Europe's Greenhouse Gas Emissions

1990-2014

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Why Emissions Data?

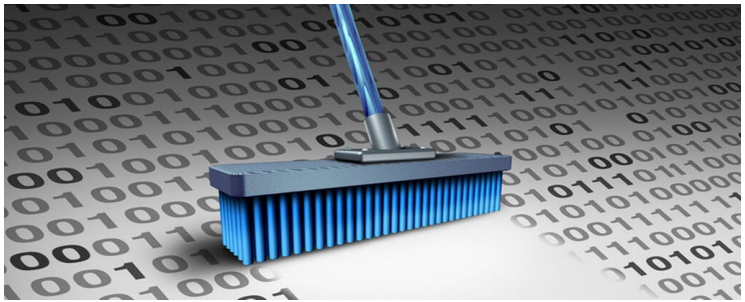
- Climate change may be the biggest problem our world is facing
- A warmer climate leads to:
  - rising sea levels, destructive erosion, lost habitat for fish and animals
  - droughts, reduced freshwater sources
  - increased frequency of dramatic weather events
- Greenhouse gases from human activities are the most significant driver of observed climate change since the mid-20th century.
- See how emissions trends have changed

Greenhouse Emission Dataset

- The United Nations' dataset: greenhouse gases pollutants of 43 countries
- 4 Columns:
    - Country/Region
    - Year (1990-2014)
    - Value (Volume of Pollutant in Kilotonnes)
    - Category of Pollutant
        - CO_2, NF_3, SF_6, CH_4, N_2O, HFCS, PFCs, SF_6, NF_3
    - 8,406 observations
- Focus: different regions of Europe

Cleaning the Dataset

- No empty values
- Add Continent Column
- Add column: name of European Regions
- Filter by Europe only
- Summarize by the different European regions & year
- Aggregated total Greenhouse Gas Emissions

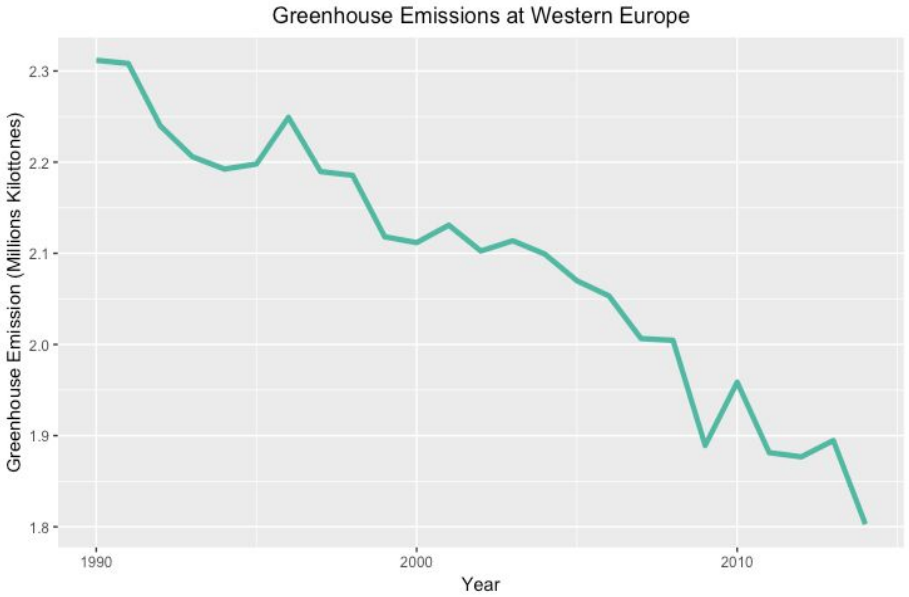


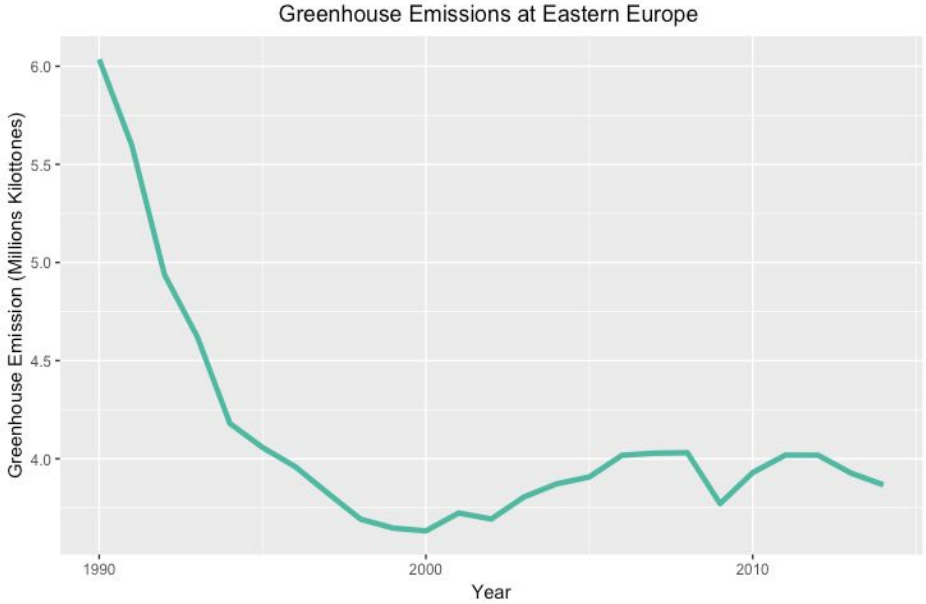
Our Final Dataset

Year	Eastern Europe	Northern Europe	Southern Europe	Western Europe	Europe
1990	6,035,327	1,239,500	1,019,458	2,311,765	10,606,049
1991	5,596,829	1,252,545	1,023,850	2,308,267	10,181,491
1992	4,937,959	1,187,915	1,033,759	2,239,906	9,399,539
1993	4,621,971	1,159,645	1,015,849	2,205,949	9,003,414
1994	4,179,613	1,161,227	1,027,777	2,192,451	8,561,068
1995	4,057,137	1,145,731	1,079,095	2,197,923	8,479,886
1996	3,959,691	1,196,851	1,066,118	2,249,178	8,471,838
1997	3,823,763	1,156,464	1,096,161	2,189,660	8,266,049
1998	3,691,612	1,148,037	1,127,582	2,185,576	8,152,807
1999	3,646,180	1,108,939	1,168,593	2,118,167	8,041,879

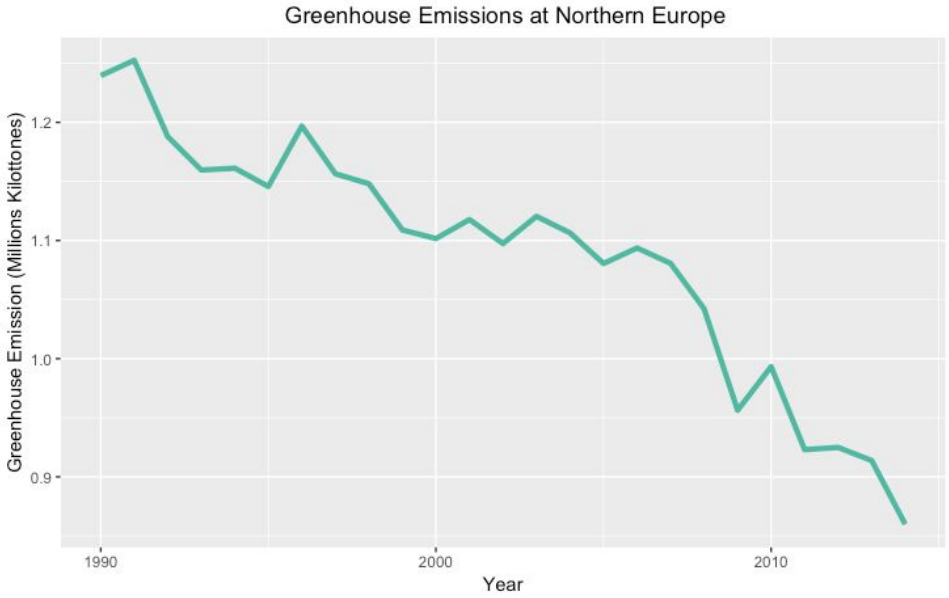
{ Outcome Variables }

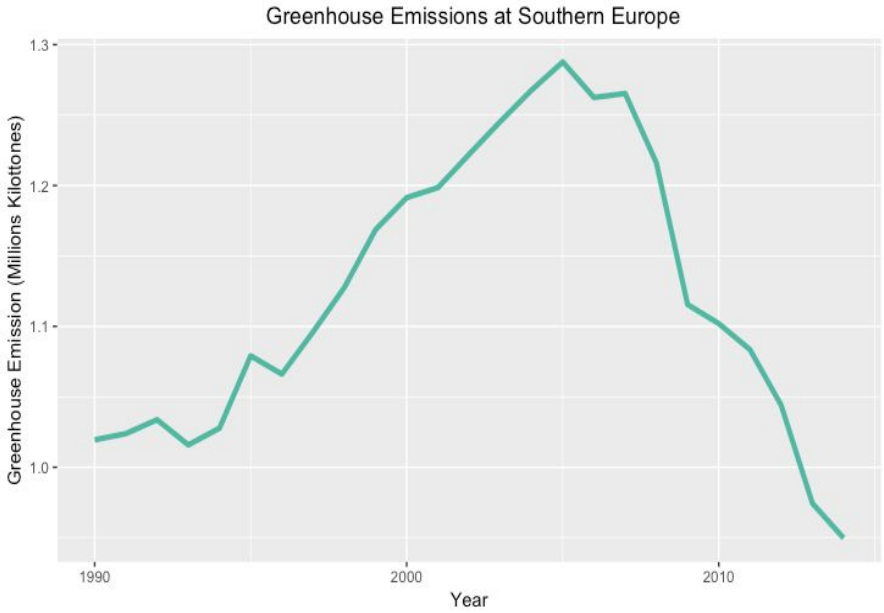
Greenhouse Gas Emissions - Different Regions of Europe



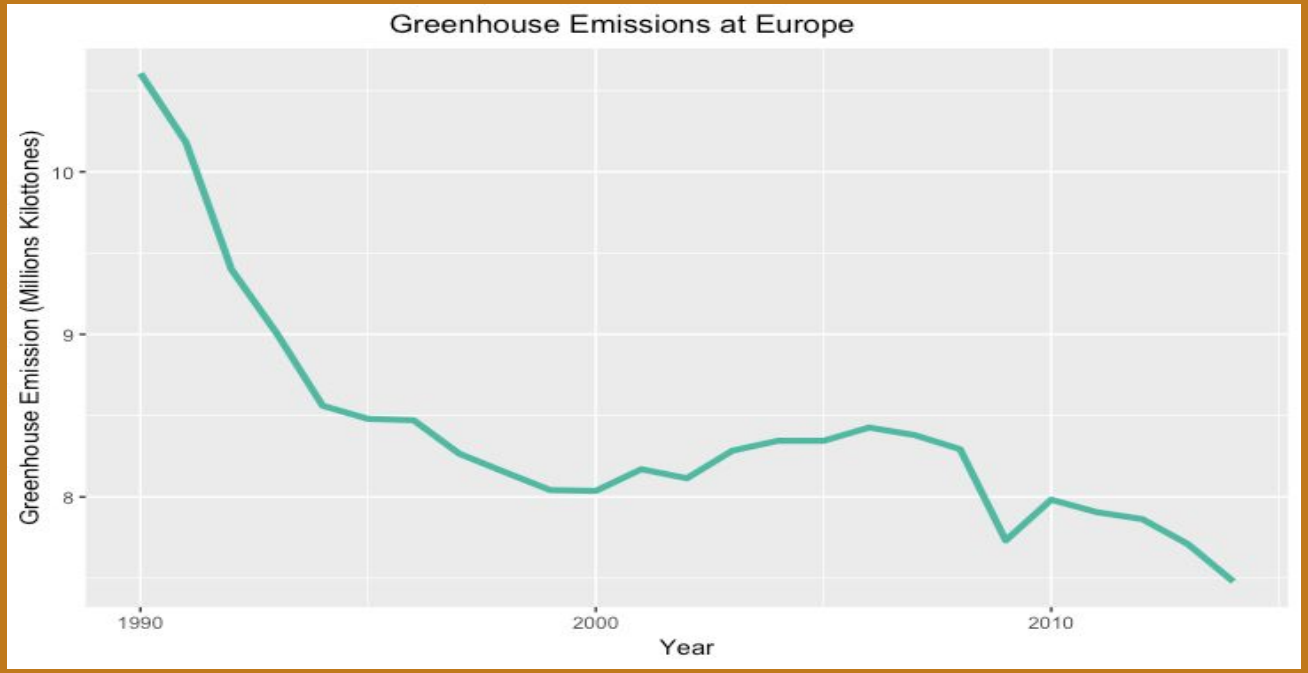


Greenhouse Gas Emissions - Different Regions of Europe



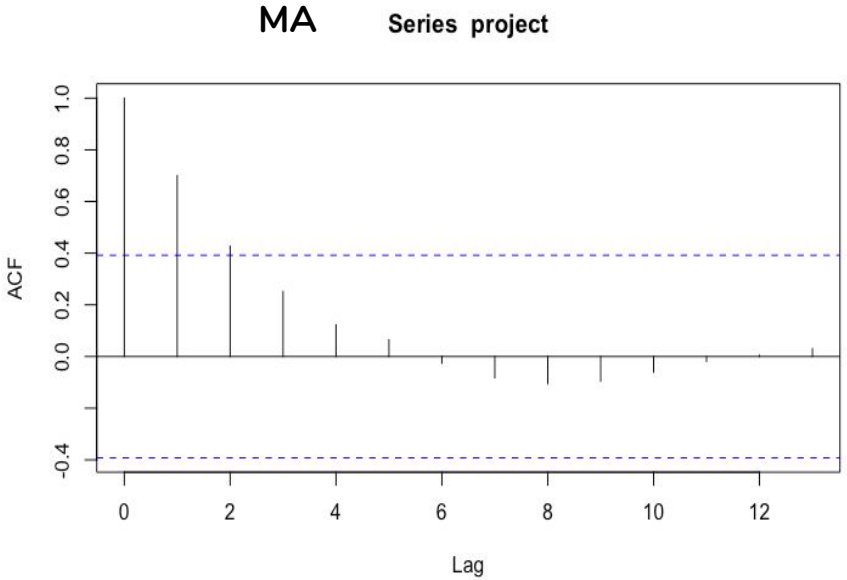


All regions of Europe show a downtrend so we grouped them all together.



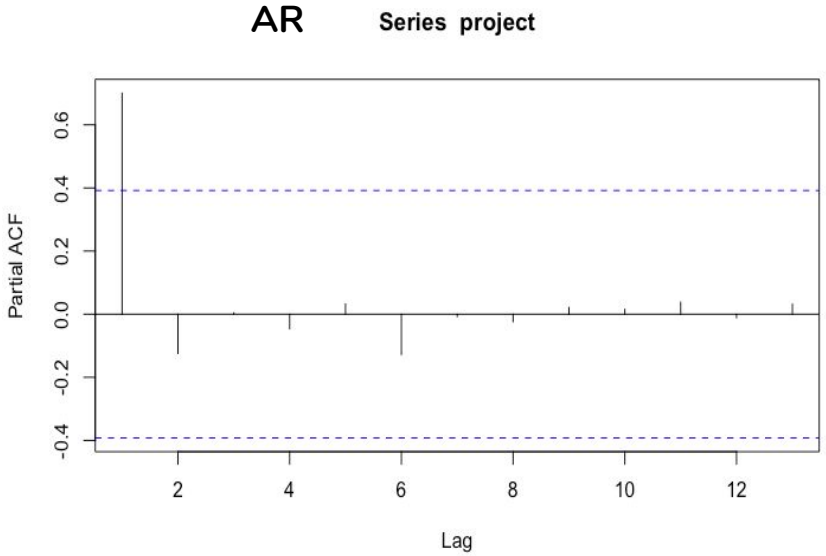
ACF & PACF of Greenhouse Emissions

MA



Regresses quickly
1 to 2 significant lags

AR



Regresses quickly
1 significant lag

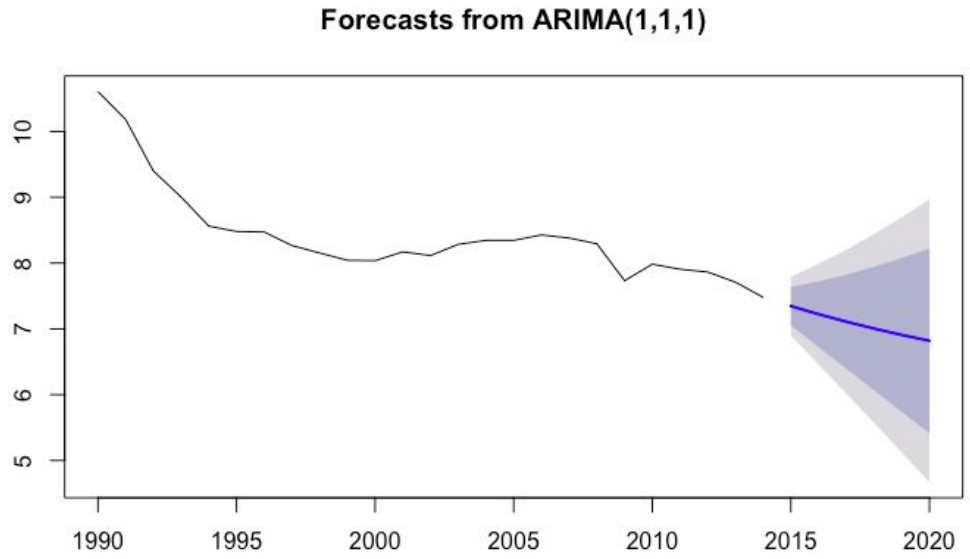
Ljung-Box Test

H0: The data is independently distributed.
Ha: The data exhibit some type of correlation.

```
> Box.test(project, lag=6 ,type = 'Ljung-Box')

        Box-Ljung test

data:  project
X-squared = 21.752, df = 6, p-value = 0.001343

> Box.test(project, lag=8 ,type = 'Ljung-Box')

        Box-Ljung test

data:  project
X-squared = 22.451, df = 8, p-value = 0.004146
```

P-values for lag= 4,6,8 and 10 < 0.05
Reject the Null Hypothesis
Correlation in our data

Model Selected for Greenhouse Emission in Europe



Analysis of Coefficients

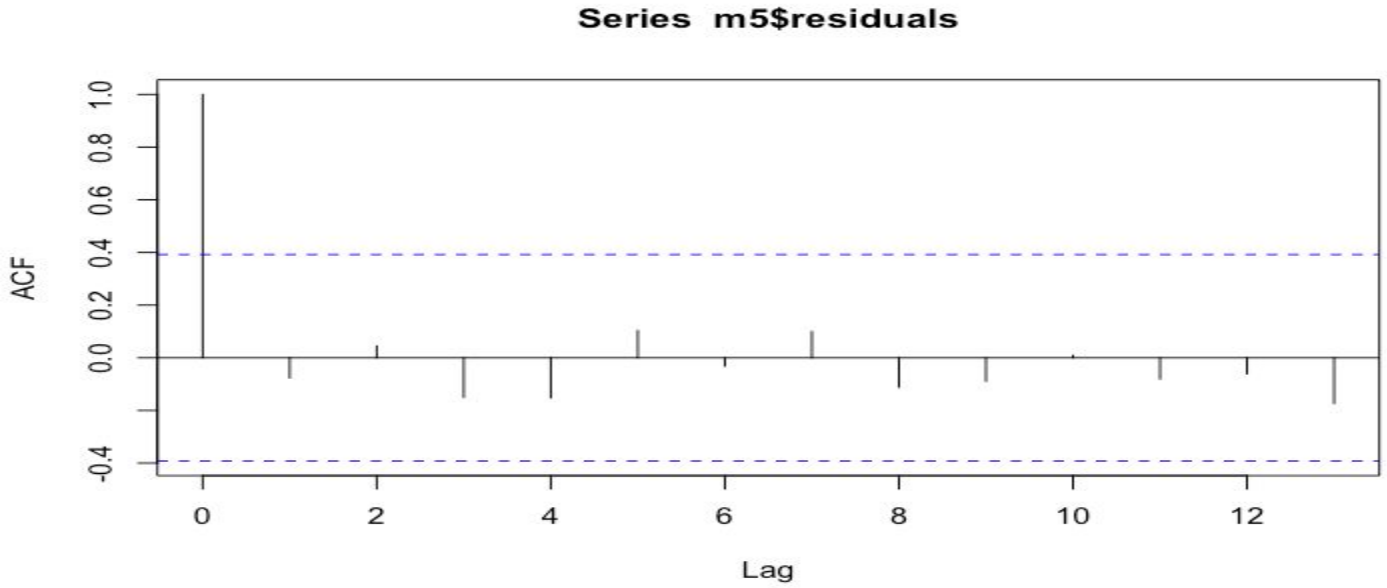
```
Series: project
ARIMA(1,1,1)

Coefficients:
         ar1      ma1
      0.9229  -0.5337
s.e.  0.1184   0.2160

sigma^2 estimated as 0.05194:  log likelihood=2.04
AIC=1.92   AICc=3.12   BIC=5.45
```

```
z test of coefficients:

    Estimate Std. Error z value  Pr(>|z|)
ar1  0.92293    0.11837  7.7972 6.331e-15 ***
ma1 -0.53374    0.21597 -2.4714   0.01346 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

$$X_t = (0.9229)X_{t-1} - (0.53374)E_{t-1}$$

Best AIC & BIC from all tested models.
All coefficients are significant to the model!

Analysis of Residuals



ACF of Residuals show no serial Autocorrelation!

Are Residuals White Noise?

```
        Box-Ljung test

data:  m5$residuals
X-squared = 1.6605, df = 4, p-value = 0.7979
```

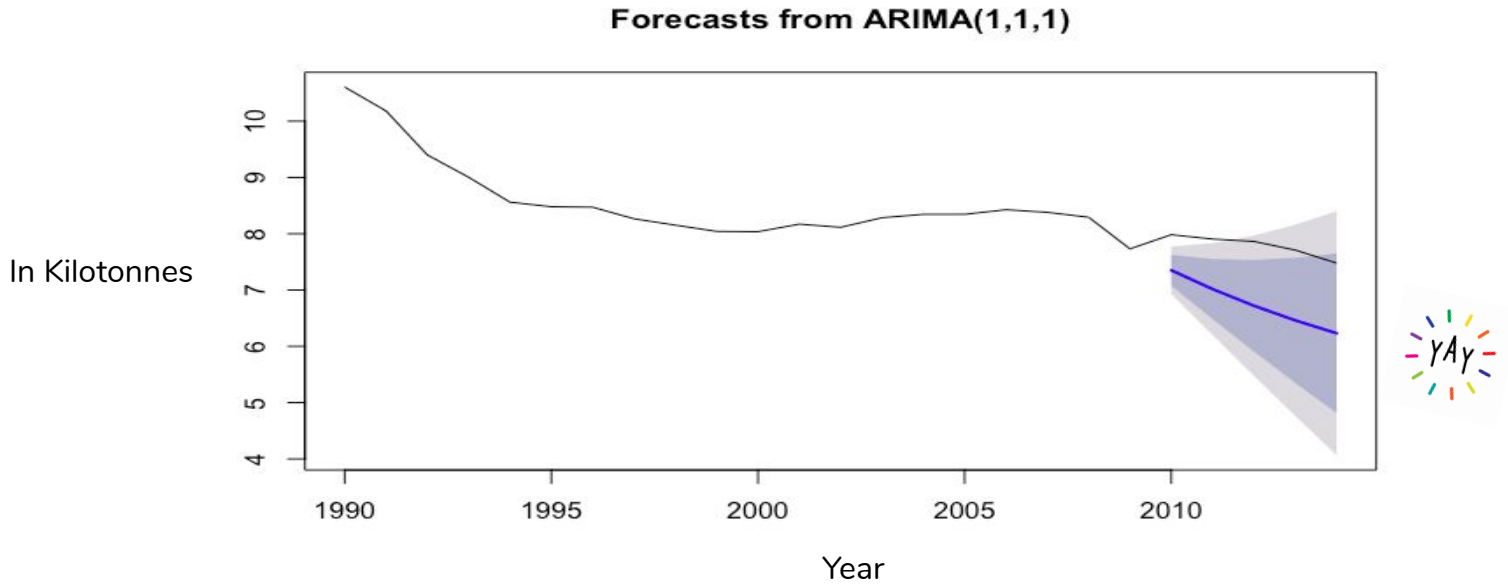
```
        Box-Ljung test

data:  m5$residuals
X-squared = 2.056, df = 6, p-value = 0.9145
```

```
        Box-Ljung test

data:  m5$residuals
X-squared = 2.9222, df = 8, p-value = 0.9391
```

P-values > 0.05
Keep the Null Hypothesis:
Residuals are independent
WHITE NOISE!

Splitting into Testing/Training

- Split the data into 80% for Training and 20% for Testing.



We would recommend ARIMA (1,1,1) for European Greenhouse Emissions

Results & Significance

Although **Downward Trend** is promising, it is still a net of 9 Kilotonnes of pollutants from Europe alone.

European Commission:
“EU greenhouse gas emissions were **reduced by 23%** between 1990 and 2018,while the **economy grew by 61%**”

European Commission’s Goal:
Carbon Neutrality & Climate-Neutral Economy by 2050