How to Use Holdout Sample in TS Forecasting

Dr. Goutam Chakraborty

Lecture and Demo

1

Outline of Session

- Forecasting：How to do training/holdout split in ESM models
  - Assume we want to forecast 4 period ahead for the Ecommerce data
    - Full sample: 57 quarters, 1999 Q4 – 2013 Q4
    - Fit sample : first 53 quarters, 1999 Q4- 2012 Q4
    - Holdout sample: last 4 quarters, 2013 Q1 – 2013 Q4
    - Forecast sample: 4 unseen quarters, 2014 Q1- 2014 Q4
  - Options in SAS that we will use are:
    - Back = how many periods of holdout, 4
    - Lead = how many periods to forecast ahead (default is 12)

2

Code Without Holdout (Program2_ESM_Models)

```
/*  Winter's multiplicative seasonal exponential smoothing
application of PROC ESM*/
proc esm data=COURSE.ECOMMERCE outfor=out
back=0 lead=12 print=all  plot=(corr errors modelforecasts) ;
id DATE interval=QUARTER;
forecast ECOMMERCE / model=winters;
Title 'Winters mult model with no holdout, back=0';
run;
proc sgplot data=out;
series x=date y=actual/markers;
series x=date y=predict/markers;
run;
```

3

Code Without Holdout (Program2_ESM_Models)

```
/*  Winter's multiplicative seasonal exponential smoothing
application of PROC ESM*/
proc esm data=COURSE.ECOMMERCE outfor=out
back=4 lead=12 print=all  plot=(corr errors modelforecasts) ;
id DATE interval=QUARTER;
forecast ECOMMERCE / model=winters;
Title 'Winters mult model with holdout, back=4';
run;
proc sgplot data=out;
series x=date y=actual/markers;
series x=date y=predict/markers;
run;
```

4

Compare Results

Winters mult model with no holdout, back=0

The ESM Procedure

Input Data Set	
Name	COURSE.ECOMMERCE
Label	
Time ID Variable	date
Time Interval	QUARTER
Length of Seasonal Cycle	4
Forecast Horizon	4

Variable Information	
Name	Ecommerce
Label	E-commerce
First	1999:4
Last	2013:4
Number of Observations Read	57

Descriptive Statistics	
Variable	Ecommerce
Number of Observations	57
Number of Missing Observations	0
Minimum	5284
Maximum	83709
Mean	30388.3
Standard Deviation	18787.38

Winters Method (Multiplicative) Parameter Estimates

Parameter	Estimate	Standard Error	t Value	Approx Pr > |t|
Level Weight	0.55945	0.07021	7.97	<.0001
Trend Weight	0.31219	0.10337	3.02	0.0039
Seasonal Weight	0.96788	0.22173	4.37	<.0001

Winters mult model with 4 quraters holdout, back=4

The ESM Procedure

Input Data Set	
Name	COURSE.ECOMMERCE
Label	
Time ID Variable	date
Time Interval	QUARTER
Length of Seasonal Cycle	4
Forecast Horizon	4
Forecast Back	4

Variable Information	
Name	Ecommerce
Label	E-commerce
First	1999:4
Last	2013:4
Number of Observations Read	57

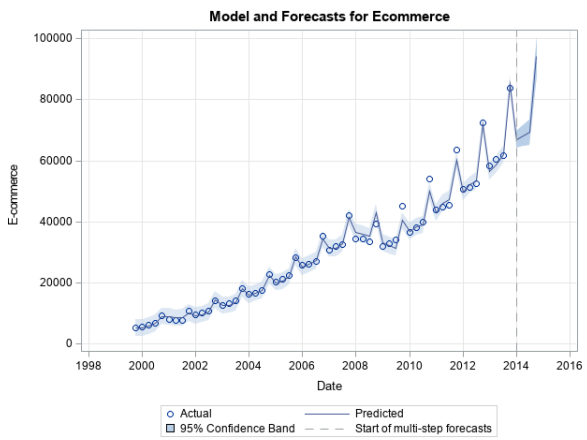
Descriptive Statistics	
Variable	Ecommerce
Number of Observations	53
Number of Missing Observations	0
Minimum	5284
Maximum	72361
Mean	27695.36
Standard Deviation	16330.38

Winters Method (Multiplicative) Parameter Estimates

Parameter	Estimate	Standard Error	t Value	Approx Pr > |t|
Level Weight	0.52849	0.06882	7.68	<.0001
Trend Weight	0.42980	0.13295	3.23	0.0022
Seasonal Weight	0.99900	0.22214	4.50	<.0001

5

Compare Results (No Holdout)



Forecasts for Variable Ecommerce

Obs	Time	Forecasts	Standard Error	95% Confidence Limits	
58	2014:1	66902.0447	1389.5301	64178.6158	69625.4736
59	2014:2	68151.3092	1717.0388	64785.9749	71516.6434
60	2014:3	69321.3375	2114.1420	65177.6952	73464.9797
61	2014:4	94150.8176	3199.2894	87880.3257	100421.3095

Statistics of Fit for Variable Ecommerce

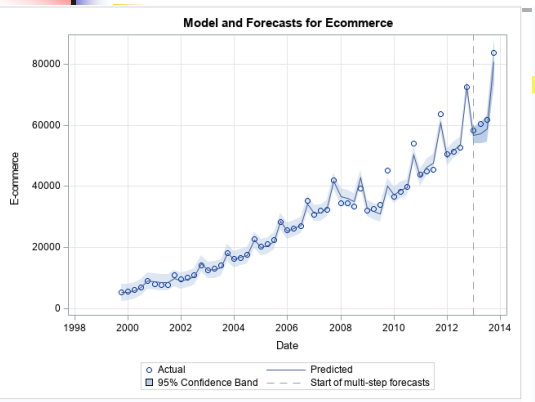
Statistic	Value
Degrees of Freedom Error	54
Number of Observations	57
Number of Observations Used	57
Number of Missing Actuals	0
Number of Missing Predicted Values	0
Number of Model Parameters	3
Total Sum of Squares	7.24027E10
Corrected Total Sum of Squares	1.97661E10
Sum of Square Error	104262867
Mean Square Error	1829173.1
Root Mean Square Error	1352.46926
Unbiased Mean Square Error	1930793.83
Unbiased Root Mean Square Error	1389.53007
Mean Absolute Percent Error	3.15737522
Mean Absolute Error	896.956725
R-Square	0.99472516
Adjusted R-Square	0.9945298
Amemiya's Adjusted R-Square	0.99413907
Random Walk R-Square	0.95785206
Akaike Information Criterion	827.90435
Schwarz Bayesian Information Criterion	834.033504
Amemiya's Prediction Criterion	2032414.55
Maximum Error	4765.9416
Minimum Error	-3713.9653
Maximum Percent Error	10.5443519
Minimum Percent Error	-12.285108
Mean Error	154.888586
Mean Percent Error	0.28988921
Computations based on fit range of data.	

Forecast Summary

Variable	2014:1	2014:2	2014:3	2014:4
Ecommerce	66902.04	68151.31	69321.34	94150.82

6

Compare Results (With Holdout)



Forecasts for Variable Ecommerce

Obs	Time	Forecasts	Standard Error	95% Confidence Limits	
54	2013:1	56726.3627	1375.5953	54030.2455	59422.4799
55	2013:2	57289.7059	1713.2294	53931.8380	60647.5738
56	2013:3	58850.8659	2176.4900	54585.0240	63116.7079
57	2013:4	80687.9213	3442.6037	73940.5420	87435.3006

Statistics of Fit for Variable Ecommerce

Statistic	Value
Degrees of Freedom Error	50
Number of Observations	53
Number of Observations Used	53
Number of Missing Actuals	0
Number of Missing Predicted Values	0
Number of Model Parameters	3
Total Sum of Squares	5.45202E10
Corrected Total Sum of Squares	1.38674E10
Sum of Square Error	94613120.6
Mean Square Error	1785153.22
Root Mean Square Error	1336.09626
Unbiased Mean Square Error	1892262.41
Unbiased Root Mean Square Error	1375.59529
Mean Absolute Percent Error	3.2998764
Mean Absolute Error	869.703271
R-Square	0.99317732
Adjusted R-Square	0.99290441
Amemiya's Adjusted R-Square	0.9923586
Random Walk R-Square	0.94752408
Akaike Information Criterion	768.935785
Schwarz Bayesian Information Criterion	774.846661
Amemiya's Prediction Criterion	1999371.61
Maximum Error	4996.94779
Minimum Error	-3489.8802
Maximum Percent Error	11.0554388
Minimum Percent Error	-12.483469
Mean Error	94.9389437
Mean Percent Error	0.10936297
Computations based on fit range of data.	

Performance Statistics for Variable Ecommerce

Statistic	Value
Degrees of Freedom Error	4
Number of Observations	4
Number of Observations Used	4
Number of Missing Actuals	0
Number of Missing Predicted Values	0
Number of Model Parameters	0
Total Sum of Squares	1.78825E10
Corrected Total Sum of Squares	421631899
Sum of Square Error	30672950.5
Mean Square Error	7668237.62
Root Mean Square Error	2769.15829
Unbiased Mean Square Error	7668237.62
Unbiased Root Mean Square Error	2769.15829
Mean Absolute Percent Error	4.08227873
Mean Absolute Error	2681.03604
R-Square	0.92725183
Adjusted R-Square	0.94543887
Amemiya's Adjusted R-Square	0.92725183
Random Walk R-Square	0.92725183
Akaike Information Criterion	63.4103895
Schwarz Bayesian Information Criterion	63.4103895
Amemiya's Prediction Criterion	7668237.62
Maximum Error	3208.29408
Minimum Error	1488.6373
Maximum Percent Error	5.30314074
Minimum Percent Error	2.55713699
Mean Error	2681.03604
Mean Percent Error	4.08227873
Computations based on forecast region of data.	

7

How do we get forecasts for 2014 Q1-2014 Q4, when using Holdout sample

- What if we use back=4 but lead =8? What do we get?

Forecasts for Variable Ecommerce

Obs	Time	Forecasts	Standard Error	95% Confidence Limits	
54	2013:1	56726.3627	1375.5953	54030.2455	59422.4799
55	2013:2	57289.7059	1713.2294	53931.8380	60647.5738
56	2013:3	58850.8659	2176.4900	54585.0240	63116.7079
57	2013:4	80687.9213	3442.6037	73940.5420	87435.3006
58	2014:1	63071.5428	3764.6385	55692.9870	70450.0986
59	2014:2	63523.5755	4321.7561	55053.0891	71994.0619
60	2014:3	65085.0207	4995.5071	55294.0067	74876.0348
61	2014:4	89014.7869	7402.3362	74506.4745	103523.0992

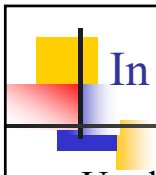
Actual Values are:
2014 Q1: 66,938
2014 Q2: 70,134
2014 Q3: 71,862
2014 Q4: 95,979

- How's that different from if we use back =0 but lead=4?

Forecasts for Variable Ecommerce

Obs	Time	Forecasts	Standard Error	95% Confidence Limits	
58	2014:1	66902.0447	1389.5301	64178.6158	69625.4736
59	2014:2	68151.3092	1717.0388	64785.9749	71516.6434
60	2014:3	69321.3375	2114.1420	65177.6952	73464.9797
61	2014:4	94150.8176	3199.2894	87880.3257	100421.3095

8



In Summary

- Use back = n, to use “n” periods of holdout data
- Find your best model using performance on holdout data
- Then for deployment, rerun the best model with back=0 so you can get the forecasts beyond the holdout period (i.e., for unseen data) using all of the available data

9