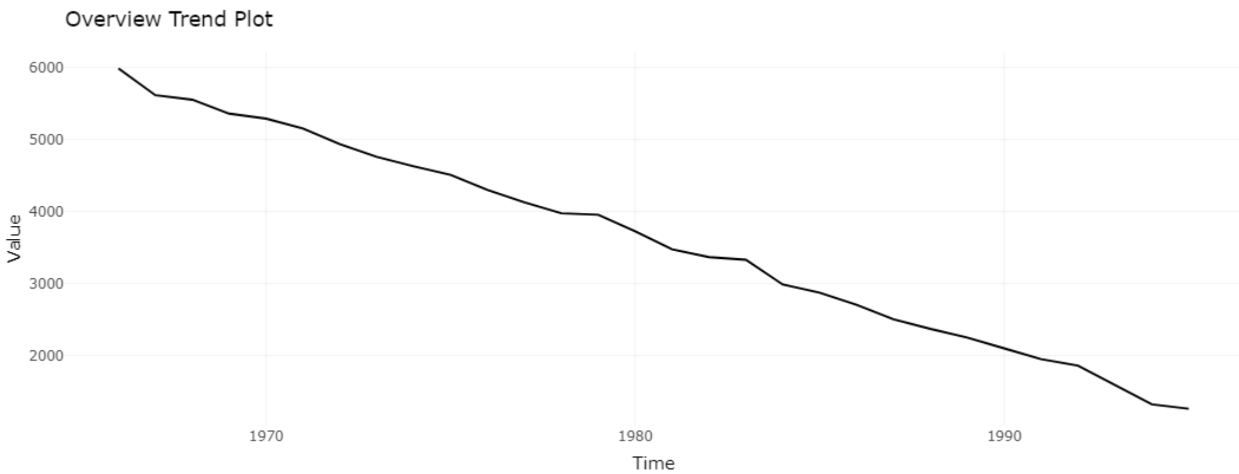
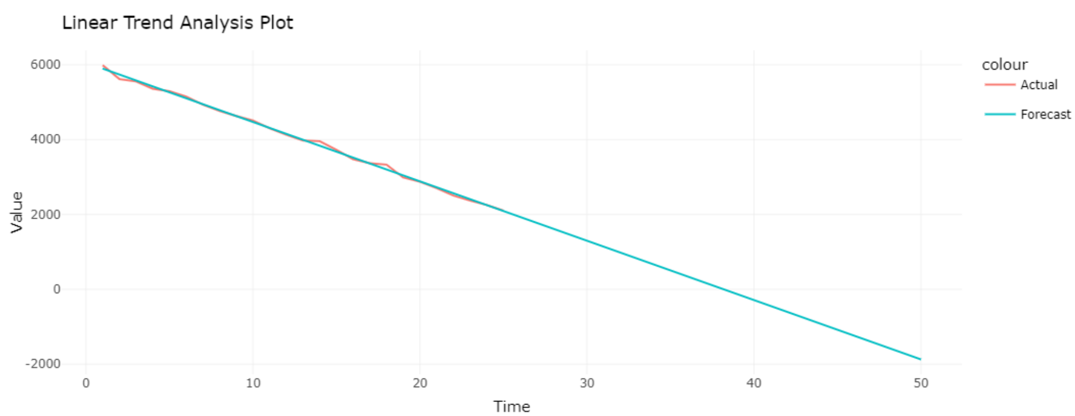
Group 1

Questions:

1. **Plot the Sales Data**: Upload the provided CSV file containing the `Time` for `Year` and `Value` for `Sales` columns. Visualize the trend of sales over the years.



2. **Linear Trend Analysis**: (Use first 25 records)
    - Perform a linear regression to fit a trend line to the sales data. (Include the plot also)
    - Display the regression equation.

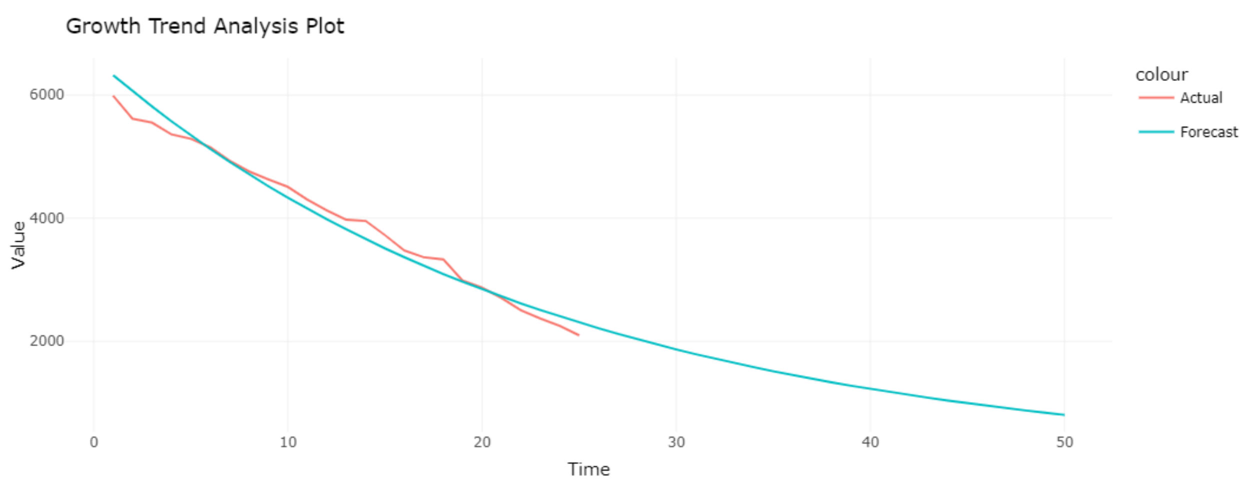


```
Call:
lm(formula = time_series ~ time_index)

Residuals:
    Min      1Q  Median      3Q     Max 
-121.89  -26.55  -10.86   27.79  130.03 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 6055.000     24.153  250.69   <2e-16 ***
time_index  -158.557      1.625  -97.59   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 58.58 on 23 degrees of freedom
Multiple R-squared:  0.9976,	Adjusted R-squared:  0.9975 
F-statistic:  9524 on 1 and 23 DF,  p-value: < 2.2e-16
```

Y(t) = 6055 – 158.557t

Growth Trend Analysis:

- Perform a growth trend analysis assuming both annual and continuous compounding.
  Annual Compounding



```
Call:
lm(formula = log_ts ~ time_index)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.040746 -0.018901  0.002784  0.015450  0.033567 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)  3.8191546  0.0087697  435.49   <2e-16 ***
time_index  -0.0182476  0.0005899  -30.93   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02127 on 23 degrees of freedom
Multiple R-squared:  0.9765,	Adjusted R-squared:  0.9755 
F-statistic: 956.8 on 1 and 23 DF,  p-value: < 2.2e-16
```

Continuous Compounding

```
Call:
lm(formula = log_ts ~ time_index)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.093822 -0.043520  0.006411  0.035576  0.077292 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)  8.793929   0.020193  435.49   <2e-16 ***
time_index  -0.042017   0.001358  -30.93   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.04898 on 23 degrees of freedom
Multiple R-squared:  0.9765,	Adjusted R-squared:  0.9755 
F-statistic: 956.8 on 1 and 23 DF,  p-value: < 2.2e-16
```

- Display the growth model equations.

Annual Compounding: log(Y(t)) = 3.8191546 - 0.0182476t

$Y(t) = 6594.085895 * 0.958860^t$

Continuous Compounding: $\ln(Y(t)) = 8.793929 – 0.042017t$

$Y(t) = 6594.089523 * \exp -^{0.042017t}$

- Find the growth rate for each case.

Annual Compounding:

$1+g = 0.958854$

$g = -0.041146$

Continuous Compounding:

$g = -0.042017$

3. **Forecast Future Sales**: (Use last 5 records)
    - Using the fitted linear trend model and growth trend model assuming both annual and continuous compounding forecast the sales for the next 5 years.

Actual	linear	Growth_annual_compounding	Growth_continuos_compounding
1950	1932.518	2211.66422	2211.634248
1859	1773.961	2120.663084	2120.633195
1594	1615.404	2033.406281	2033.376519
1323	1456.847	1949.739746	1949.710151
1262	1298.29	1869.515755	1869.486363

- Discuss the goodness of the fitted model.

    Linear Trend Model: R^2 =0.9975 which is almost 99%. The model fits the data well.

    Growth model with Annual Compounding: R^2 =0.9755 which is almost 97%. The model fits the data well.

    Growth model with Continuous Compounding: R^2 =0.9755 which is almost 97%. The model fits the data well.

- By looking at the forecasted values what do you think about the most suitable model?

In Linear Trend Model: R2 =0.9975 which is almost 99% and also the forecasted values are very close to actual values compared to other models. Therefore Linear Trend Model is more suitable.

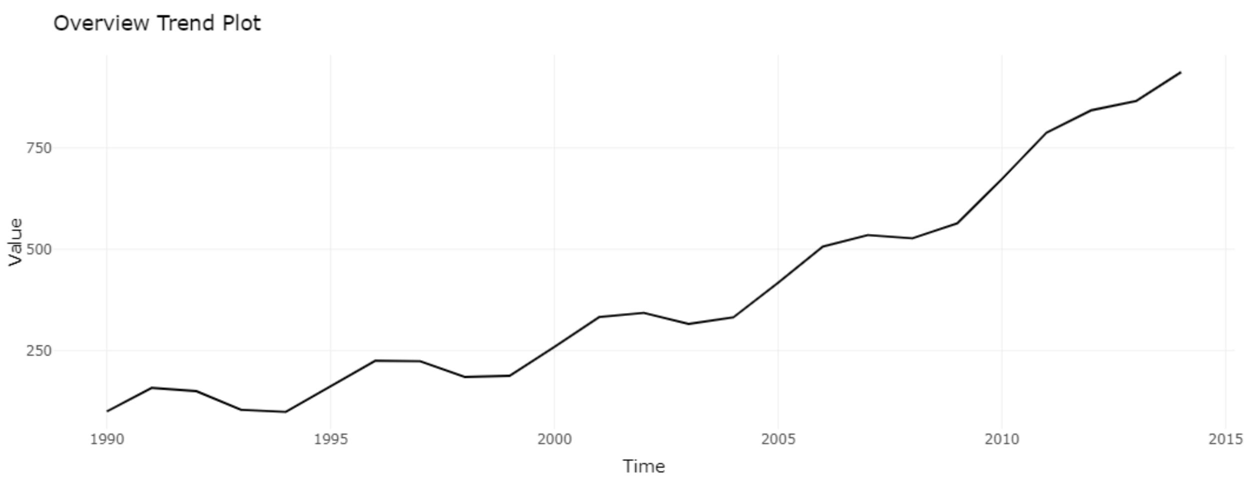
- Suggest a suitable exponential smoothing method.

  Since only the trend is present in the data Holt's Two-Parameter Exponential Smoothing is the most suitable exponential smoothing method.

Group 2

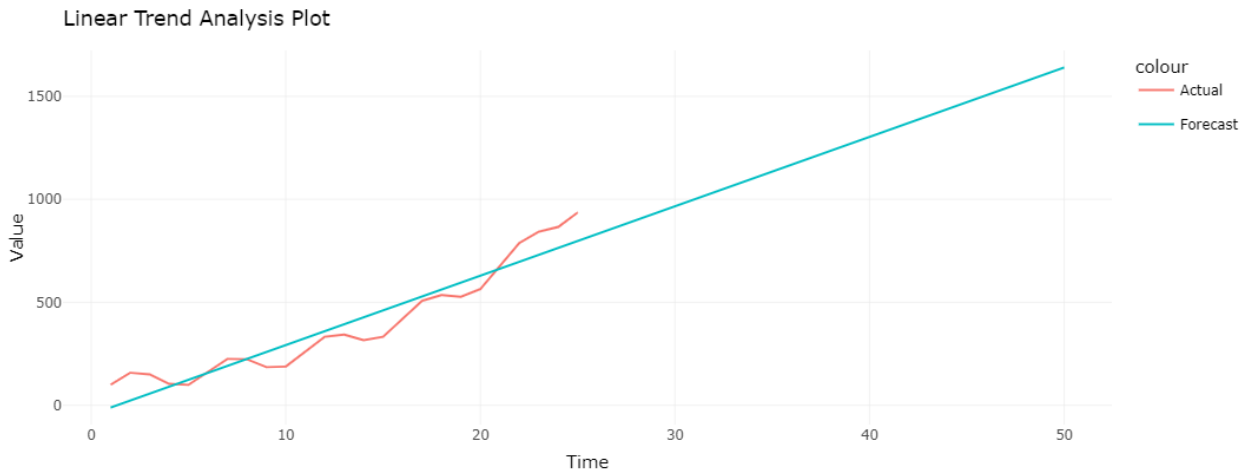
Questions:

1. **Plot the Sales Data**: Upload the provided CSV file containing the `Year` and `Sales` columns. Visualize the trend of sales over the years.



2. **Linear Trend Analysis**:

- Perform a linear regression to fit a trend line to the sales data.



- Display the regression equation.

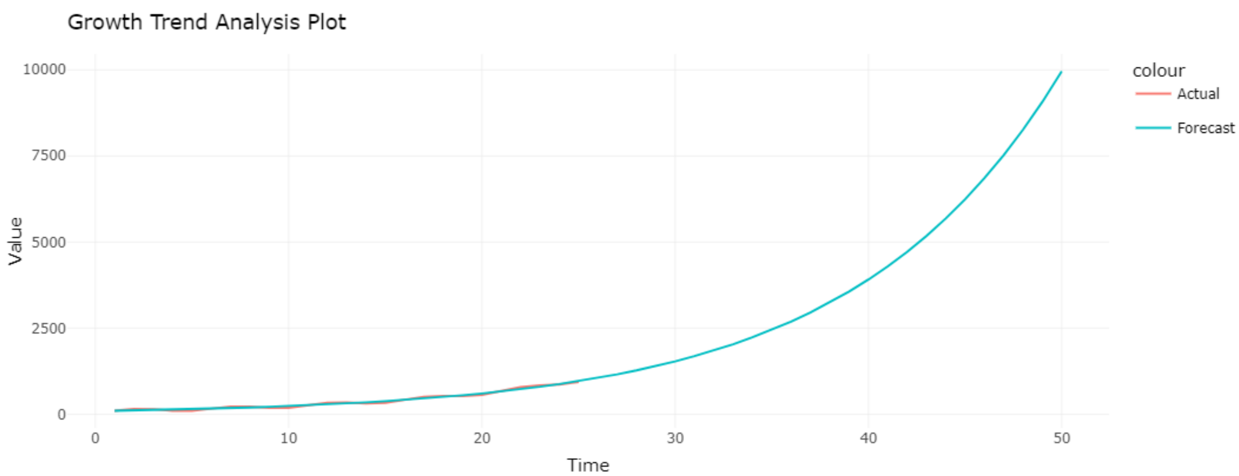
```
Call:
lm(formula = time_series ~ time_index)

Residuals:
    Min      1Q  Median      3Q     Max 
-128.79  -67.01  -21.18   91.33  139.25 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  -44.650     34.517  -1.294    0.209    
time_index    33.696      2.322  14.513 4.56e-13 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 83.72 on 23 degrees of freedom
Multiple R-squared:  0.9015,	Adjusted R-squared:  0.8973 
F-statistic: 210.6 on 1 and 23 DF,  p-value: 4.561e-13
```

$Y(t) = -44.650 + 33.696t$

Growth Trend Analysis:

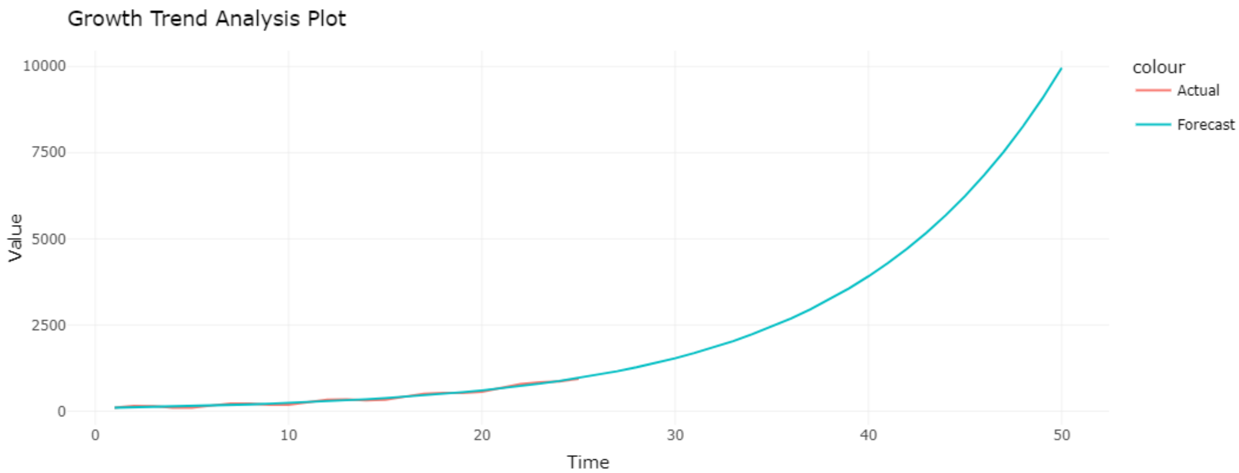
- Perform a growth trend analysis assuming both annual and continuous compounding.

Annual Compounding




```
Call:
lm(formula = log_ts ~ time_index)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.176342 -0.029525 -0.002208  0.038609  0.148445 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 1.969035   0.029521   66.70  < 2e-16 ***
time_index  0.040588   0.001986   20.44 3.01e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.0716 on 23 degrees of freedom
Multiple R-squared:  0.9478,	Adjusted R-squared:  0.9455 
F-statistic: 417.8 on 1 and 23 DF,  p-value: 3.011e-16
```

Continuous Compounding




```
Call:
lm(formula = log_ts ~ time_index)

Residuals:
     Min       1Q   Median       3Q      Max
-0.40604 -0.06798 -0.00508  0.08890  0.34181

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 4.533871   0.067976   66.70  < 2e-16 ***
time_index  0.093458   0.004573   20.44 3.01e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1649 on 23 degrees of freedom
Multiple R-squared:  0.9478,    Adjusted R-squared:  0.9455
F-statistic: 417.8 on 1 and 23 DF,  p-value: 3.011e-16
```

- Display the growth model equations.

Annual Compounding: $\log(Y(t)) = 1.969035 + 0.040588t$

$Y(t) = 93.11829169 * 1.097963745^{t}$

Continuous Compounding: $\ln(Y(t)) = 4.533811 + 0.093458t$

$Y(t) = 93.11273841 * \exp(0.093458t)$

- Find the growth rate for each case.

Annual Compounding:

1+g = 1.097963745

g = 0.097963745

Continuous Compounding:

g = 0.093458

3. Forecast Future Sales:

- Using the fitted linear trend model and growth trend model assuming both annual and continuous compounding forecast the sales for the next 5 years.

Actual	linear	growth_annual_compounding	growth_continuous_compounding
1083	831.446	1057.603784	1057.559316
1239	865.142	1161.210612	1161.162573
1340	898.838	1274.967152	1274.915269
1413	932.534	1399.867709	1399.811691
1539	966.23	1537.003992	1536.943526

- Discuss the goodness of the fitted model.

  Linear Trend Model: R^2 =0.8973 which is almost 90%. The model fits the data well.

  Growth model with Annual Compounding: R^2 =0.9455 which is almost 95%. The model fits the data well.

  Growth model with Continuous Compounding: R^2 =0.9455 which is almost 95%. The model fits the data well.

- Suggest a suitable exponential smoothing method.

  Since both the trend and seasonality are present in the data Winters' Three-Parameter Exponential Smoothing is the most suitable exponential smoothing method.

Group 3:

Questions:

1. **Multiple Regression Analysis**: (Use first 25 records)
   - Perform a multiple regression analysis with `Regional_Demand` as the dependent variable and `Price_per_Case`, `Competitor_Price`, `Advertising`, and `Household_Income` as independent variables.

```
Call:
lm(formula = formula, data = df)

Residuals:
    Min      1Q  Median      3Q     Max 
-44.360 -24.756  -9.339  29.788  61.259 

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)    
(Intercept)      922.372304 173.352172   5.321 3.30e-05 ***
Price_per_Case    -5.073803   0.512195  -9.906 3.71e-09 ***
Competitor_Price   4.423604   1.105779   4.000 0.000703 ***
Advertising        0.263183   0.123456   2.132 0.045612 *  
Household_Income   0.008321   0.001297   6.416 2.94e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 36.37 on 20 degrees of freedom
Multiple R-squared:  0.896,	Adjusted R-squared:  0.8752 
F-statistic: 43.09 on 4 and 20 DF,  p-value: 1.471e-09
```

   - Display the regression equation.

D(i) = 922.372304 – 5.073803P(i) + 4.423604C(i) + 0.263183A(i) + 0.008321H(i)

2. **Interpret Coefficients**:
   - Interpret the coefficients of the regression model. Discuss the impact of each independent variable on regional demand.

If the price is increased by 1 unit the demand will be decreased by 5.073803 units when all the other independent variables remains unchanged.

If the Competitor price is increased by 1 unit the demand will be increased by 4.423604 units when all the other independent variables remains unchanged.

If the advertising is increased by 1 unit the demand will be increased by 0.263183 units when all the other independent variables remains unchanged.

If the household income is increased by 1 unit the demand will be increased by 0.008321 units when all the other independent variables remains unchanged.

3. **Forecast Regional Demand**: (Use last 5 records)
    - Use the fitted regression model to predict the regional demand for new markets with given values of independent variables.

	Price_per_Case	Competitor_Price	Advertising	Household_Income	Forecast_Value
1	138	97	929	46084	1279.23197039463
2	116	97	1000	52249	1460.83964262043
3	148	84	951	50855	1216.47585880182
4	134	88	848	54546	1308.80789580743
5	127	87	891	38085	1214.24837194392

    - Discuss the goodness of the fitted model.

    Model R^2 =0.8752 which is almost 88%. The model fits the data well.