, S.N., and Johnson, P.A. (1995). Multiple Regimes and Cross-Country Growth Behavior. *Journal of Applied Econometrics*, **10**, 365–384.

**Other References:**

**Resource on Econometric Technique: Log Transformations**

2. https://kenbenoit.net/assets/courses/ME104/logmodels2.pdf
3. https://stats.idre.ucla.edu/sas/faq/how-can-i-interpret-log-transformed-variables-in-terms-of-percent-change-in-linear-regression/

**Video Series on Solow's Growth Model:**

4. https://www.youtube.com/watch?v=eVAS-t83Tx0&list=PL-uRhZ_p-BM6L_I3IHvE85NHooK2Ln9Rm