

BSTA 477 – Winter 2021

Tutorial 4 - March 14th, 2021

[Review of naive method and seasonal naive method](#)

[Exponential Smoothing](#)

[Simple exponential smoothing](#)

[Holt's linear method](#)

[Holt-Winters method](#)

[Evaluation](#)

Data used: Bike sharing data

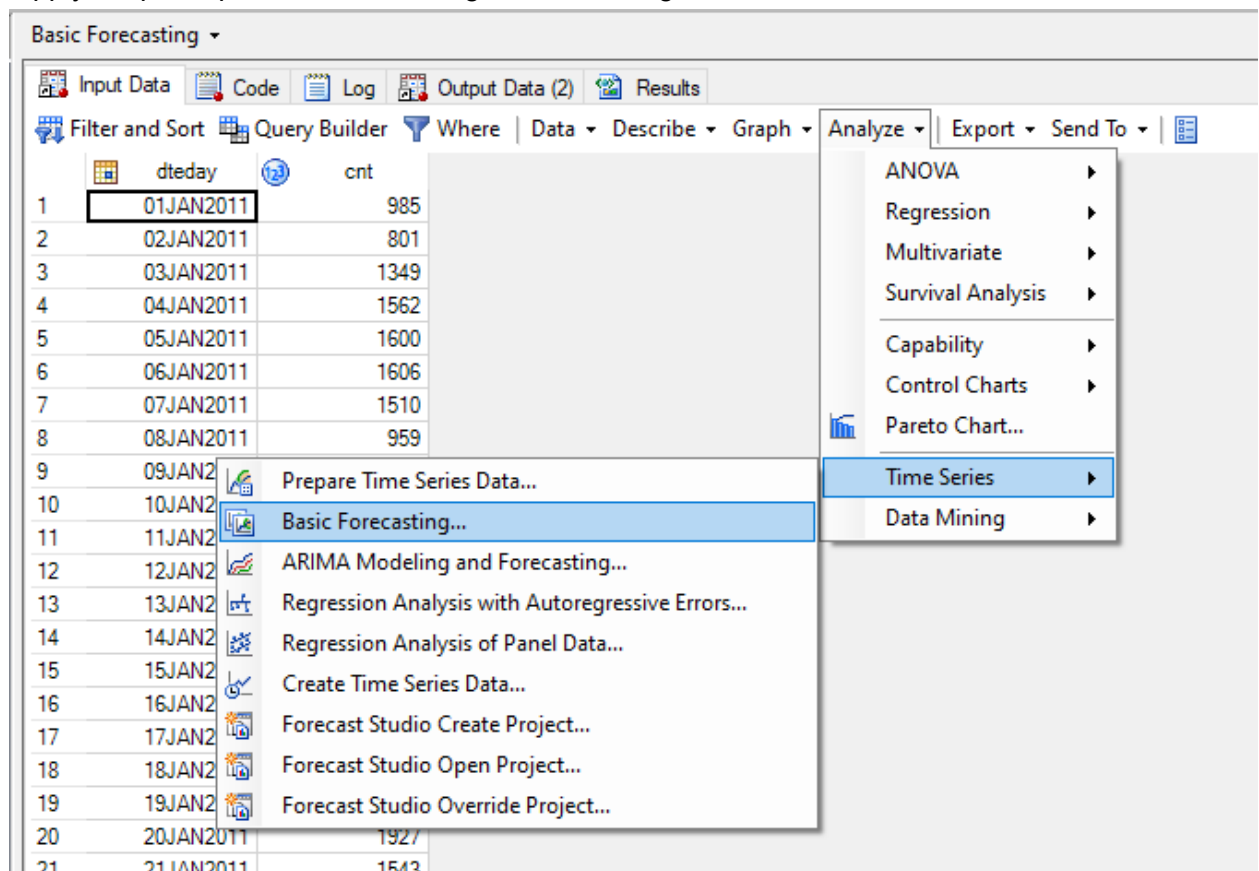
Exponential Smoothing

The Exponential Smoothing method only takes in observations of the dependent variable and creates forecasts based on the weighted average of previous observations. The general steps in applying Exponential Smoothing in SAS:

1. Partition the data into training and validation set
2. Use SAS to apply Exponential smoothing methods on training sets.
3. Code the forecast observations to select only validation set observations.
4. Evaluate the performance of the method.

Simple exponential smoothing

1. Prepare time series if needed, make sure that the time variable is recognized by SAS as time type. Partition the data into training and validation.
2. Apply simple exponential smoothing on the training set.



Basic Forecasting for Local:BSTA477.TRAINING_SET

Data

Data source: Local:BSTA477.TRAINING_SET
Task filter: None Edit...

Variables to assign:

Name
New TimeID
dteday
cnt

Task roles:

Forecast variable
cnt
Time ID variable (Limit: 1)
dteday
Group forecasts by

Basic Forecasting for Local:BSTA477.TRAINING_SET

Forecast Options

Forecasting method: Exponential smoothing

Number of intervals to forecast: 146

Input data options

Time interval between observations: Daily
Time units per interval: 1

Seasonal cycle length

Number of intervals:
Intervals per seasonal cycle: 2

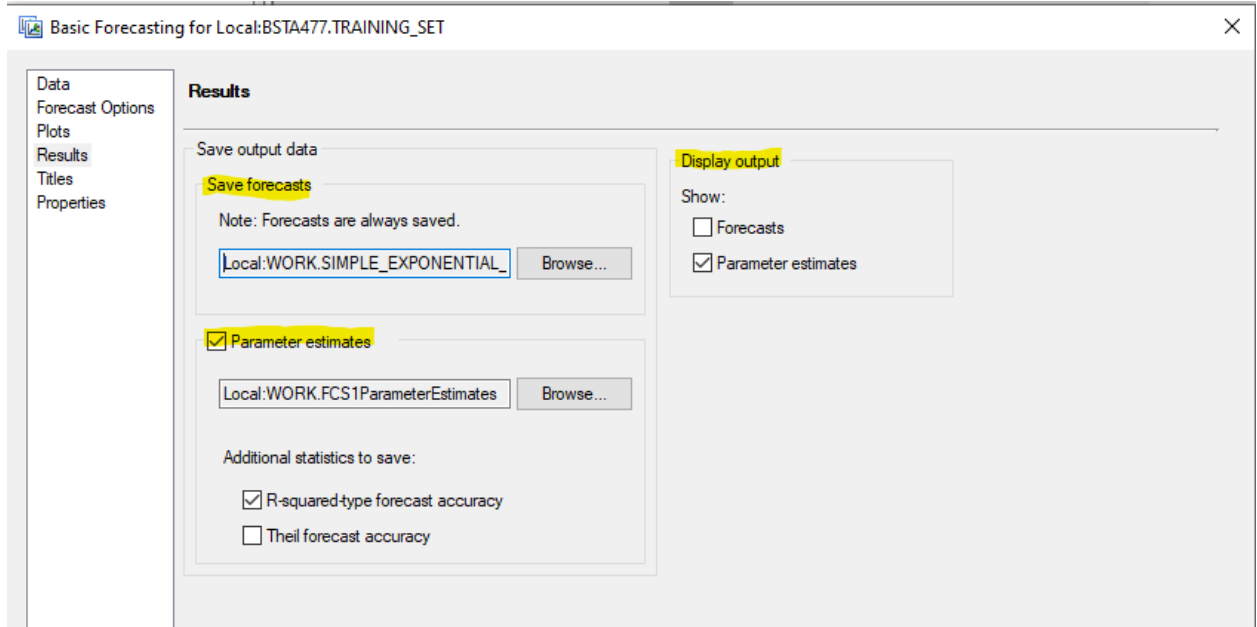
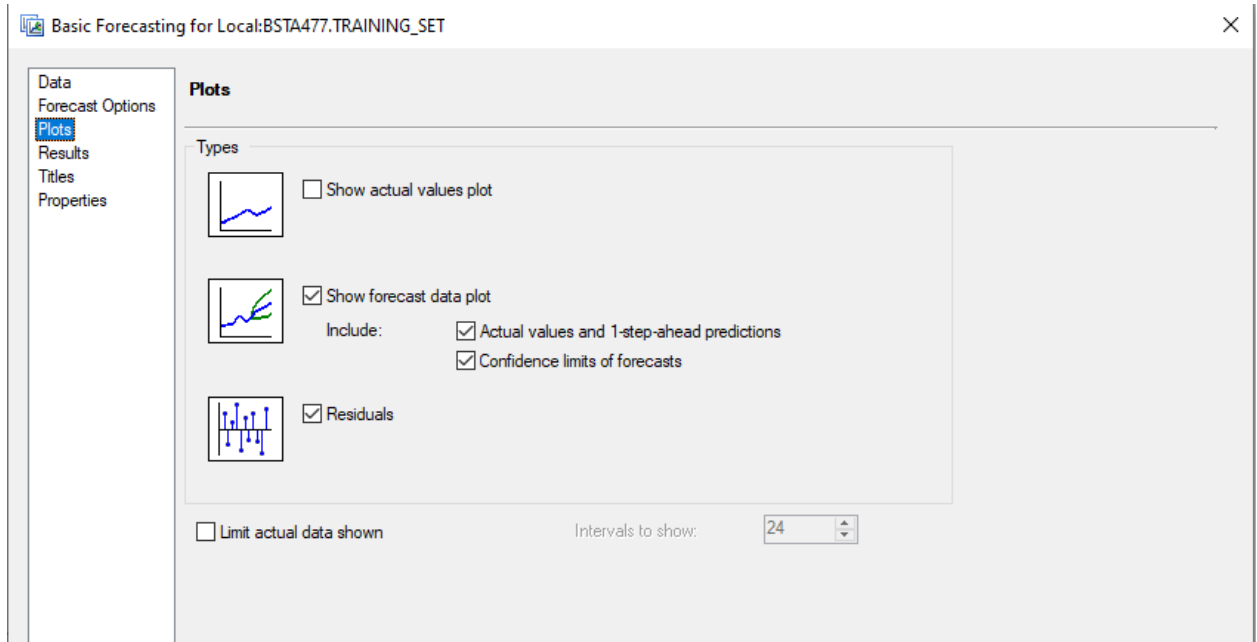
Method options

Degree of time trend model: Constant

Confidence level: 95%

Component smoothing weights

<input checked="" type="checkbox"/> Constant:	0.5
<input type="checkbox"/> Linear, quadratic:	0.2
<input type="checkbox"/> Seasonal:	0.2



3. Output the forecasts: Filter the forecasts of validation set observations and merge with the original validation set to calculate the residuals and error terms

```
data simple_exponential_forecast;
set work.simple_exponential_smoothing;
where _type_='FORECAST' and dteday >= '08AUG2012'd;
rename cnt=forecast_cnt;
run;
```

```
data simple_exponential_merged;
merge work.simple_exponential_forecast bsta477.validation_set;
by dteday;
residual = cnt - forecast_cnt;
abs = abs(residual);
square = residual**2;
proportion = residual/cnt;
abs_proportion = abs/cnt;
run;
```

4. Calculate error terms

```
proc means data= simple_exponential_merged;
var abs square proportion abs_proportion;
output out=work.simple_exponential_result
Mean(abs)=MAE
Mean(square)=MSE
Mean(proportion) = MPE
Mean(abs_proportion) = MAPE;
run;
```

Holt's linear method

1. Prepare time series if needed, make sure that the time variable is recognized by SAS as time type. Partition the data into training and validation.
2. Apply Holt's linear method: As SAS does not have a separate option to run Holt's linear method. We can apply Holt's linear method on the training set by applying Holt-Winters (or Winter's in SAS) without selecting the seasonal factor.

Holt's linear method 1 ▾

Input Data | Code | Log | Output Data | Results

Filter and Sort | Query Builder | Where | Data ▾ | Describe ▾ | Graph ▾ | Analyze ▾ | Export ▾ | Send To ▾ |

	dteday	cnt
1	01JAN2011	985
2	02JAN2011	801
3	03JAN2011	1349
4	04JAN2011	1562
5	05JAN2011	1600
6	06JAN2011	1606
7	07JAN2011	1510
8	08JAN2011	959
9	09JAN2011	
10	10JAN2011	
11	11JAN2011	
12	12JAN2011	
13	13JAN2011	
14	14JAN2011	

Analyze ▾

- ANOVA ▸
- Regression ▸
- Multivariate ▸
- Survival Analysis ▸
- Capability ▸
- Control Charts ▸
- Pareto Chart...
- Time Series ▸**
- Data Mining ▸

Time Series ▸

- Prepare Time Series Data...
- Basic Forecasting...**
- ARIMA Modeling and Forecasting...
- Regression Analysis with Autoregressive Errors...
- Regression Analysis of Panel Data...

Holt's linear method 1 for Local:BSTA477.TRAINING_SET

Data

Forecast Options
Plots
Results
Titles
Properties

Data source: Local:BSTA477.TRAINING_SET
Task filter: None

Variables to assign:

Name
NewTimeID
dteday
cnt

Task roles:

Forecast variable
cnt
Time ID variable (Limit: 1)
dteday
Group forecasts by

Basic Forecasting for Local:BSTA477.TRAINING_SET

Data
Forecast Options
Plots
Results
Titles
Properties

Forecast Options

Forecasting method: Winters Additive Method

Number of intervals to forecast: 146

Input data options

Time interval between observations: Daily

Time units per interval: 1

Seasonal cycle length

Number of intervals: 2

Intervals per seasonal cycle: 2

Method options

Degree of time trend model: Linear

Confidence level: 95%

Component smoothing weights

Constant: 0.10557

Linear, quadratic: 0.10557

Seasonal: 0.10557

Holt's linear method 1 for Local:BSTA477.TRAINING_SET

Data
Forecast Options
Plots
Results
Titles
Properties

Plots

Types

☐ Show actual values plot

☒ Show forecast data plot

Include:

☒ Actual values and 1-step-ahead predictions

☒ Confidence limits of forecasts

☐ Residuals

☐ Limit actual data shown

Intervals to show: 24

Holt's linear method 1 for Local:BSTA477.TRAINING_SET

Data
Forecast Options
Plots
Results
Titles
Properties

Results

Save output data

Save forecasts

Note: Forecasts are always saved.

Local:WORK.HOLT_FORECAST Browse...

☒ Parameter estimates

Local:WORK.FCS1PARAMETERESTIM Browse...

Additional statistics to save:

☐ R-squared-type forecast accuracy

☐ Theil forecast accuracy

Display output

Show:

☐ Forecasts

☒ Parameter estimates

- Output the forecasts: Filter the forecasts of validation set observations and merge with the original validation set to calculate the residuals and error terms.

```
data holt_validation_forecast;
set work.holt_forecast;
where _type_='FORECAST' and dteday >= '08AUG2012'd;
rename cnt=forecast_cnt;
run;
```

```
data holt_forecast_merged;
merge work.holt_validation_forecast bsta477.validation_set;
by dteday;
residual = cnt - forecast_cnt;
abs = abs(residual);
square = residual**2;
proportion = residual/cnt;
abs_proportion = abs/cnt;
run;
```

4. Calculate error terms

```
proc means data= holt_forecast_merged;
var abs square proportion abs_proportion;
output out=work.holt_result
Mean(abs)=MAE
Mean(square)=MSE
Mean(proportion) = MPE
Mean(abs_proportion) = MAPE;
run;
```

Note:

- Choose Winter's Additive method on SAS to appropriately reflect Holt's linear method.

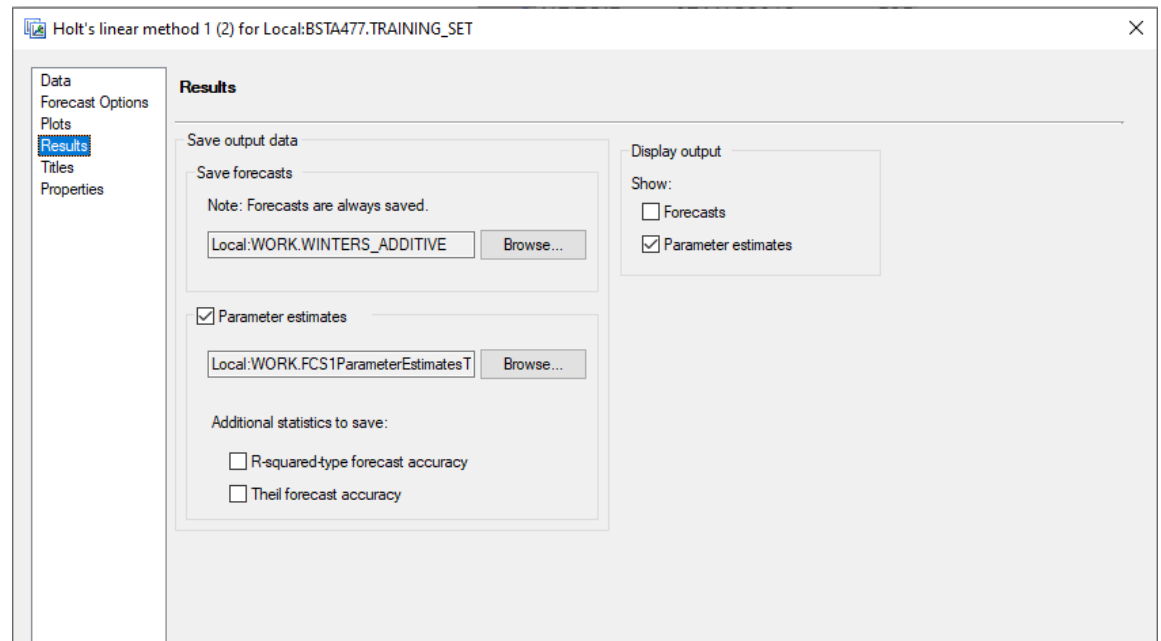
Holt-Winters method

- Additive Holt- Winter linear method
 1. Prepare time series if needed, make sure that the time variable is recognized by SAS as time type. Partition the data into training and validation.
 2. Apply Winters additive method on the training set. (Similar options and operations to the above with minor changes)

The screenshot shows the 'Forecast Options' dialog box in SAS. The title bar reads 'Holt's linear method 1 (2) for Local:BSTA477.TRAINING_SET'. On the left is a navigation pane with options: Data, Forecast Options (selected), Plots, Results, Titles, and Properties. The main area is divided into several sections:

- Forecasting method:** A dropdown menu set to 'Winters Additive Method'.
- Number of intervals to forecast:** A numeric input field set to 146.
- Input data options:**
 - Time interval between observations:** A dropdown menu set to 'Daily'.
 - Time units per interval:** A numeric input field set to 1.
 - Seasonal cycle length:** A dropdown menu set to 'Number of intervals'.
 - Intervals per seasonal cycle:** A numeric input field set to 7.
- Method options:**
 - Degree of time trend model:** A dropdown menu set to 'Linear'.
 - Confidence level:** A dropdown menu set to '95%'.
 - Component smoothing weights:** A section with three checked options, each with a numeric input field set to 0.10557:
 - ☒ Constant:
 - ☒ Linear, quadratic:
 - ☒ Seasonal:

Note that the seasonal cycle length is based on personal judgement and analysis. Here, intervals per seasonal cycle equals 7 are used due to previous analysis that there is seasonality within the date of the week.



Save the output data to the library intended.

3. Output the forecasts: Filter the forecasts of validation set observations and merge with the original validation set to calculate the residuals and error terms.

```
data winters_add_forecast;
  set work.winters_additive;
  where _type_='FORECAST' and dteday >= '08AUG2012'd;
  rename cnt=forecast_cnt;
  run;

data Winters_add_merged;
  merge work.winters_add_forecast bsta477.validation_set;
  by dteday;
  residual = cnt - forecast_cnt;
  abs = abs(residual);
  square = residual**2;
  proportion = residual/cnt;
  abs_proportion = abs/cnt;
  run;
```

4. Calculate error terms

```
proc means data= winters_add_merged;  
var abs square proportion abs_proportion;  
output out=work.winters_add_result  
Mean(abs)=MAE  
Mean(square)=MSE  
Mean(proportion) = MPE  
Mean(abs_proportion) = MAPE;  
run;
```

- Multiplicative Holt-Winter linear method
 1. Prepare time series if needed, make sure that the time variable is recognized by SAS as time type. Partition the data into training and validation.
 2. Apply Winters multiplicative method on the training set. (Similar options and operations to the above with minor changes in Forecast options and Results tab)

Winters' Mult for Local:BSTA477.TRAINING_SET

Forecast Options

Forecasting method: Winters (Multiplicative) Method

Number of intervals to forecast: 146

Input data options

Time interval between observations: Daily

Time units per interval: 1

Seasonal cycle length

Number of intervals: 7

Intervals per seasonal cycle: 7

Method options

Degree of time trend model: Linear

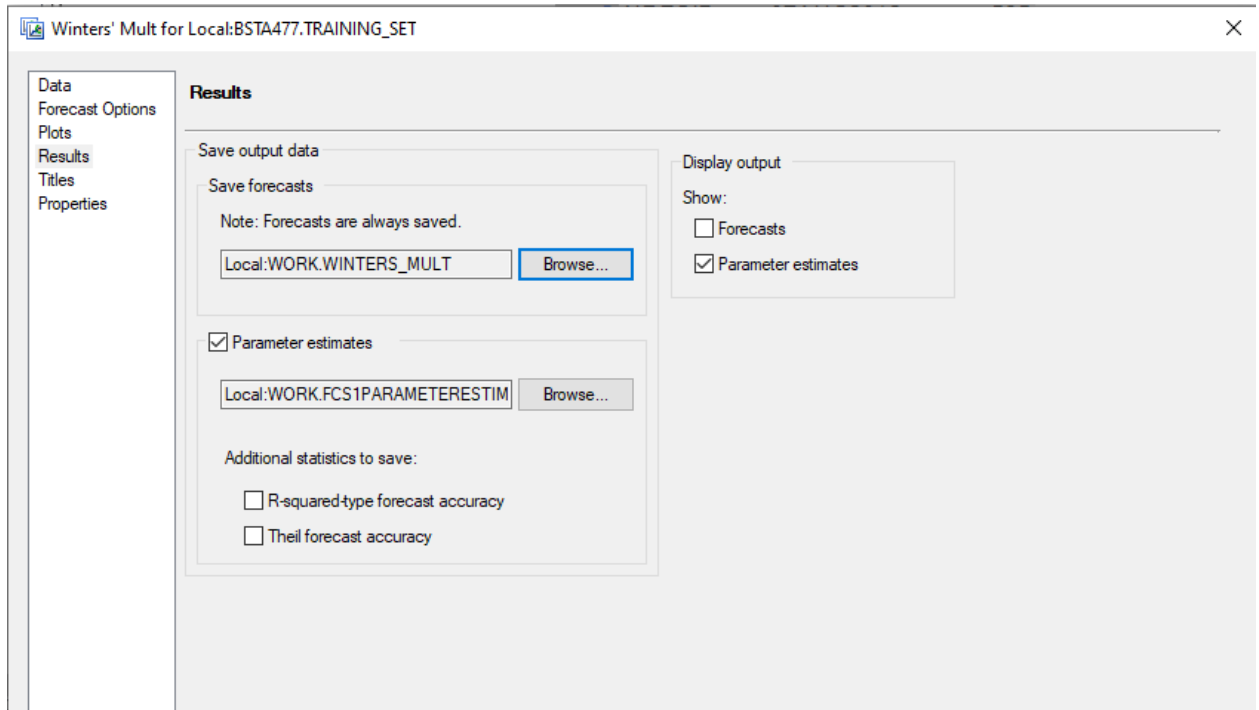
Confidence level: 95%

Component smoothing weights

☒ Constant: 0.10557

☒ Linear, quadratic: 0.10557

☒ Seasonal: 0.10557



3. Like Step 3 from Additive Holt-Winter linear method.
4. Like step 4 from Additive Holt-Winter linear method.

Evaluation

Each method outputs training and validation error terms. We compare the training set error terms together to determine the goodness of fit of the model. Then, we compare the validation set error terms to determine the forecasting power of the method. Choose the overall best method with lowest error terms in both training and validation, taking into considerations of project priorities as well.