

```

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        3542.93k
      OS Memory     29868.00k
      Timestamp     04/26/2022 01:42:44 AM
      Step Count     52  Switch Count  0
      Page Faults   0
      Page Reclaims 363
      Page Swaps    0
      Voluntary Context Switches 4
      Involuntary Context Switches 0
      Block Input Operations 0
      Block Output Operations 32

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	0.44 seconds
user cpu time	0.14 seconds
system cpu time	0.03 seconds
memory	20943.37k
OS Memory	48808.00k
Timestamp	04/26/2022 01:42:44 AM
Step Count	53 Switch Count 1
Page Faults	0
Page Reclaims	5404
Page Swaps	0
Voluntary Context Switches	1993
Involuntary Context Switches	0
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	1.19 seconds
user cpu time	0.20 seconds
system cpu time	0.04 seconds
memory	5848.09k
OS Memory	53076.00k
Timestamp	04/26/2022 01:42:45 AM
Step Count	54 Switch Count 2
Page Faults	0
Page Reclaims	1988
Page Swaps	0
Voluntary Context Switches	3700
Involuntary Context Switches	4
Block Input Operations	0
Block Output Operations	1888

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 SGANEL used (Total process time):

real time	0.65 seconds
user cpu time	0.17 seconds
system cpu time	0.02 seconds
memory	4161.56k
OS Memory	51892.00k
Timestamp	04/26/2022 01:42:46 AM
Step Count	55 Switch Count 26
Page Faults	0
Page Reclaims	1579
Page Swaps	0
Voluntary Context Switches	1122
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 SGSCATTER.;
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	0.91 seconds
user cpu time	0.36 seconds
system cpu time	0.02 seconds
memory	7307.59k
OS Memory	56752.00k
Timestamp	04/26/2022 01:42:47 AM
Step Count	56 Switch Count 1
Page Faults	0
Page Reclaims	2334
Page Swaps	0
Voluntary Context Switches	2334
Involuntary Context Switches	0
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	0.55 seconds
user cpu time	0.32 seconds
system cpu time	0.01 seconds
memory	6930.59k

OS Memory	59568.00k
Timestamp	04/26/2022 01:42:47 AM
Step Count	57 Switch Count 1
Page Faults	0
Page Reclaims	2125
Page Swaps	0
Voluntary Context Switches	391
Involuntary Context Switches	3
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	0.56 seconds
user cpu time	0.22 seconds
system cpu time	0.02 seconds
memory	5547.62k
OS Memory	59824.00k
Timestamp	04/26/2022 01:42:48 AM
Step Count	58 Switch Count 1
Page Faults	0
Page Reclaims	1893
Page Swaps	0
Voluntary Context Switches	2019
Involuntary Context Switches	0
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	0.36 seconds
user cpu time	0.13 seconds
system cpu time	0.01 seconds
memory	4135.81k
OS Memory	55992.00k
Timestamp	04/26/2022 01:42:48 AM
Step Count	59 Switch Count 1
Page Faults	0
Page Reclaims	927
Page Swaps	0
Voluntary Context Switches	283
Involuntary Context Switches	4
Block Input Operations	0
Block Output Operations	1000

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

```

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

```

NOTE: PROCEDURE UNIVARIATE used (Total process time):

real time	1.18 seconds
user cpu time	0.62 seconds
system cpu time	0.03 seconds
memory	4425.56k
OS Memory	55476.00k
Timestamp	04/26/2022 01:42:49 AM
Step Count	60 Switch Count 0
Page Faults	0
Page Reclaims	1928
Page Swaps	0
Voluntary Context Switches	1190
Involuntary Context Switches	15
Block Input Operations	0
Block Output Operations	2976

```

192      ****;
193      * Bivariate analyses of price and covariates, ignoring time;
194      ****;
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	1.36 seconds
user cpu time	1.35 seconds
system cpu time	0.00 seconds
memory	2491.68k
OS Memory	55728.00k
Timestamp	04/26/2022 01:42:51 AM
Step Count	61 Switch Count 0
Page Faults	0
Page Reclaims	358
Page Swaps	0
Voluntary Context Switches	6
Involuntary Context Switches	3
Block Input Operations	0
Block Output Operations	488

```

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	0.05 seconds
system cpu time	0.00 seconds
memory	2094.18k
OS Memory	57012.00k
Timestamp	04/26/2022 01:42:51 AM
Step Count	62 Switch Count 4
Page Faults	0
Page Reclaims	413
Page Swaps	0
Voluntary Context Switches	16
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	1.86 seconds
user cpu time	0.68 seconds
system cpu time	0.07 seconds
memory	10573.71k
OS Memory	63204.00k
Timestamp	04/26/2022 01:42:53 AM
Step Count	63 Switch Count 23
Page Faults	0
Page Reclaims	14451
Page Swaps	0
Voluntary Context Switches	1103
Involuntary Context Switches	9
Block Input Operations	0
Block Output Operations	8632

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	1.51 seconds
user cpu time	0.81 seconds
system cpu time	0.07 seconds
memory	10172.96k
OS Memory	65764.00k
Timestamp	04/26/2022 01:42:54 AM
Step Count	64 Switch Count 23
Page Faults	0
Page Reclaims	12972
Page Swaps	0
Voluntary Context Switches	2331
Involuntary Context Switches	133
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	1.56 seconds
user cpu time	0.86 seconds
system cpu time	0.07 seconds
memory	10234.93k
OS Memory	67044.00k
Timestamp	04/26/2022 01:42:56 AM
Step Count	65 Switch Count 23
Page Faults	0
Page Reclaims	13593
Page Swaps	0
Voluntary Context Switches	2879
Involuntary Context Switches	147
Block Input Operations	0
Block Output Operations	12640

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	1.39 seconds
user cpu time	0.79 seconds
system cpu time	0.07 seconds
memory	10281.78k
OS Memory	67044.00k
Timestamp	04/26/2022 01:42:57 AM
Step Count	66 Switch Count 23
Page Faults	0
Page Reclaims	13818
Page Swaps	0
Voluntary Context Switches	2906
Involuntary Context Switches	6
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	1.41 seconds
user cpu time	0.80 seconds
system cpu time	0.06 seconds
memory	10254.78k
OS Memory	68324.00k
Timestamp	04/26/2022 01:42:59 AM
Step Count	67 Switch Count 23
Page Faults	0
Page Reclaims	13861
Page Swaps	0
Voluntary Context Switches	2781
Involuntary Context Switches	1
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	1.50 seconds
user cpu time	0.86 seconds
system cpu time	0.08 seconds
memory	10263.31k
OS Memory	69348.00k
Timestamp	04/26/2022 01:43:00 AM
Step Count	68 Switch Count 23
Page Faults	0
Page Reclaims	13731
Page Swaps	0
Voluntary Context Switches	2891
Involuntary Context Switches	2
Block Input Operations	0
Block Output Operations	12304

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	1.43 seconds
user cpu time	0.83 seconds
system cpu time	0.08 seconds
memory	10355.40k
OS Memory	70116.00k
Timestamp	04/26/2022 01:43:02 AM
Step Count	69 Switch Count 23
Page Faults	0
Page Reclaims	13803
Page Swaps	0
Voluntary Context Switches	2906
Involuntary Context Switches	4
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	1.27 seconds
user cpu time	0.73 seconds
system cpu time	0.07 seconds
memory	10398.93k
OS Memory	71140.00k
Timestamp	04/26/2022 01:43:03 AM
Step Count	70 Switch Count 24
Page Faults	0
Page Reclaims	13437
Page Swaps	0
Voluntary Context Switches	4424
Involuntary Context Switches	1
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	1.77 seconds
user cpu time	0.92 seconds
system cpu time	0.11 seconds
memory	11242.09k

OS Memory	73188.00k
Timestamp	04/26/2022 01:43:05 AM
Step Count	71 Switch Count 44
Page Faults	0
Page Reclaims	22677
Page Swaps	0
Voluntary Context Switches	3164
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	1.62 seconds
user cpu time	0.90 seconds
system cpu time	0.11 seconds
memory	10615.09k
OS Memory	73956.00k
Timestamp	04/26/2022 01:43:06 AM
Step Count	72 Switch Count 44
Page Faults	0
Page Reclaims	22375
Page Swaps	0
Voluntary Context Switches	3164
Involuntary Context Switches	4
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	1.40 seconds
user cpu time	0.75 seconds

system cpu time	0.09 seconds
memory	9951.81k
OS Memory	73952.00k
Timestamp	04/26/2022 01:43:08 AM
Step Count	73 Switch Count 42
Page Faults	0
Page Reclaims	21272
Page Swaps	0
Voluntary Context Switches	2069
Involuntary Context Switches	3
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	0.01 seconds
system cpu time	0.00 seconds
memory	947.09k
OS Memory	67764.00k
Timestamp	04/26/2022 01:43:08 AM
Step Count	74 Switch Count 2
Page Faults	0
Page Reclaims	171
Page Swaps	0
Voluntary Context Switches	16
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	1.23 seconds
user cpu time	0.74 seconds
system cpu time	0.03 seconds
memory	4924.31k
OS Memory	69044.00k
Timestamp	04/26/2022 01:43:09 AM
Step Count	75 Switch Count 1
Page Faults	1
Page Reclaims	2121
Page Swaps	0
Voluntary Context Switches	1386
Involuntary Context Switches	118
Block Input Operations	1784
Block Output Operations	4000

```

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	2.68 seconds
user cpu time	1.39 seconds
system cpu time	0.15 seconds
memory	10713.53k
OS Memory	75220.00k
Timestamp	04/26/2022 01:43:12 AM
Step Count	76 Switch Count 49
Page Faults	0
Page Reclaims	30268
Page Swaps	0
Voluntary Context Switches	4267
Involuntary Context Switches	26
Block Input Operations	0
Block Output Operations	10680

```

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	2.61 seconds
user cpu time	1.42 seconds

system cpu time	0.17 seconds
memory	9935.46k
OS Memory	76500.00k
Timestamp	04/26/2022 01:43:14 AM
Step Count	77 Switch Count 49
Page Faults	0
Page Reclaims	30011
Page Swaps	0
Voluntary Context Switches	4279
Involuntary Context Switches	3
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      * MODEL 4: ARMA(1, 1);

```

NOTE: PROCEDURE ARIMA used (Total process time):

real time	2.65 seconds
user cpu time	1.43 seconds
system cpu time	0.15 seconds
memory	10031.90k
OS Memory	77524.00k
Timestamp	04/26/2022 01:43:17 AM
Step Count	78 Switch Count 49
Page Faults	0
Page Reclaims	29931
Page Swaps	0
Voluntary Context Switches	4247
Involuntary Context Switches	0
Block Input Operations	0
Block Output Operations	10176

```

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      * MODEL 5: ARIMA(1, 1, 0);

```

NOTE: PROCEDURE ARIMA used (Total process time):

real time	2.56 seconds
user cpu time	1.45 seconds
system cpu time	0.16 seconds
memory	10138.46k
OS Memory	78548.00k
Timestamp	04/26/2022 01:43:19 AM
Step Count	79 Switch Count 49
Page Faults	0
Page Reclaims	29953
Page Swaps	0
Voluntary Context Switches	4274

Involuntary Context Switches	6
Block Input Operations	0
Block Output Operations	10680

```
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	2.52 seconds
user cpu time	1.37 seconds
system cpu time	0.15 seconds
memory	9734.28k
OS Memory	79060.00k
Timestamp	04/26/2022 01:43:22 AM
Step Count	80 Switch Count 49
Page Faults	0
Page Reclaims	29853
Page Swaps	0
Voluntary Context Switches	4274
Involuntary Context Switches	6
Block Input Operations	0
Block Output Operations	10224

```
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	2.53 seconds
user cpu time	1.44 seconds
system cpu time	0.16 seconds
memory	9925.09k
OS Memory	79828.00k
Timestamp	04/26/2022 01:43:25 AM
Step Count	81 Switch Count 49
Page Faults	0
Page Reclaims	29916
Page Swaps	0
Voluntary Context Switches	4279
Involuntary Context Switches	9
Block Input Operations	0
Block Output Operations	10128

```
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	2.54 seconds
user cpu time	1.38 seconds
system cpu time	0.15 seconds
memory	10354.71k
OS Memory	81108.00k
Timestamp	04/26/2022 01:43:27 AM
Step Count	82 Switch Count 49
Page Faults	0
Page Reclaims	30404
Page Swaps	0
Voluntary Context Switches	4273
Involuntary Context Switches	15
Block Input Operations	0
Block Output Operations	11264

```
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	2.48 seconds
user cpu time	1.40 seconds
system cpu time	0.16 seconds
memory	9501.34k
OS Memory	81620.00k
Timestamp	04/26/2022 01:43:30 AM
Step Count	83 Switch Count 49
Page Faults	0
Page Reclaims	31670
Page Swaps	0
Voluntary Context Switches	4273
Involuntary Context Switches	7
Block Input Operations	0
Block Output Operations	10192

```
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  
412  
413  
414  
415  
416  
417  
418  
419  
420  
421  
422     OPTIONS NONOTES NOSTIMER NOSOURCE NOSYNTAXCHECK;  
434
```