# Emissions Toll on the Earth's Temperature over Time

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```r
# Load necessary packages
library(forecast)
library(dplyr)
library(purrr)

# Load the CSV file
data <- read.csv("Project_Dataset_CLEANED.csv", header=TRUE)

# Convert each variable (except Year) to time series, starting from 1882 with annual frequency
data_ts <- data %>%
  select(-Year) %>%
  map(~ ts(.x, start=1882, frequency=1))  # Annual data, frequency=1

# Define a range of alpha and beta values to test
alpha_values <- seq(0.1, 1, by=0.1)
beta_values <- seq(0.1, 1, by=0.1)

# Define the training and test periods
train_end <- 2012  # Use data up to 2012 for training
test_start <- 2013 # Forecast the period from 2013 to 2022

# Initialize a list to store the results
results <- list()

# Loop through each variable to perform forecasting
for (variable in names(data_ts)) {

  # Extract the time series data for the current variable
  ts_data <- data_ts[[variable]]

```

Firstly, there needs to be a load of all the necessary packages before proceeding to reading the csv file to get the outputs of the calculations. A conversion needs to be made for each variable starting from 1882 with an annual frequency and this way it can be tested in a defined range of alpha and beta values. Next, is to define the periods in order to test the calculations in each time period which results in an initialization of a list in order to store results. This will then loop each variable to get the forecasting calculation and result, which allows the extraction of each time series data to get the current variable.

```r
# Split data into training and test sets
train_data <- window(ts_data, end=train_end)
test_data <- window(ts_data, start=test_start)

# Loop over each alpha and beta combination
for (alpha in alpha_values) {
  for (beta in beta_values) {

    # Use tryCatch to handle any errors in model fitting
    tryCatch({
      # Fit the Holt model with the specified alpha and beta values
      model <- holt(train_data, alpha=alpha, beta=beta, damped=FALSE)

      # Forecast the test period (2013-2022)
      forecasted_values <- forecast(model, h=length(test_data))

      # Calculate accuracy metrics for this combination
      accuracy_metrics <- accuracy(forecasted_values, test_data)

      # Store results in the list
      results[[length(results) + 1]] <- data.frame(
        Variable = variable,
        Alpha = alpha,
        Beta = beta,
        ME = accuracy_metrics["Test set", "ME"],
        RMSE = accuracy_metrics["Test set", "RMSE"],
        MAE = accuracy_metrics["Test set", "MAE"],
        MAPE = accuracy_metrics["Test set", "MAPE"]
      )
```

The portion of this program shows that it needs to split data into test datasets to allow the calculation of AES and MAPE. This will then loop each alpha and beta value. The line that shows tryCatch is used to find any error and handle it along with Holt finding specific alpha and beta values. Forecasting is now being implemented for the time periods and along with calculation of the accuracy. The accuracy results are then stored inside a list, which will show in the output of the program.

```r
      }, error = function(e) {
        # If an error occurs, print a message and skip this combination
        message("Error for variable: ", variable, " Alpha: ", alpha, " Beta: ", beta, "\n", e)
      })
    }
  }
}

# Combine all results into a single data frame
results_df <- do.call(rbind, results)

best_params <- results_df %>%
  group_by(Variable) %>%
  filter(RMSE == min(RMSE)) %>%
  arrange(Variable)

# Display the best alpha-beta combinations for each variable
print(best_params)
```

For the last portion of the program, the line shows that if an error occurs, it will print an output error occurrence message and skip the combination entirely. Now, is the combination of all the results in an organized, single output data frame and will display the best alpha and beta value combinations for each variable of the code.

```
# Groups:   Variable [5]
  Variable             Alpha  Beta       ME          RMSE       MAE   MAPE
  <chr>                <dbl> <dbl>    <dbl>         <dbl>     <dbl>  <dbl>
1 Average.Temp           0.4   0.1  3.07e-1          1.15   9.85e-1 1.78
2 Coal.Emissions         0.9   0.6 -5.36e+7   412922404.    3.46e+8 0.0462
3 Cumulative.Emissions   0.8   0.8  3.81e+9  4867866707.    3.81e+9 0.226
4 Gas.Emissions          0.7   0.7  2.63e+9  3541859616.    2.63e+9 1.07
5 Oil.Emissions          0.8   0.8  1.91e+9  2274110398.    1.91e+9 0.328
>
```

Here, the values of the Alpha and Beta are shown with their corresponding Error values (methods include ME, RMSE, MAE, and MAPE) for each variable in our project data. For all the variables besides the Average Temperature, it is best to look at the MAPE as the values are too large to reasonably compare, as the MAPE returns a percentage rather than an amount. However, for the Average Temperature, one can look at all of the other error calculations because the numbers are much smaller and we can infer what each error calculation output means within the context of the data.

Furthermore, the function used to calculate the best alpha and beta values with the lowest error tested all possible combinations of alpha and beta values. This prevented the program from overlooking a possible better combination of alpha/beta values that may have yielded more accurate forecasts.

```
> # Display the best alpha-beta combinations for each variable
> print(results_df)
          Variable Alpha Beta            ME         RMSE          MAE        MAPE
1     Average.Temp   0.1  0.1  2.379599e+00 2.601493e+00 2.379599e+00  4.25595973
2     Average.Temp   0.2  0.1  1.591320e+00 1.905180e+00 1.715413e+00  3.06697726
3     Average.Temp   0.2  0.2 -4.863654e-01 1.770660e+00 1.452663e+00  2.62152377
4     Average.Temp   0.3  0.1  9.355328e-01 1.424399e+00 1.252970e+00  2.24759337
5     Average.Temp   0.3  0.2 -1.155552e+00 2.157918e+00 1.720084e+00  3.10910519
6     Average.Temp   0.3  0.3 -3.538222e+00 4.660893e+00 3.617892e+00  6.52360157
7     Average.Temp   0.4  0.1  3.068369e-01 1.149756e+00 9.853958e-01  1.78078715
8     Average.Temp   0.4  0.2 -1.846972e+00 2.665579e+00 2.089607e+00  3.77920711
9     Average.Temp   0.4  0.3 -4.449006e+00 5.485558e+00 4.449006e+00  8.01948375
10    Average.Temp   0.4  0.4 -7.631903e+00 9.033968e+00 7.631903e+00 13.73723136
11    Average.Temp   0.5  0.1 -3.063951e-01 1.183357e+00 9.927252e-01  1.80487002
12    Average.Temp   0.5  0.2 -2.510162e+00 3.208179e+00 2.524612e+00  4.56546675
13    Average.Temp   0.5  0.3 -5.156596e+00 6.116283e+00 5.156596e+00  9.29357370
14    Average.Temp   0.5  0.4 -8.133130e+00 9.441399e+00 8.133130e+00 14.64076709
15    Average.Temp   0.5  0.5 -1.118587e+01 1.285918e+01 1.118587e+01 20.12508925
16    Average.Temp   0.6  0.1 -9.003750e-01 1.480651e+00 1.136188e+00  2.07090188
17    Average.Temp   0.6  0.2 -3.128804e+00 3.742309e+00 3.128804e+00  5.65365601
18    Average.Temp   0.6  0.3 -5.749713e+00 6.641644e+00 5.749713e+00 10.36188723
19    Average.Temp   0.6  0.4 -8.580754e+00 9.808979e+00 8.580754e+00 15.44775608
20    Average.Temp   0.6  0.5 -1.145271e+01 1.302947e+01 1.145271e+01 20.60724162
21    Average.Temp   0.6  0.6 -1.422377e+01 1.613834e+01 1.422377e+01 25.58556250
22    Average.Temp   0.7  0.1 -1.473915e+00 1.903261e+00 1.500775e+00  2.73124119
23    Average.Temp   0.7  0.2 -3.709850e+00 4.260337e+00 3.709850e+00  6.70011313
24    Average.Temp   0.7  0.3 -6.285102e+00 7.118138e+00 6.285102e+00 11.32638373
25    Average.Temp   0.7  0.4 -9.008376e+00 1.016776e+01 9.008376e+00 16.21865111
26    Average.Temp   0.7  0.5 -1.174900e+01 1.324457e+01 1.174900e+01 21.14213865
27    Average.Temp   0.7  0.6 -1.440261e+01 1.622661e+01 1.440261e+01 25.90936021
28    Average.Temp   0.7  0.7 -1.690511e+01 1.904068e+01 1.690511e+01 30.40509968
29    Average.Temp   0.8  0.1 -2.031758e+00 2.374804e+00 2.031758e+00  3.68819511
30    Average.Temp   0.8  0.2 -4.269799e+00 4.771262e+00 4.269799e+00  7.70863900
31    Average.Temp   0.8  0.3 -6.803534e+00 7.586271e+00 6.803534e+00 12.26035168
32    Average.Temp   0.8  0.4 -9.455850e+00 1.055754e+01 9.455850e+00 17.02512898
33    Average.Temp   0.8  0.5 -1.212341e+01 1.355442e+01 1.212341e+01 21.81731713
34    Average.Temp   0.8  0.6 -1.473708e+01 1.649479e+01 1.473708e+01 26.51268625
35    Average.Temp   0.8  0.7 -1.726622e+01 1.934287e+01 1.726622e+01 31.05619709
36    Average.Temp   0.8  0.8 -1.972248e+01 2.211153e+01 1.972248e+01 35.46874387
37    Average.Temp   0.9  0.1 -2.583149e+00 2.870833e+00 2.583149e+00  4.68129353
38    Average.Temp   0.9  0.2 -4.828140e+00 5.290514e+00 4.828140e+00  8.71428160
39    Average.Temp   0.9  0.3 -7.338123e+00 8.078791e+00 7.338123e+00 13.22334122
40    Average.Temp   0.9  0.4 -9.959218e+00 1.101427e+01 9.959218e+00 17.93202292
41    Average.Temp   0.9  0.5 -1.261155e+01 1.399408e+01 1.261155e+01 22.69682897
42    Average.Temp   0.9  0.6 -1.525389e+01 1.696734e+01 1.525389e+01 27.44367924
43    Average.Temp   0.9  0.7 -1.787955e+01 1.992476e+01 1.787955e+01 32.16053556
44    Average.Temp   0.9  0.8 -2.051498e+01 2.289542e+01 2.051498e+01 36.89495626
45    Average.Temp   0.9  0.9 -2.321363e+01 2.593917e+01 2.321363e+01 41.74291429
46  Coal.Emissions   0.1  0.1  4.557445e+07 3.336886e+09 2.925889e+09  0.39107593
47  Coal.Emissions   0.2  0.1  4.871689e+09 4.883141e+09 4.871689e+09  0.65079764
48  Coal.Emissions   0.2  0.2 -7.585878e+08 1.636747e+09 1.421351e+09  0.18523459
```

This table takes into account all of the accuracy values for each alpha and beta combination for each variable, and then selects the most accurate alpha and beta combination for each variable. The table above showcases the best alpha and beta combination for variables Average Temperature and Coal Emissions.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 49 | Coal.Emissions | 0.3 | 0.1 | 7.930352e+09 | 8.151511e+09 | 7.930352e+09 | 1.04279695 |
| 50 | Coal.Emissions | 0.3 | 0.2 | 9.241472e+08 | 1.108836e+09 | 9.244326e+08 | 0.12736354 |
| 51 | Coal.Emissions | 0.3 | 0.3 | 1.879800e+08 | 7.168018e+08 | 5.905047e+08 | 0.08036272 |
| 52 | Coal.Emissions | 0.4 | 0.1 | 1.008452e+10 | 1.064593e+10 | 1.008452e+10 | 1.31840554 |
| 53 | Coal.Emissions | 0.4 | 0.2 | 2.457531e+09 | 2.487930e+09 | 2.457531e+09 | 0.32529595 |
| 54 | Coal.Emissions | 0.4 | 0.3 | 7.373265e+08 | 8.540451e+08 | 7.385668e+08 | 0.10103185 |
| 55 | Coal.Emissions | 0.4 | 0.4 | 2.029307e+07 | 7.106319e+08 | 6.167452e+08 | 0.08278444 |
| 56 | Coal.Emissions | 0.5 | 0.1 | 1.175008e+10 | 1.262892e+10 | 1.175008e+10 | 1.53124493 |
| 57 | Coal.Emissions | 0.5 | 0.2 | 3.798881e+09 | 3.960526e+09 | 3.798881e+09 | 0.49808565 |
| 58 | Coal.Emissions | 0.5 | 0.3 | 1.332582e+09 | 1.356483e+09 | 1.332582e+09 | 0.17745734 |
| 59 | Coal.Emissions | 0.5 | 0.4 | 1.846423e+08 | 5.941281e+08 | 4.716250e+08 | 0.06447389 |
| 60 | Coal.Emissions | 0.5 | 0.5 | -7.702372e+08 | 1.259468e+09 | 1.086582e+09 | 0.14067278 |
| 61 | Coal.Emissions | 0.6 | 0.1 | 1.312544e+10 | 1.429123e+10 | 1.312544e+10 | 1.70686035 |
| 62 | Coal.Emissions | 0.6 | 0.2 | 4.985877e+09 | 5.318123e+09 | 4.985877e+09 | 0.65071989 |
| 63 | Coal.Emissions | 0.6 | 0.3 | 1.987324e+09 | 2.050578e+09 | 1.987324e+09 | 0.26157075 |
| 64 | Coal.Emissions | 0.6 | 0.4 | 5.245340e+08 | 6.346241e+08 | 5.515029e+08 | 0.07521798 |
| 65 | Coal.Emissions | 0.6 | 0.5 | -4.989573e+08 | 9.317127e+08 | 8.181241e+08 | 0.10646662 |
| 66 | Coal.Emissions | 0.6 | 0.6 | -1.348803e+09 | 1.794734e+09 | 1.473763e+09 | 0.18908428 |
| 67 | Coal.Emissions | 0.7 | 0.1 | 1.431738e+10 | 1.574458e+10 | 1.431738e+10 | 1.85899316 |
| 68 | Coal.Emissions | 0.7 | 0.2 | 6.056508e+09 | 6.566321e+09 | 6.056508e+09 | 0.78822603 |
| 69 | Coal.Emissions | 0.7 | 0.3 | 2.682145e+09 | 2.836354e+09 | 2.682145e+09 | 0.35080266 |
| 70 | Coal.Emissions | 0.7 | 0.4 | 9.731109e+08 | 1.006973e+09 | 9.731109e+08 | 0.12927638 |
| 71 | Coal.Emissions | 0.7 | 0.5 | -1.320372e+08 | 5.629507e+08 | 4.980677e+08 | 0.06598789 |
| 72 | Coal.Emissions | 0.7 | 0.6 | -9.671451e+08 | 1.341350e+09 | 1.114533e+09 | 0.14331539 |
| 73 | Coal.Emissions | 0.7 | 0.7 | -1.624229e+09 | 2.043437e+09 | 1.670910e+09 | 0.21408868 |
| 74 | Coal.Emissions | 0.8 | 0.1 | 1.538793e+10 | 1.705589e+10 | 1.538793e+10 | 1.99562885 |
| 75 | Coal.Emissions | 0.8 | 0.2 | 7.038867e+09 | 7.723837e+09 | 7.038867e+09 | 0.91430965 |
| 76 | Coal.Emissions | 0.8 | 0.3 | 3.398593e+09 | 3.665506e+09 | 3.398593e+09 | 0.44282001 |
| 77 | Coal.Emissions | 0.8 | 0.4 | 1.493778e+09 | 1.566293e+09 | 1.493778e+09 | 0.19610599 |
| 78 | Coal.Emissions | 0.8 | 0.5 | 3.078099e+08 | 4.438239e+08 | 3.721632e+08 | 0.05064670 |
| 79 | Coal.Emissions | 0.8 | 0.6 | -5.291699e+08 | 8.486483e+08 | 7.339002e+08 | 0.09510678 |
| 80 | Coal.Emissions | 0.8 | 0.7 | -1.146722e+09 | 1.491512e+09 | 1.220470e+09 | 0.15652243 |
| 81 | Coal.Emissions | 0.8 | 0.8 | -1.589452e+09 | 1.970041e+09 | 1.606711e+09 | 0.20578832 |
| 82 | Coal.Emissions | 0.9 | 0.1 | 1.637449e+10 | 1.826605e+10 | 1.637449e+10 | 2.12157740 |
| 83 | Coal.Emissions | 0.9 | 0.2 | 7.952712e+09 | 8.806782e+09 | 7.952712e+09 | 1.03156721 |
| 84 | Coal.Emissions | 0.9 | 0.3 | 4.122756e+09 | 4.511147e+09 | 4.122756e+09 | 0.53585414 |
| 85 | Coal.Emissions | 0.9 | 0.4 | 2.061232e+09 | 2.210934e+09 | 2.061232e+09 | 0.26902491 |
| 86 | Coal.Emissions | 0.9 | 0.5 | 7.985086e+08 | 8.451862e+08 | 7.985086e+08 | 0.10558321 |
| 87 | Coal.Emissions | 0.9 | 0.6 | -5.358619e+07 | 4.129224e+08 | 3.459121e+08 | 0.04618506 |
| 88 | Coal.Emissions | 0.9 | 0.7 | -6.518804e+08 | 9.386892e+08 | 7.924246e+08 | 0.10221748 |
| 89 | Coal.Emissions | 0.9 | 0.8 | -1.062254e+09 | 1.373724e+09 | 1.121841e+09 | 0.14385990 |
| 90 | Coal.Emissions | 0.9 | 0.9 | -1.316766e+09 | 1.649169e+09 | 1.345092e+09 | 0.17234012 |
| 91 | Oil.Emissions | 0.1 | 0.1 | 2.734001e+09 | 2.971085e+09 | 2.734001e+09 | 0.47563202 |
| 92 | Oil.Emissions | 0.2 | 0.1 | 2.186492e+09 | 2.504852e+09 | 2.186492e+09 | 0.37729840 |
| 93 | Oil.Emissions | 0.2 | 0.2 | 3.021528e+09 | 3.548697e+09 | 3.021528e+09 | 0.51898848 |
| 94 | Oil.Emissions | 0.3 | 0.1 | 2.845421e+09 | 3.228830e+09 | 2.845421e+09 | 0.49134199 |
| 95 | Oil.Emissions | 0.3 | 0.2 | 2.823096e+09 | 3.277594e+09 | 2.823096e+09 | 0.48579264 |
| 96 | Oil.Emissions | 0.3 | 0.3 | 3.100558e+09 | 3.563337e+09 | 3.100558e+09 | 0.53425698 |
| 97 | Oil.Emissions | 0.4 | 0.1 | 3.576973e+09 | 4.037201e+09 | 3.576973e+09 | 0.61792916 |
| 98 | Oil.Emissions | 0.4 | 0.2 | 2.866969e+09 | 3.308662e+09 | 2.866969e+09 | 0.49376971 |

The table above showcases the best alpha and beta combination for variables: Coal Emissions and Oil Emissions.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 99 | Oil.Emissions | 0.4 | 0.3 | 2.989015e+09 | 3.439307e+09 | 2.989015e+09 | 0.51497733 |
| 100 | Oil.Emissions | 0.4 | 0.4 | 2.962123e+09 | 3.397419e+09 | 2.962123e+09 | 0.51060272 |
| 101 | Oil.Emissions | 0.5 | 0.1 | 4.232534e+09 | 4.775755e+09 | 4.232534e+09 | 0.73106645 |
| 102 | Oil.Emissions | 0.5 | 0.2 | 2.986432e+09 | 3.437168e+09 | 2.986432e+09 | 0.51451427 |
| 103 | Oil.Emissions | 0.5 | 0.3 | 2.893197e+09 | 3.335597e+09 | 2.893197e+09 | 0.49835279 |
| 104 | Oil.Emissions | 0.5 | 0.4 | 2.770652e+09 | 3.193272e+09 | 2.770652e+09 | 0.47731248 |
| 105 | Oil.Emissions | 0.5 | 0.5 | 2.488648e+09 | 2.873955e+09 | 2.488648e+09 | 0.42871765 |
| 106 | Oil.Emissions | 0.6 | 0.1 | 4.818767e+09 | 5.446874e+09 | 4.818767e+09 | 0.83200499 |
| 107 | Oil.Emissions | 0.6 | 0.2 | 3.142259e+09 | 3.613889e+09 | 3.142259e+09 | 0.54137013 |
| 108 | Oil.Emissions | 0.6 | 0.3 | 2.851018e+09 | 3.294760e+09 | 2.851018e+09 | 0.49092707 |
| 109 | Oil.Emissions | 0.6 | 0.4 | 2.666927e+09 | 3.088349e+09 | 2.666927e+09 | 0.45915438 |
| 110 | Oil.Emissions | 0.6 | 0.5 | 2.414502e+09 | 2.806150e+09 | 2.414502e+09 | 0.41557965 |
| 111 | Oil.Emissions | 0.6 | 0.6 | 2.113519e+09 | 2.472901e+09 | 2.113519e+09 | 0.36357094 |
| 112 | Oil.Emissions | 0.7 | 0.1 | 5.364856e+09 | 6.079083e+09 | 5.364856e+09 | 0.92587973 |
| 113 | Oil.Emissions | 0.7 | 0.2 | 3.324657e+09 | 3.824995e+09 | 3.324657e+09 | 0.57271284 |
| 114 | Oil.Emissions | 0.7 | 0.3 | 2.862919e+09 | 3.315762e+09 | 2.862919e+09 | 0.49280992 |
| 115 | Oil.Emissions | 0.7 | 0.4 | 2.629381e+09 | 3.056379e+09 | 2.629381e+09 | 0.45244944 |
| 116 | Oil.Emissions | 0.7 | 0.5 | 2.400423e+09 | 2.801933e+09 | 2.400423e+09 | 0.41289417 |
| 117 | Oil.Emissions | 0.7 | 0.6 | 2.163005e+09 | 2.539442e+09 | 2.163005e+09 | 0.37186116 |
| 118 | Oil.Emissions | 0.7 | 0.7 | 1.948202e+09 | 2.303698e+09 | 1.948202e+09 | 0.33471510 |
| 119 | Oil.Emissions | 0.8 | 0.1 | 5.895802e+09 | 6.697972e+09 | 5.895802e+09 | 1.01706456 |
| 120 | Oil.Emissions | 0.8 | 0.2 | 3.527881e+09 | 4.062203e+09 | 3.527881e+09 | 0.60759361 |
| 121 | Oil.Emissions | 0.8 | 0.3 | 2.918687e+09 | 3.386237e+09 | 2.918687e+09 | 0.50225977 |
| 122 | Oil.Emissions | 0.8 | 0.4 | 2.638449e+09 | 3.075105e+09 | 2.638449e+09 | 0.45382563 |
| 123 | Oil.Emissions | 0.8 | 0.5 | 2.420750e+09 | 2.833458e+09 | 2.420750e+09 | 0.41620941 |
| 124 | Oil.Emissions | 0.8 | 0.6 | 2.221764e+09 | 2.613221e+09 | 2.221764e+09 | 0.38182268 |
| 125 | Oil.Emissions | 0.8 | 0.7 | 2.048631e+09 | 2.422447e+09 | 2.048631e+09 | 0.35189534 |
| 126 | Oil.Emissions | 0.8 | 0.8 | 1.913272e+09 | 2.274110e+09 | 1.913272e+09 | 0.32848805 |
| 127 | Oil.Emissions | 0.9 | 0.1 | 6.427757e+09 | 7.320356e+09 | 6.427757e+09 | 1.10837888 |
| 128 | Oil.Emissions | 0.9 | 0.2 | 3.746329e+09 | 4.318111e+09 | 3.746329e+09 | 0.64507081 |
| 129 | Oil.Emissions | 0.9 | 0.3 | 3.006791e+09 | 3.492935e+09 | 3.006791e+09 | 0.51729327 |
| 130 | Oil.Emissions | 0.9 | 0.4 | 2.678913e+09 | 3.127771e+09 | 2.678913e+09 | 0.46064864 |
| 131 | Oil.Emissions | 0.9 | 0.5 | 2.460426e+09 | 2.884764e+09 | 2.460426e+09 | 0.42290595 |
| 132 | Oil.Emissions | 0.9 | 0.6 | 2.281627e+09 | 2.686290e+09 | 2.281627e+09 | 0.39201881 |
| 133 | Oil.Emissions | 0.9 | 0.7 | 2.131972e+09 | 2.520586e+09 | 2.131972e+09 | 0.36616421 |
| 134 | Oil.Emissions | 0.9 | 0.8 | 2.012966e+09 | 2.389183e+09 | 2.012966e+09 | 0.34560228 |
| 135 | Oil.Emissions | 0.9 | 0.9 | 1.924661e+09 | 2.291943e+09 | 1.924661e+09 | 0.33034278 |
| 136 | Gas.Emissions | 0.1 | 0.1 | 5.003921e+09 | 5.625325e+09 | 5.003921e+09 | 2.11354526 |
| 137 | Gas.Emissions | 0.2 | 0.1 | 5.464405e+09 | 6.284248e+09 | 5.464405e+09 | 2.29493965 |
| 138 | Gas.Emissions | 0.2 | 0.2 | 3.592169e+09 | 4.426527e+09 | 3.592169e+09 | 1.48801122 |
| 139 | Gas.Emissions | 0.3 | 0.1 | 6.044334e+09 | 7.009925e+09 | 6.044334e+09 | 2.53296728 |
| 140 | Gas.Emissions | 0.3 | 0.2 | 3.993706e+09 | 4.881089e+09 | 3.993706e+09 | 1.65647744 |
| 141 | Gas.Emissions | 0.3 | 0.3 | 3.449646e+09 | 4.326395e+09 | 3.449646e+09 | 1.42389896 |
| 142 | Gas.Emissions | 0.4 | 0.1 | 6.613835e+09 | 7.706036e+09 | 6.613835e+09 | 2.76821187 |

[ reached 'max' / getOption("max.print") -- omitted 83 rows ]

The table above showcases the best alpha and beta combination for variables: Oil Emissions and Gas Emissions.

```
> model.1 = holt(data_ts$Average.Temp, alpha = 0.4, beta = 0.1, damped = FALSE)
> View(model.1)
> View(model.1)
> print(model.1)
     Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
2023       56.10737 54.11683 58.09790 53.06310 59.15163
2024       56.20292 53.97743 58.42841 52.79933 59.60651
2025       56.29848 53.77277 58.82418 52.43574 60.16121
2026       56.39403 53.50947 59.27859 51.98248 60.80559
2027       56.48959 53.19466 59.78451 51.45043 61.52874
2028       56.58514 52.83468 60.33560 50.84931 62.32097
2029       56.68069 52.43474 60.92665 50.18706 63.17433
2030       56.77625 51.99896 61.55354 49.47002 64.08248
2031       56.87180 51.53064 62.21297 48.70319 65.04042
2032       56.96736 51.03236 62.90236 47.89056 66.04416
```

The table above shows the best forecasting alpha and beta combination for Average Temperature from 2023 - 2032.

```
> model.2 = holt(data_ts$Coal.Emissions, alpha = 0.9, beta = 0.6, damped = FALSE)
> print(model.2)
     Point Forecast        Lo 80        Hi 80        Lo 95        Hi 95
2023   834172501676 833713527664 834631475688 833470561498 834874441853
2024   849226743181 848399316014 850054170349 847961302530 850492183832
2025   864280984687 863010695853 865551273520 862338245564 866223723809
2026   879335226192 877560592625 881109859759 876621158361 882049294023
2027   894389467698 892056362344 896722573052 890821290974 897957644421
2028   909443709203 906503050136 912384368270 904946359259 913941059147
2029   924497950709 920904445051 928091456366 919002158065 929993743352
2030   939552192214 935263547298 943840837130 932993275816 946111108612
2031   954606433719 949582816913 959630050525 946923474815 962289392624
2032   969660675225 963864322247 975457028203 960795918329 978525432121
```

The table above shows the best forecasting alpha and beta combination for Coal Emissions from 2023 - 2032.

```
> model.3 = holt(data_ts$Oil.Emissions, alpha = 0.9, beta = 0.6, damped = FALSE)
> print(model.3)
     Point Forecast        Lo 80        Hi 80        Lo 95        Hi 95
2023    6.27552e+11 627155564208 627948529800 626945678894 628158415114
2024    6.39239e+11 638524269929 639953808980 638145893798 640332185110
2025    6.50926e+11 649828698166 652023365643 649247804774 652604259035
2026    6.62613e+11 661080014511 664146034200 660268488120 664957560591
2027    6.74300e+11 672284573426 676315460186 671217662148 677382371464
2028    6.85987e+11 683446733122 688527285391 682101992166 689872026347
2029    6.97674e+11 694569766755 700778236660 692926484034 702421519381
2030    7.09361e+11 705656266041 713065722275 703695101440 715026886875
2031    7.21048e+11 716708356073 725387617144 714411094435 727684878782
2032    7.32735e+11 727727823588 737742134530 725077195594 740392762525
```

The table above shows the best forecasting alpha and beta combination for Oil Emissions from 2023 - 2032.

```
> model.4 = holt(data_ts$Gas.Emissions, alpha = 0.9, beta = 0.6, damped = FALSE)
> print(model.4)
     Point Forecast        Lo 80        Hi 80        Lo 95        Hi 95
2023   269558200067 269371292871 269745107262 269272350179 269844049955
2024   277342277116 277005325377 277679228855 276826953902 277857600330
2025   285126354165 284609056634 285643651697 284335215862 285917492468
2026   292910431215 292187750247 293633112182 291805186052 294015676378
2027   300694508264 299744401794 301644614735 299241445809 302147570719
2028   308478585313 307281065792 309676104835 306647137250 310310033377
2029   316262662363 314799285250 317726039475 314024620200 318500704525
2030   324046739412 322300281937 325793196887 321375763196 326717715628
2031   331830816461 329785057651 333876575271 328702098354 334959534569
2032   339614893511 337254454682 341975332340 336004913845 343224873177
```

The table above shows the best forecasting alpha and beta combination for Gas Emissions from 2023 - 2032.

```
> model.5 = holt(data_ts$Cumulative.Emissions, alpha = 0.9, beta = 0.6, damped = FALSE)
> print(model.5)
     Point Forecast        Lo 80        Hi 80        Lo 95        Hi 95
2023   1.809635e+12 1.808729e+12 1.810541e+12 1.808249e+12 1.811020e+12
2024   1.846495e+12 1.844862e+12 1.848129e+12 1.843997e+12 1.848993e+12
2025   1.883356e+12 1.880848e+12 1.885863e+12 1.879521e+12 1.887191e+12
2026   1.920216e+12 1.916713e+12 1.923719e+12 1.914859e+12 1.925574e+12
2027   1.957077e+12 1.952472e+12 1.961682e+12 1.950034e+12 1.964120e+12
2028   1.993938e+12 1.988133e+12 1.999742e+12 1.985060e+12 2.002815e+12
2029   2.030798e+12 2.023705e+12 2.037892e+12 2.019950e+12 2.041647e+12
2030   2.067659e+12 2.059193e+12 2.076124e+12 2.054712e+12 2.080606e+12
2031   2.104519e+12 2.094603e+12 2.114436e+12 2.089354e+12 2.119685e+12
2032   2.141380e+12 2.129938e+12 2.152822e+12 2.123881e+12 2.158878e+12
```

The table above shows the best forecasting alpha and beta combination for Cumulative Emissions from 2023 - 2032.

These tables all utilize the Adjusted Exponential Smoothing (AES) Holt function in order to calculate the next 10 years' values for each individual variable and are sorted using MAPE at the bottom table.