```
1          OPTIONS NONOTES NOSTIMER NOSOURCE NOSYNTAXCHECK;
NOTE: ODS statements in the SAS Studio environment may disable some output features.
73
74         ********************************************************************************
75         *  TITLE :      SAS GRAIN PRICE PROJECT ANALYSIS
76         *
77         *  DESCRIPTION: Final project for BIOS 7400 with Xiao Song, UGA, Spring 2022.
78         *               Simple analysis of grain price data.
79         *
80         *-------------------------------------------------------------------------------
81         *  JOB NAME:    analysis.SAS
82         *  LANGUAGE:    SAS v9.4 (on demand for academics)
83         *
84         *  NAME:        Zane Billings
85         *  DATE:        2022-04-22
86         *
87         ********************************************************************************;
88
89         FOOTNOTE "Job run by Zane Billings on &SYSDATE at &SYSTIME.";
90
91         TITLE 'ANALYSIS OF USDA HISTORICAL GRAIN PRICE DATA';
92
93         OPTIONS NODATE LS=95 PS=42;
94
95         LIBNAME HOME '/home/u59465388/SAS-Grain-Prices';
NOTE: Libref HOME was successfully assigned as follows:
      Engine:        V9
      Physical Name: /home/u59465388/SAS-Grain-Prices
96
97         ODS GRAPHICS / WIDTH = 6in HEIGHT = 3in;
98
99         ********************************************************************************;
100        * Show the descriptor portion of the dataset;
101        ********************************************************************************;
102
103        TITLE2 "CONTENTS OF GRAINS DATASET";
104
105        PROC CONTENTS DATA = HOME.GRAINS;
106        RUN;

NOTE: PROCEDURE CONTENTS used (Total process time):
      real time           0.09 seconds
      user cpu time       0.09 seconds
      system cpu time     0.00 seconds
      memory              3472.28k
      OS Memory           33452.00k
      Timestamp           05/05/2022 02:14:57 PM
      Step Count                        51  Switch Count  0
      Page Faults                       0
      Page Reclaims                     363
      Page Swaps                        0
      Voluntary Context Switches        3
      Involuntary Context Switches      0
      Block Input Operations            0
      Block Output Operations           24


107
108        ********************************************************************************;
109        * Plot outcome time series;
110        ********************************************************************************;
111
112        FOOTNOTE; * Remove the footnote so it isn't on the graphs;
```

```
113
114         * Plot the time series of log grain price over time. This makes a separate
115         time series line for each grain.;
116         TITLE2 "PRICE PER BUSHEL OF GRAINS OVER TIME";
117         PROC SGPLOT DATA = HOME.GRAINS;
118         SERIES X = YEAR Y = LPE / GROUP = GRN;
119         RUN;

NOTE: PROCEDURE SGPLOT used (Total process time):
      real time           2.84 seconds
      user cpu time       0.16 seconds
      system cpu time     0.03 seconds
      memory              21094.56k
      OS Memory           54184.00k
      Timestamp           05/05/2022 02:14:59 PM
      Step Count                        52  Switch Count  1
      Page Faults                       0
      Page Reclaims                     6656
      Page Swaps                        0
      Voluntary Context Switches        2147
      Involuntary Context Switches      5
      Block Input Operations            0
      Block Output Operations           1040

NOTE: There were 571 observations read from the data set HOME.GRAINS.

120
121         * Color the points of the time series by the President's political party. The
122         default colors are already red and blue so we don't need to change them!
123         Also plots a gray line underneath the points, since the JOIN option for
124         the SCATTER statement will not connect the points in order.;
125         TITLE2 "GRAIN PRICES AND PRESIDENT'S POLITICAL PARTY OVER TIME";
126         PROC SGPANEL DATA = HOME.GRAINS;
127         PANELBY GRN;
128         SERIES X = YEAR Y = LPE / LINEATTRS = (COLOR = "GRAY") SMOOTHCONNECT;
129         SCATTER X = YEAR Y = LPE / GROUP = PARTY
130         MARKERATTRS = (SYMBOL = CIRCLEFILLED);
131         RUN;

NOTE: PROCEDURE SGPANEL used (Total process time):
      real time           1.30 seconds
      user cpu time       0.20 seconds
      system cpu time     0.02 seconds
      memory              5829.03k
      OS Memory           58708.00k
      Timestamp           05/05/2022 02:15:01 PM
      Step Count                        53  Switch Count  2
      Page Faults                       0
      Page Reclaims                     2023
      Page Swaps                        0
      Voluntary Context Switches        3703
      Involuntary Context Switches      0
      Block Input Operations            0
      Block Output Operations           1880

NOTE: There were 571 observations read from the data set HOME.GRAINS.

132
133         ODS GRAPHICS / WIDTH = 6in HEIGHT = 6in;
134
135         * Make a boxplot of log price vs. president's political party. This ignores the
136         time series information, but can tell us if either party has more high or
137         low years compared to the other.;
138         TITLE2 "LOG PRICE DISTRIBUTION BY PRESIDENT'S POLITICAL PARTY";
139         PROC SGPANEL DATA = HOME.GRAINS;
```

```
140         PANELBY GRN;
141         HBOX LPE / GROUP = PARTY;
142         RUN;

NOTE: PROCEDURE SGPANEL used (Total process time):
      real time           0.67 seconds
      user cpu time       0.16 seconds
      system cpu time     0.01 seconds
      memory              4242.37k
      OS Memory           57524.00k
      Timestamp           05/05/2022 02:15:01 PM
      Step Count                        54  Switch Count  26
      Page Faults                       0
      Page Reclaims                     1606
      Page Swaps                        0
      Voluntary Context Switches        1123
      Involuntary Context Switches      0
      Block Input Operations            0
      Block Output Operations           2072

NOTE: There were 571 observations read from the data set HOME.GRAINS.

143
144         ODS GRAPHICS / WIDTH = 6in HEIGHT = 9in;
145
146         * Make a scatterplot of the log price vs each covariate, ignoring the time
147         series component of the data. There is not an easy way to connect the points
148         like a phase portrait using PROC SGPLOT.;
149         * I divided this into two plots so they would fit on one page nicer. In the final
150         manuscript they could be put side by side.;
151         TITLE2 "SCATTERPLOTS OF PRICE VS COVARIATES";
152         PROC SGSCATTER DATA = HOME.GRAINS;
153         PLOT LPE * (ACR HVT LNR PRD YLD) / REG
154         COLUMNS = 2 GROUP = GRN;
155         RUN;

NOTE: PROCEDURE SGSCATTER used (Total process time):
      real time           0.93 seconds
      user cpu time       0.33 seconds
      system cpu time     0.03 seconds
      memory              7316.03k
      OS Memory           62384.00k
      Timestamp           05/05/2022 02:15:02 PM
      Step Count                        55  Switch Count  1
      Page Faults                       0
      Page Reclaims                     2194
      Page Swaps                        0
      Voluntary Context Switches        2327
      Involuntary Context Switches      2
      Block Input Operations            0
      Block Output Operations           5696

NOTE: There were 571 observations read from the data set HOME.GRAINS.

156
157         PROC SGSCATTER DATA = HOME.GRAINS;
158         PLOT LPE * (INFL PWR TEMP VALUE) / REG
159         COLUMNS = 2;
160         RUN;

NOTE: PROCEDURE SGSCATTER used (Total process time):
      real time           0.59 seconds
      user cpu time       0.31 seconds
      system cpu time     0.01 seconds
      memory              6946.53k
```

```
      OS Memory           65200.00k
      Timestamp           05/05/2022 02:15:03 PM
      Step Count                        56  Switch Count  1
      Page Faults                       0
      Page Reclaims                     2037
      Page Swaps                        0
      Voluntary Context Switches        385
      Involuntary Context Switches      1
      Block Input Operations            0
      Block Output Operations           4504

NOTE: There were 571 observations read from the data set HOME.GRAINS.

161
162        ********************************************************************************;
163        * Plots of covariates across time;
164        ********************************************************************************;
165
166        * Plot the time series of each covariate, to assess how they change. I split
167        this one into two plots to prevent the plots being too small as before.;
168        TITLE2 "CHANGE IN COVARIATES ACROSS TIME";
169        PROC SGSCATTER DATA = HOME.GRAINS;
170        PLOT (ACR HVT LNR PRD YLD) * YEAR /
171        COLUMNS = 2 GROUP = GRN JOIN MARKERATTRS = (SIZE = 0);
172        RUN;

NOTE: PROCEDURE SGSCATTER used (Total process time):
      real time           0.54 seconds
      user cpu time       0.19 seconds
      system cpu time     0.04 seconds
      memory              5665.34k
      OS Memory           64688.00k
      Timestamp           05/05/2022 02:15:04 PM
      Step Count                        57  Switch Count  1
      Page Faults                       0
      Page Reclaims                     1924
      Page Swaps                        0
      Voluntary Context Switches        2021
      Involuntary Context Switches      5
      Block Input Operations            0
      Block Output Operations           1592

NOTE: There were 571 observations read from the data set HOME.GRAINS.

173
174        PROC SGSCATTER DATA = HOME.GRAINS;
175        PLOT (INFL PWR TEMP VALUE) * YEAR /
176        COLUMNS = 2 JOIN MARKERATTRS = (SIZE = 0);
177        RUN;

NOTE: PROCEDURE SGSCATTER used (Total process time):
      real time           0.35 seconds
      user cpu time       0.15 seconds
      system cpu time     0.01 seconds
      memory              4023.28k
      OS Memory           61796.00k
      Timestamp           05/05/2022 02:15:04 PM
      Step Count                        58  Switch Count  1
      Page Faults                       0
      Page Reclaims                     805
      Page Swaps                        0
      Voluntary Context Switches        283
      Involuntary Context Switches      1
      Block Input Operations            0
      Block Output Operations           1000
```

```
NOTE: There were 571 observations read from the data set HOME.GRAINS.

178
179        ********************************************************************************;
180        * Univariate analyses;
181        ********************************************************************************;
182
183        * Univariate analysis of main outcome (log price) by grain type;
184        TITLE2 "UNIVARIATE SUMMARY OF GRAIN DATA OVER TIME";
185
186        ODS GRAPHICS / WIDTH = 4in HEIGHT = 4in;
187
188        PROC UNIVARIATE DATA = HOME.GRAINS PLOTS;
189        VAR LPE;
190        CLASS GRN;
191        RUN;

NOTE: PROCEDURE UNIVARIATE used (Total process time):
      real time           1.23 seconds
      user cpu time       0.62 seconds
      system cpu time     0.03 seconds
      memory              4600.90k
      OS Memory           61108.00k
      Timestamp           05/05/2022 02:15:05 PM
      Step Count                        59  Switch Count  0
      Page Faults                       0
      Page Reclaims                     1841
      Page Swaps                        0
      Voluntary Context Switches        1177
      Involuntary Context Switches      3
      Block Input Operations            0
      Block Output Operations           2968


192
193        ********************************************************************************;
194        * Bivariate analyses of price and covariates, ignoring time;
195        ********************************************************************************;
196
197        TITLE2 "BIVARIATE CORRELATIONS ACROSS NUMERICAL VARIABLES";
198        * Correlations -- check to see which covariates are correlated with the outcome,
199        and which are correlated with each other and should not be modeled
200        together.;
201        PROC CORR PEARSON SPEARMAN DATA = HOME.GRAINS;
202        VAR LPE ACR HVT LNR PRD YLD INFL PWR TEMP VALUE;
203        BY GRN;
204        RUN;

NOTE: PROCEDURE CORR used (Total process time):
      real time           1.43 seconds
      user cpu time       1.44 seconds
      system cpu time     0.00 seconds
      memory              2523.09k
      OS Memory           61616.00k
      Timestamp           05/05/2022 02:15:07 PM
      Step Count                        60  Switch Count  0
      Page Faults                       0
      Page Reclaims                     313
      Page Swaps                        0
      Voluntary Context Switches        7
      Involuntary Context Switches      2
      Block Input Operations            0
      Block Output Operations           496
```

```
205
206         TITLE2 "SUMMARY STATISTICS BY PRESIDENTIAL PARTY AND GRAIN";
207         * Mean difference in LPE by party -- proc corr does not have a point biserial
208         option, so we can check the difference/overlap in means and standard errors
209         to assess if party seems to impact log price for any of the grains.;
210         PROC MEANS DATA = HOME.GRAINS MEAN STDERR MEDIAN RANGE NWAY;
211         VAR LPE;
212         CLASS PARTY;
213         BY GRN;
214         RUN;

NOTE: There were 571 observations read from the data set HOME.GRAINS.
NOTE: PROCEDURE MEANS used (Total process time):
      real time           0.06 seconds
      user cpu time       0.06 seconds
      system cpu time     0.00 seconds
      memory              2101.04k
      OS Memory           62900.00k
      Timestamp           05/05/2022 02:15:07 PM
      Step Count                        61  Switch Count  4
      Page Faults                       0
      Page Reclaims                     323
      Page Swaps                        0
      Voluntary Context Switches        17
      Involuntary Context Switches      0
      Block Input Operations            0
      Block Output Operations           24


215
216         ********************************************************************************;
217         * Simple and multiple OLS regression models;
218         ********************************************************************************;
219
220         TITLE2 "SIMPLE LINEAR REGRESSION MODELS";
221
222         * Model stratified by grain only;
223         PROC GLM DATA = HOME.GRAINS PLOTS = ALL;
224         CLASS GRN;
225         MODEL LPE = GRN / NOINT;
226         RUN;

NOTE: Due to the presence of CLASS variables, an intercept is implicitly fitted.  R-Square has
      been corrected for the mean.
227
228         * Write a macro to fit all regression models of the form
229         MODEL COVAR GRN COVAR * GRN
230          without having to type out all of the PROC GLM statements. This model will
231          be parametrized without an intercept, and will generate all appropriate
232          diagnostic plots for the model.;
233
234         %MACRO ALLSIMPLE(DAT = , RESP = , PRED = );
235         %LET N = %SYSFUNC(COUNTW(&PRED));
236         %DO I = 1 %TO &N;
237         PROC GLM DATA = &DAT PLOTS = ALL;
238         CLASS GRN;
239         MODEL &RESP = %SCAN(&PRED, &I) | GRN / NOINT;
240         RUN;
241         %END;
242         %MEND;
243
244         %ALLSIMPLE(
245         DAT = HOME.GRAINS,
246         RESP = LPE,
```

```
247         PRED = ACR PRD INFL TEMP PWR YEAR
248         );

NOTE: PROCEDURE GLM used (Total process time):
      real time           1.70 seconds
      user cpu time       0.74 seconds
      system cpu time     0.06 seconds
      memory              10466.12k
      OS Memory           69860.00k
      Timestamp           05/05/2022 02:15:08 PM
      Step Count                        62  Switch Count  23
      Page Faults                       0
      Page Reclaims                     14213
      Page Swaps                        0
      Voluntary Context Switches        1112
      Involuntary Context Switches      3
      Block Input Operations            0
      Block Output Operations           8624



NOTE: Due to the presence of CLASS variables, an intercept is implicitly fitted.  R-Square has
      been corrected for the mean.

NOTE: PROCEDURE GLM used (Total process time):
      real time           1.40 seconds
      user cpu time       0.64 seconds
      system cpu time     0.09 seconds
      memory              10185.98k
      OS Memory           71652.00k
      Timestamp           05/05/2022 02:15:10 PM
      Step Count                        63  Switch Count  23
      Page Faults                       0
      Page Reclaims                     12998
      Page Swaps                        0
      Voluntary Context Switches        2324
      Involuntary Context Switches      0
      Block Input Operations            0
      Block Output Operations           8944



NOTE: Due to the presence of CLASS variables, an intercept is implicitly fitted.  R-Square has
      been corrected for the mean.

NOTE: PROCEDURE GLM used (Total process time):
      real time           1.45 seconds
      user cpu time       0.81 seconds
      system cpu time     0.08 seconds
      memory              10281.42k
      OS Memory           72676.00k
      Timestamp           05/05/2022 02:15:11 PM
      Step Count                        64  Switch Count  23
      Page Faults                       0
      Page Reclaims                     13642
      Page Swaps                        0
      Voluntary Context Switches        2866
      Involuntary Context Switches      3
      Block Input Operations            0
      Block Output Operations           12312



NOTE: Due to the presence of CLASS variables, an intercept is implicitly fitted.  R-Square has
      been corrected for the mean.
```

```
NOTE: PROCEDURE GLM used (Total process time):
      real time           1.46 seconds
      user cpu time       0.80 seconds
      system cpu time     0.07 seconds
      memory              10256.25k
      OS Memory           73700.00k
      Timestamp           05/05/2022 02:15:13 PM
      Step Count                       65  Switch Count  23
      Page Faults                      0
      Page Reclaims                    13633
      Page Swaps                       0
      Voluntary Context Switches       2906
      Involuntary Context Switches     8
      Block Input Operations           0
      Block Output Operations          12120


NOTE: Due to the presence of CLASS variables, an intercept is implicitly fitted.  R-Square has
      been corrected for the mean.

NOTE: PROCEDURE GLM used (Total process time):
      real time           1.44 seconds
      user cpu time       0.80 seconds
      system cpu time     0.08 seconds
      memory              10135.45k
      OS Memory           73956.00k
      Timestamp           05/05/2022 02:15:14 PM
      Step Count                       66  Switch Count  23
      Page Faults                      0
      Page Reclaims                    13688
      Page Swaps                       0
      Voluntary Context Switches       2778
      Involuntary Context Switches     2
      Block Input Operations           0
      Block Output Operations          11864


NOTE: Due to the presence of CLASS variables, an intercept is implicitly fitted.  R-Square has
      been corrected for the mean.

NOTE: PROCEDURE GLM used (Total process time):
      real time           1.45 seconds
      user cpu time       0.79 seconds
      system cpu time     0.09 seconds
      memory              10242.68k
      OS Memory           74724.00k
      Timestamp           05/05/2022 02:15:16 PM
      Step Count                       67  Switch Count  23
      Page Faults                      0
      Page Reclaims                    13710
      Page Swaps                       0
      Voluntary Context Switches       2902
      Involuntary Context Switches     1
      Block Input Operations           0
      Block Output Operations          12296


NOTE: Due to the presence of CLASS variables, an intercept is implicitly fitted.  R-Square has
      been corrected for the mean.
249
250        * Fit the same model that was used as before, but with party as a covariate.
```

```
251        Party needs to be in the class statement, and is the only categorical
252        variable, so it wasn't worth modifying the above macro to use party
253        correctly and I did it manually.;

NOTE: PROCEDURE GLM used (Total process time):
      real time           1.61 seconds
      user cpu time       1.00 seconds
      system cpu time     0.08 seconds
      memory              10340.65k
      OS Memory           75492.00k
      Timestamp           05/05/2022 02:15:17 PM
      Step Count                        68  Switch Count  23
      Page Faults                       0
      Page Reclaims                     13814
      Page Swaps                        0
      Voluntary Context Switches        2904
      Involuntary Context Switches      3
      Block Input Operations            0
      Block Output Operations           12568


254        PROC GLM DATA = HOME.GRAINS PLOTS = ALL;
255        CLASS GRN PARTY;
256        MODEL LPE = GRN | PARTY / NOINT;
257        RUN;

NOTE: Due to the presence of CLASS variables, an intercept is implicitly fitted.  R-Square has
      been corrected for the mean.
258
259        TITLE2 "1866 FULL MODEL";
260        * 1866 FULL MODEL: this model includes all non-correlated predictors that were
261        measured in 1866.;

NOTE: PROCEDURE GLM used (Total process time):
      real time           1.26 seconds
      user cpu time       0.72 seconds
      system cpu time     0.07 seconds
      memory              10287.93k
      OS Memory           76516.00k
      Timestamp           05/05/2022 02:15:18 PM
      Step Count                        69  Switch Count  24
      Page Faults                       0
      Page Reclaims                     13243
      Page Swaps                        0
      Voluntary Context Switches        4419
      Involuntary Context Switches      3
      Block Input Operations            0
      Block Output Operations           10104


262        PROC MIXED DATA = HOME.GRAINS PLOTS = ALL;
263        CLASS GRN PARTY;
264        MODEL LPE =
265        GRN HVT PRD INFL PWR YEAR PARTY
266        GRN*HVT GRN*PRD GRN*INFL GRN*PWR GRN*YEAR GRN*PARTY /
267        NOINT SOLUTION
268        ;
269        RUN;

NOTE: 10 observations are not included because of missing values.
NOTE: PROCEDURE MIXED used (Total process time):
      real time           1.67 seconds
      user cpu time       0.91 seconds
      system cpu time     0.10 seconds
      memory              11203.28k
```

```
      OS Memory           78308.00k
      Timestamp           05/05/2022 02:15:20 PM
      Step Count                        70  Switch Count  44
      Page Faults                       0
      Page Reclaims                     22500
      Page Swaps                        0
      Voluntary Context Switches        3146
      Involuntary Context Switches      2
      Block Input Operations            0
      Block Output Operations           10544


270
271       TITLE2 "1880 FULL MODEL";
272       * FULL MODEL WITH TEMP (1880 MODEL): this model is the same as the previous
273       model, but also includes the temperature anomaly information. Consequently,
274       it only uses data from 1880 onwards (even less for sorghum).;
275       PROC MIXED DATA = HOME.GRAINS PLOTS = ALL;
276       CLASS PARTY GRN;
277       MODEL LPE =
278       GRN HVT PRD INFL PWR YEAR PARTY TEMP
279       GRN*HVT GRN*PRD GRN*INFL GRN*PWR GRN*YEAR GRN*PARTY TEMP*PARTY/
280       NOINT SOLUTION
281       ;
282       RUN;

NOTE: 52 observations are not included because of missing values.
NOTE: PROCEDURE MIXED used (Total process time):
      real time           1.67 seconds
      user cpu time       0.86 seconds
      system cpu time     0.11 seconds
      memory              10662.59k
      OS Memory           79076.00k
      Timestamp           05/05/2022 02:15:22 PM
      Step Count                        71  Switch Count  44
      Page Faults                       0
      Page Reclaims                     21920
      Page Swaps                        0
      Voluntary Context Switches        3163
      Involuntary Context Switches      2
      Block Input Operations            0
      Block Output Operations           10232


283
284       ************************************************************************;
285       * GLS multiple regression analysis;
286       ************************************************************************;
287
288       * Take the better fitting (by AIC) of the two previous models, and run a model
289       that can account for correlation using generalized least squares.
290       This model assumes exchangeable correlations between each of the time points.;
291       TITLE2 "GENERALIZED LEAST SQUARES MODEL";
292       PROC MIXED DATA = HOME.GRAINS PLOTS = ALL;
293       CLASS GRN;
294       MODEL LPE = HVT PRD INFL PWR YEAR GRN GRN*HVT GRN*PRD /
295       NOINT SOLUTION CHISQ;
296       REPEATED;
297       RUN;

NOTE: 10 observations are not included because of missing values.
NOTE: Convergence criteria met.
NOTE: PROCEDURE MIXED used (Total process time):
      real time           1.38 seconds
      user cpu time       0.74 seconds
```

```
      system cpu time     0.10 seconds
      memory              9928.65k
      OS Memory           79072.00k
      Timestamp           05/05/2022 02:15:23 PM
      Step Count                        72  Switch Count  42
      Page Faults                       0
      Page Reclaims                     21062
      Page Swaps                        0
      Voluntary Context Switches        2054
      Involuntary Context Switches      2
      Block Input Operations            0
      Block Output Operations           9528


298
299         ********************************************************************************;
300         * Simple forecasting;
301         ********************************************************************************;
302
303         * Now instead of just using regression models, we can try to fit a more
304         flexible forecasting model using PROC ARIMA.
305         First, we need a time variable that is actually a SAS date, so we create
306         that first.;
307         DATA TS_DAT;
308         SET HOME.GRAINS;
309         T = MDY(1, 1, YEAR);
310         RUN;

NOTE: There were 571 observations read from the data set HOME.GRAINS.
NOTE: The data set WORK.TS_DAT has 571 observations and 17 variables.
NOTE: DATA statement used (Total process time):
      real time           0.00 seconds
      user cpu time       0.00 seconds
      system cpu time     0.00 seconds
      memory              977.46k
      OS Memory           72372.00k
      Timestamp           05/05/2022 02:15:23 PM
      Step Count                        73  Switch Count  2
      Page Faults                       0
      Page Reclaims                     171
      Page Swaps                        0
      Voluntary Context Switches        14
      Involuntary Context Switches      0
      Block Input Operations            0
      Block Output Operations           264


311
312         * Next we use the IDENTIFY modeling stage. We check up to 30 lags in the
313         first ARIMA modeling stage, and also explicitly test for stationarity at
314         the first 10 differences using the random walk with drift test. We
315         also use the SCAN method, which is a heuristic for identifying
316         candidate ARIMA models.;
317         PROC ARIMA DATA = TS_DAT;
318         IDENTIFY VAR = LPE NLAG = 30 SCAN STATIONARITY = (RW = 10);
319         BY GRN;
320         TITLE2 "ARIMA TESTS";
321         RUN;

NOTE: Interactivity disabled with BY processing.
322
323         * Next we use the ESTIMATE modeling stage. We fit several different ARIMA
324         models to the data in order to see which fits our time series the best,
325         and if any have white noise as the error term.;
326         * One PROC ARIMA can contain multiple ESTIMATE statements, but I split these
```

```
327        into multiple PROC steps to make the output easier to read.;
328        * We are basically fitting all of these models to get the AIC and see which is
329        the best fit.;
330
331        * Model 1: AR(1);

NOTE: PROCEDURE ARIMA used (Total process time):
      real time           1.22 seconds
      user cpu time       0.77 seconds
      system cpu time     0.03 seconds
      memory              5024.46k
      OS Memory           73908.00k
      Timestamp           05/05/2022 02:15:24 PM
      Step Count                        74  Switch Count  1
      Page Faults                       0
      Page Reclaims                     2294
      Page Swaps                        0
      Voluntary Context Switches        1384
      Involuntary Context Switches      2
      Block Input Operations            0
      Block Output Operations           4008


332        PROC ARIMA DATA = TS_DAT;
333        IDENTIFY VAR = LPE;
334        ESTIMATE P = 1;
335        BY GRN;
336        TITLE2 "AR(1)";
337        RUN;

NOTE: Interactivity disabled with BY processing.
338
339        * MODEL 2: AR(2);

NOTE: PROCEDURE ARIMA used (Total process time):
      real time           2.71 seconds
      user cpu time       1.39 seconds
      system cpu time     0.16 seconds
      memory              10472.65k
      OS Memory           80340.00k
      Timestamp           05/05/2022 02:15:27 PM
      Step Count                        75  Switch Count  49
      Page Faults                       0
      Page Reclaims                     30583
      Page Swaps                        0
      Voluntary Context Switches        4245
      Involuntary Context Switches      4
      Block Input Operations            0
      Block Output Operations           10688


340        PROC ARIMA DATA = TS_DAT;
341        IDENTIFY VAR = LPE;
342        ESTIMATE P = 2;
343        BY GRN;
344        TITLE2 "AR(2)";
345        RUN;

NOTE: Interactivity disabled with BY processing.
346
347        * MODEL 3: MA(1);

NOTE: PROCEDURE ARIMA used (Total process time):
      real time           2.50 seconds
      user cpu time       1.36 seconds
```

```
      system cpu time     0.16 seconds
      memory              10165.31k
      OS Memory           81620.00k
      Timestamp           05/05/2022 02:15:30 PM
      Step Count                        76  Switch Count  49
      Page Faults                       0
      Page Reclaims                     30673
      Page Swaps                        0
      Voluntary Context Switches        4265
      Involuntary Context Switches      2
      Block Input Operations            0
      Block Output Operations           10784


348        PROC ARIMA DATA = TS_DAT;
349        IDENTIFY VAR = LPE;
350        ESTIMATE Q = 1;
351        BY GRN;
352        TITLE2 "MA(1)";
353        RUN;

NOTE: Interactivity disabled with BY processing.
354
355        * MODEL 4: ARMA(1, 1);

NOTE: PROCEDURE ARIMA used (Total process time):
      real time           2.54 seconds
      user cpu time       1.34 seconds
      system cpu time     0.15 seconds
      memory              10138.21k
      OS Memory           82388.00k
      Timestamp           05/05/2022 02:15:32 PM
      Step Count                        77  Switch Count  49
      Page Faults                       0
      Page Reclaims                     30129
      Page Swaps                        0
      Voluntary Context Switches        4250
      Involuntary Context Switches      4
      Block Input Operations            0
      Block Output Operations           10704


356        PROC ARIMA DATA = TS_DAT;
357        IDENTIFY VAR = LPE;
358        ESTIMATE P = 1 Q = 1;
359        BY GRN;
360        TITLE2 "ARMA(1, 1)";
361        RUN;

NOTE: Interactivity disabled with BY processing.
362
363        * MODEL 5: ARIMA(1, 1, 0);

NOTE: PROCEDURE ARIMA used (Total process time):
      real time           2.51 seconds
      user cpu time       1.40 seconds
      system cpu time     0.14 seconds
      memory              10185.68k
      OS Memory           83412.00k
      Timestamp           05/05/2022 02:15:35 PM
      Step Count                        78  Switch Count  49
      Page Faults                       0
      Page Reclaims                     30226
      Page Swaps                        0
      Voluntary Context Switches        4255
```

```
      Involuntary Context Switches      2
      Block Input Operations            0
      Block Output Operations           10672


364         PROC ARIMA DATA = TS_DAT;
365         IDENTIFY VAR = LPE(1);
366         ESTIMATE P = 1;
367         BY GRN;
368         TITLE2 "ARIMA(1, 1, 0)";
369         RUN;

NOTE: Interactivity disabled with BY processing.
370
371         * MODEL 6: ARIMA(1, 1, 1);

NOTE: PROCEDURE ARIMA used (Total process time):
      real time           2.49 seconds
      user cpu time       1.36 seconds
      system cpu time     0.14 seconds
      memory              9820.65k
      OS Memory           83924.00k
      Timestamp           05/05/2022 02:15:37 PM
      Step Count                        79  Switch Count  49
      Page Faults                       0
      Page Reclaims                     29877
      Page Swaps                        0
      Voluntary Context Switches        4248
      Involuntary Context Switches      4
      Block Input Operations            0
      Block Output Operations           10824


372         PROC ARIMA DATA = TS_DAT;
373         IDENTIFY VAR = LPE(1);
374         ESTIMATE P = 1 Q = 1;
375         BY GRN;
376         TITLE2 "ARIMA(1, 1, 1)";
377         RUN;

NOTE: Interactivity disabled with BY processing.
378
379         * MODEL 7: ARIMA(0,0,0) (WHITE NOISE);

NOTE: PROCEDURE ARIMA used (Total process time):
      real time           2.46 seconds
      user cpu time       1.42 seconds
      system cpu time     0.12 seconds
      memory              9998.53k
      OS Memory           84436.00k
      Timestamp           05/05/2022 02:15:40 PM
      Step Count                        80  Switch Count  49
      Page Faults                       0
      Page Reclaims                     29916
      Page Swaps                        0
      Voluntary Context Switches        4254
      Involuntary Context Switches      2
      Block Input Operations            0
      Block Output Operations           10120


380         PROC ARIMA DATA = TS_DAT;
381         IDENTIFY VAR = LPE;
382         ESTIMATE P = 0 Q = 0;
383         BY GRN;
```

```
384         TITLE2 "ARIMA(0, 0, 0)";
385         RUN;

NOTE: Interactivity disabled with BY processing.
386
387         * MODEL 8: ARIMA(0,1,0) (RANDOM WALK);

NOTE: PROCEDURE ARIMA used (Total process time):
      real time           3.00 seconds
      user cpu time       1.35 seconds
      system cpu time     0.14 seconds
      memory              10463.75k
      OS Memory           85716.00k
      Timestamp           05/05/2022 02:15:43 PM
      Step Count                        81  Switch Count  49
      Page Faults                       0
      Page Reclaims                     30647
      Page Swaps                        0
      Voluntary Context Switches        4267
      Involuntary Context Switches      7
      Block Input Operations            0
      Block Output Operations           11256


388         PROC ARIMA DATA = TS_DAT;
389         IDENTIFY VAR = LPE(1);
390         ESTIMATE P = 0 Q = 0;
391         BY GRN;
392         TITLE2 "ARIMA(0, 1, 0)";
393         RUN;

NOTE: Interactivity disabled with BY processing.
394
395         * Finally, we use the best fitting model to make some simple forecasts in
396         the FORECAST modeling stage. We also identify outliers of the best
397         fitting model.;
398

NOTE: PROCEDURE ARIMA used (Total process time):
      real time           2.38 seconds
      user cpu time       1.34 seconds
      system cpu time     0.13 seconds
      memory              9568.68k
      OS Memory           86484.00k
      Timestamp           05/05/2022 02:15:45 PM
      Step Count                        82  Switch Count  49
      Page Faults                       0
      Page Reclaims                     31627
      Page Swaps                        0
      Voluntary Context Switches        4249
      Involuntary Context Switches      8
      Block Input Operations            0
      Block Output Operations           10200


399         PROC ARIMA DATA = TS_DAT;
400         IDENTIFY VAR = LPE(1);
401         ESTIMATE P = 1 Q = 1;
402         OUTLIER;
403         FORECAST LEAD = 10 INTERVAL = YEAR ID = T OUT = GRAIN_FC;
404         BY GRN;
405         TITLE2 "FORECASTING";
406         RUN;

NOTE: Interactivity disabled with BY processing.
```

```
407
408
409
410
411
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418
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420
421
422         OPTIONS NONOTES NOSTIMER NOSOURCE NOSYNTAXCHECK;
434
```