A Quick Demonstration of Time Series Analysis and Forecasting using SAS

Demo using SAS EG version 7.100.5.6165

Time Series Analysis in SAS

- Time-series data can be analyzed by many different SAS tools and programs:
  - SAS/ETS (econometric and time series)
    - Data handling: PROC TIMESERIES, PROC EXPAND..
    - Data Analysis: PROC ESM, PROC X12, PROC UCM..
  - SAS EG (Analyze > Time Series …)
  - SAS EM (use nodes from Time Series Tab)
  - Forecast Server and Forecast Studio

Which SAS Tools to use?

- **SAS/ETS** : Ideal for those who have good SAS programming and skills and knowledge in forecasting methods.

- **SAS EG** : Allows fast model development with minimal programming and good reporting and graphics.

- **SAS EM** : Non-programming development tool for data preprocessing and data mining/forecasting.

- **SAS Forecast Server/Studio** : Automatic model and report generation for large-scale industrial forecasting.

SAS Functions for Datetime Variables

- A datetime variable in SAS can be manipulated in many ways. Some of the most commonly used ones are:
    - **Datepart**: to extract day, month, year etc.
    - **Lag**: value of previous observation
        - **Lag12** on a monthly data will return the value from 12 months before
    - **Dif**: difference between actual and the observation before it
        - **Dif12** on a monthly data will take the difference between current month and the value 12m months before
    - **Intck**: returns number of weeks, months and so on between two points
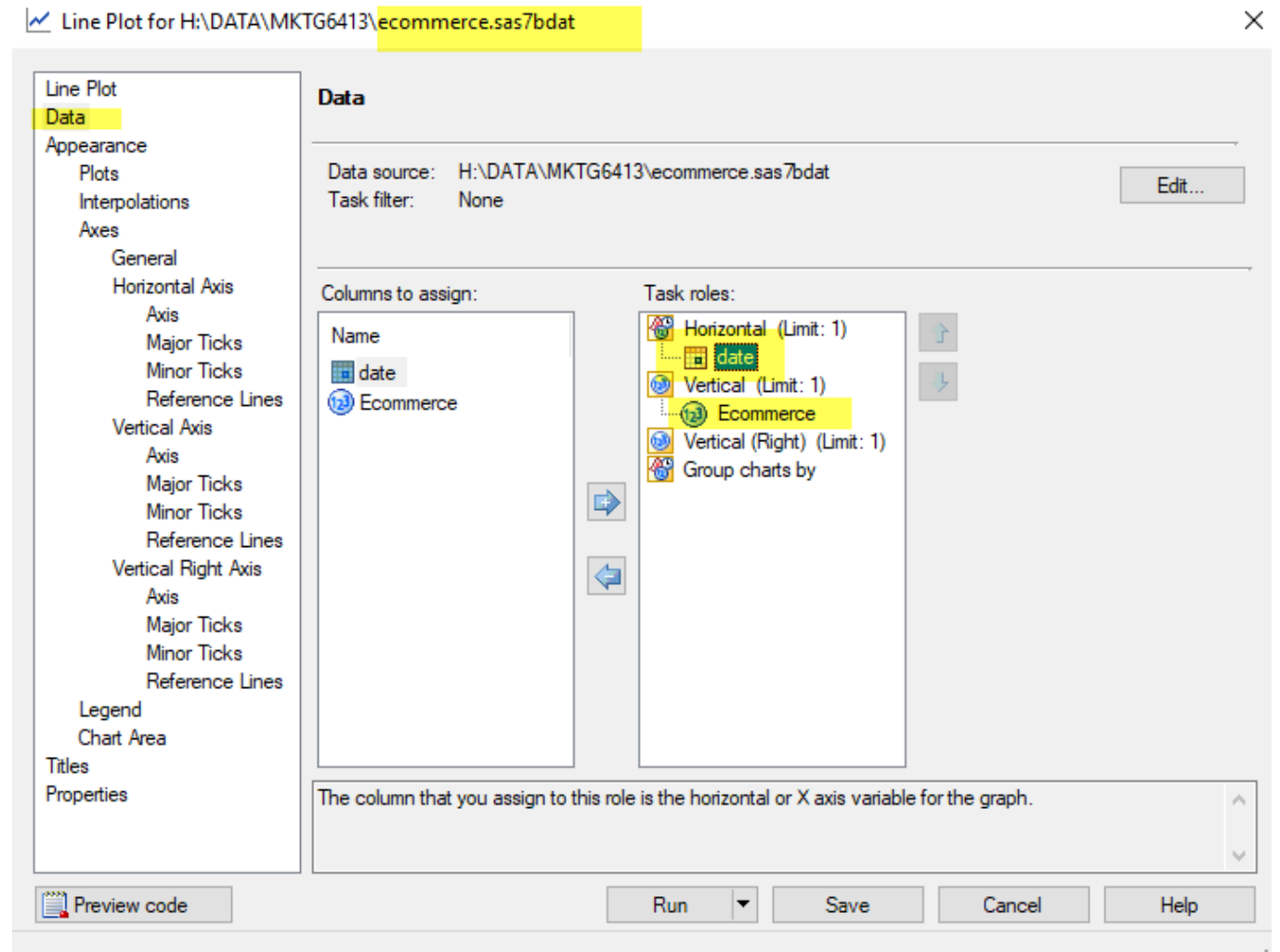
Data Aggregation and Interpolation Procedures in SAS

- Proc Timeseries for aggregation
- Proc Expand for interpolation

Plotting Time Series Data

- Tool: SAS Enterprise Guide

- Data set : Ecommerce

- SAS EG top menu > File > Open > Data …

- Then, from SAS EG Data Table Menu click Graph > Line Plot > On Left panel click Data > date as horizontal and ecommerce as vertical > Run

What Does the Plot Look Like?

Line Plot
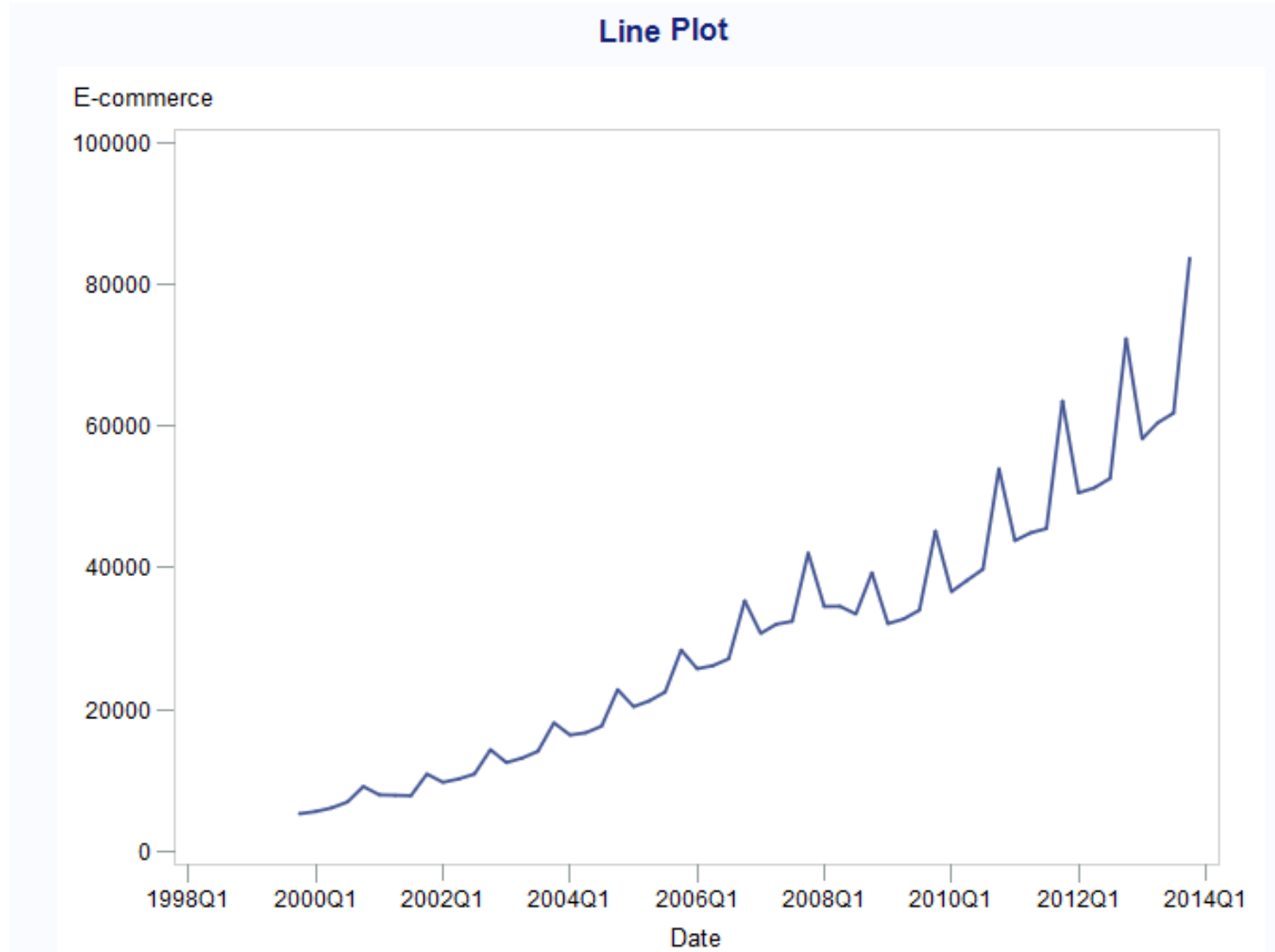
What do you see
with regards to
Time Series components?

Naïve Forecast in SAS (Program_ESM_Models)

```sas
/* File name: Program_ESM_Models.sas */
/* Please change LIBNAME path below to where your data are located*/
/* If you have installed SAS on your PC, then you can use your C drive */
/* If you are accessing SAS Via VMware, Use One Drive or USB drive */
/* Check  instructions shared on class site*/

LIBNAME COURSE 'H:\DATA\MKTG6413';

/* US retail ecommerce sales data from census.gov site */
/* A simple exponential smoothing application of PROC ESM*/

/* Creating a temporary data set with Naive forecst (lagged 1) values */

Data temp; set course.ecommerce;
N_Forecast= Lag(Ecommerce);

/* Plotting Acatual versus Lagged values */

proc sgplot data=temp;
series x=date y=Ecommerce/markers;
series x=date y=N_Forecast/markers;
Title 'Plot of Actual vs. Naive Forecast';
run;
```
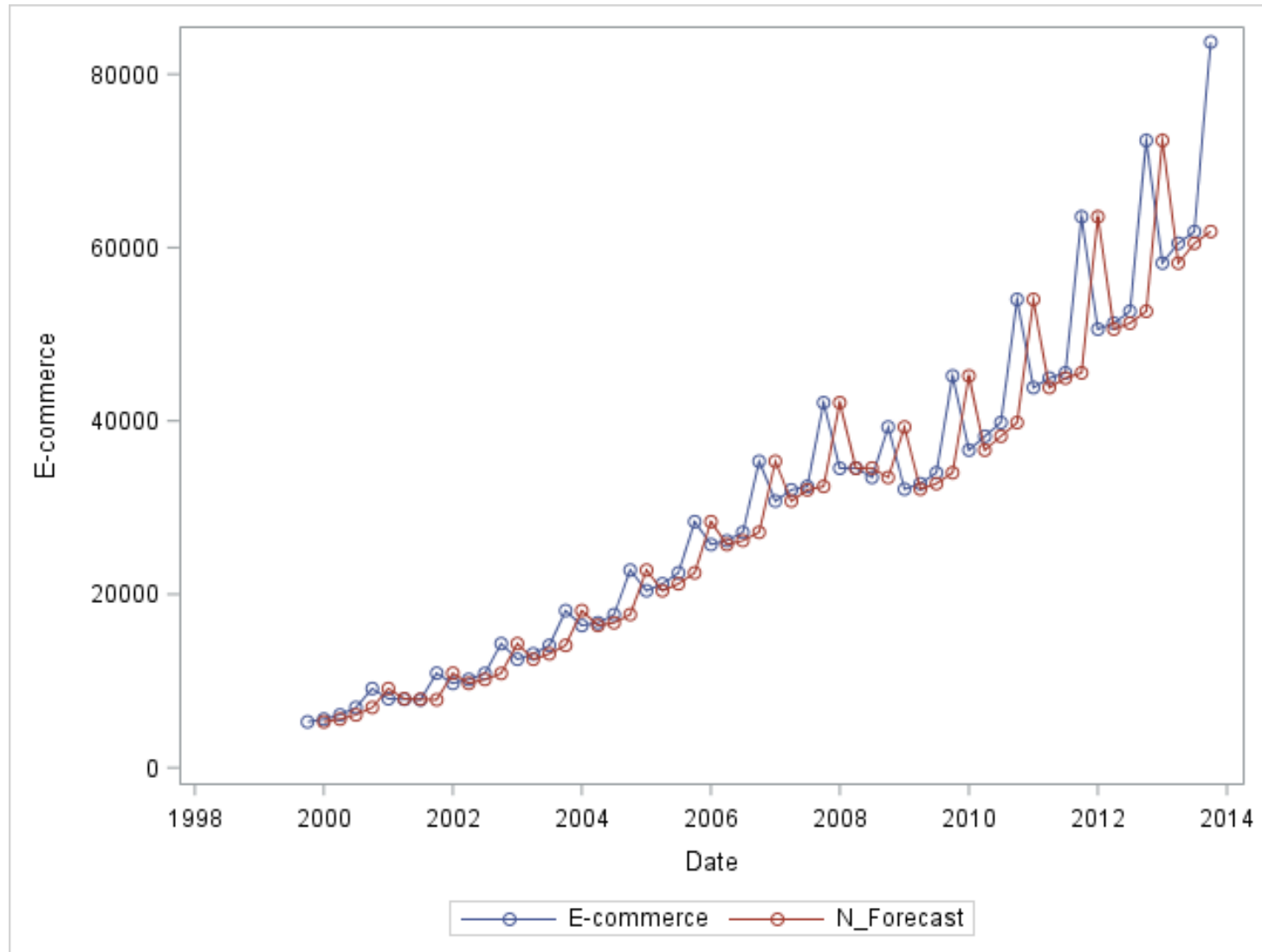
SAS Output of Naïve Forecast Plot Against Actual

Program_ESM_MODELS

```sas
/* Exponential smoothing model with no trend or seasonality */

proc esm data=COURSE.ECOMMERCE outfor=out
back=0 lead=12 print=all;
id DATE interval=QUARTER;
forecast ECOMMERCE;
Title 'ESM Model with no trend or seasonality';
run;
proc sgplot data=out;
series x=date y=actual/markers;
series x=date y=predict/markers;
run;
```

Model Comparison Results

Model	MAPE	RMSE	Adj R-Sqr	AIC	BIC
SES	9.76	5998.3	89.6%	993.7	995.7
Holt					
Winter (Additive)					
Winter (Multiplicative)					

Table 1.   Estimated Quarterly U.S. Retail Sales: Total and E–commerce[1]
(Estimates are based on data from the Monthly Retail Trade Survey and administrative records.)

Quarter	Retail Sales (millions of dollars)		E-commerce as a Percent of	Percent Change From Prior Quarter		Percent Change From Same Quarter A Year Ago	
	Total	E-commerce	Total	Total	E-commerce	Total	E-commerce
Adjusted[2]							
4th quarter 2014(p)	1,187,169	79,567	6.7	0.1	2.3	3.7	14.6
3rd quarter 2014(r)	1,185,773	77,789	6.6	0.9	3.6	4.3	15.8
2nd quarter 2014	1,174,741	75,080	6.4	2.2	5.0	4.5	15.8
1st quarter 2014	1,149,198	71,503	6.2	0.4	3.0	2.6	15.5
4th quarter 2013(r)	1,145,128	69,426	6.1	0.7	3.4	3.8	16.0
Not Adjusted							
4th quarter 2014(p)	1,243,321	95,979	7.7	5.0	33.6	3.8	14.7
3rd quarter 2014(r)	1,184,499	71,862	6.1	−0.9	2.5	4.3	16.2
2nd quarter 2014	1,195,158	70,134	5.9	10.9	4.8	4.8	15.9
1st quarter 2014	1,077,723	66,938	6.2	−10.0	−20.0	2.1	15.0
4th quarter 2013	1,197,402	83,709	7.0	5.5	35.3	3.7	15.7

Program_ESM_MODELS

```sas
/* A double exponential smoothing (Holt with trend) application of PROC ESM*/
proc esm data=COURSE.ECOMMERCE outfor=out
back=0 lead=12 print=all;
id DATE interval=QUARTER;
forecast ECOMMERCE / model=Linear;
Title 'ESM Model with linear trend but no seasonality';
run;
proc sgplot data=out;
series x=date y=actual/markers;
series x=date y=predict/markers;
run;
```

Model Comparison Results

Model	MAPE	RMSE	Adj R-Sqr	AIC	BIC
SES	**9.76**	5998.3	89.6%	993.7	995.7
Holt (Linear)	**8.98**	**5135.3**	**92.2%**	**978.0**	**982.1**
Winter (Additive)					
Winter (Multiplicative)					

Program_ESM_MODELS

```
/*  Winter's additive seasonal with linear trend exponential smoothing application of PROC ESM*/
proc esm data=COURSE.ECOMMERCE outfor=out
back=0 lead=12 print=all;
id DATE interval=QUARTER;
forecast ECOMMERCE / model=addwinters;
Title 'ESM Model with linear trend and additive seasonality';
run;
proc sgplot data=out;
series x=date y=actual/markers;
series x=date y=predict/markers;
run;
```

Model Comparison Results

Model	MAPE	RMSE	Adj R-Sqr	AIC	BIC
SES	9.76	5998.3	89.6%	993.7	995.7
Holt (Linear)	8.98	5135.3	92.2%	978.0	982.1
Winter (Additive)	**4.24**	**1612.3**	**99.2%**	**847.9**	**854.1**
Winter (Multiplicative)					

Program_ESM_MODELS

```sas
/*  Winter's multiplicative seasonal with linear trend exponential smoothing application of PROC ESM*/
proc esm data=COURSE.ECOMMERCE outfor=out
back=0 lead=12 print=all;
id DATE interval=QUARTER;
forecast ECOMMERCE / model=winters;
Title 'ESM Model with linear trend and multiplicative seasonality';
run;
proc sgplot data=out;
series x=date y=actual/markers;
series x=date y=predict/markers;
run;
```

Model Comparison Results

Model	MAPE	RMSE	Adj R-Sqr	AIC	BIC
SES	9.76	5998.3	89.6%	993.7	995.7
Holt (Linear)	8.98	5135.3	92.2%	978.0	982.1
Winter (Additive)	4.24	1612.3	99.2%	847.9	854.1
Winter (Multiplicative)	**3.15**	**1352.4**	**99.4%**	**827.9**	**834.0**

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https://www2.census.gov/retail/releases/historical/ecomm/14q4.pdf   (look for Q4 2014 and get last 4 quarters – for the year 2014 and compare with forecasts from each model)

What Else Can We Do?

- Look at residuals, autocorrelation plots, partial autocorrelation plots and other diagnostics to improve these models

- We can build other models such as ARMA