INTRODUCTION

SAS/STAT™ software contains several procedures that perform regression analysis. PROC REG is the most general tool of these procedures. In Version 5, REG is a noninteractive procedure that fits the model specified. In Version 6, REG is an interactive procedure with nine model selection methods. Additional enhancements include the ability to add or delete variables from the model, reweight or exclude observations from the model, plot the data and many model statistics, and highlight selected points in plots. The next several sections of this paper give a summary of new features in PROC REG. The final section, EXAMPLE, gives an annotated program (with output) that illustrates many of the new features in PROC REG.

INTERACTIVITY

Starting with Release 6.02, PROC REG is interactive. This means that you can submit a group of statements, look at the results of the analysis, and submit additional statements without re-calling the procedure. For example, the statements on the left below can be used in both Version 5 and Version 6, but the statements on the right can only be used in Version 6.

```
proc reg;
model y=x1 x2 x3;
output out=ml p=yhat;
run;
```

```
proc reg:
model y=x1 x2 x3;
output out .. ml p .. yhat;
run;
```

Notice that interactivity of a procedure differs from using SAS software in interactive mode. You can use the features of an interactive procedure even if you use the software in batch mode. However, these features are most useful when you use the software in interactive mode (either line mode or Display Manager mode).

BY-processing and Interactivity

When you use a BY statement with PROC REG, you cannot use interactivity. You need to list all statements before the first RUN statement since later statements will not be run.

Using Specific Statements

Interactivity allows you to use most statements, including the MODEL statement, after the first RUN statement. However, some statements must appear before the first RUN statement or they are ignored. These noninteractive statements are the BY, FREQ, ID, VAR, and WEIGHT statements.

MODEL SELECTION

Version 5 software includes the RSQUARE, REG, and STEPWISE procedures. In Version 6, these procedures are combined into the REG procedure. Release 6.03 adds two new selection techniques, giving a total of nine model-selection methods. The default method (NONE) fits the model you specify in the MODEL statement. The other eight methods involve various ways of including or excluding variables from the model. Five methods (BACKWARD, FORWARD, MAXR, MINR, and STEPWISE) are as previously implemented in PROC STEPWISE. Another method (RSQUARE) is as previously implemented in PROC RSQUARE. Two additional methods, new in Release 6.03, are ADJRSQ and CP. These methods are very similar to the RSQUARE method but use a different criterion for including a variable in the model.

CHANGING THE MODEL

In Version 5, you could change the model in the sense that you could submit several MODEL statements, and PROC REG would fit each model. In Version 6, you can still use this method. However, you can also change the model just by adding or deleting variables.

Starting with Release 6.02, the ADD statement allows you to interactively add variables to a model, and the DELETE statement allows you to interactively delete variables from the model. Both of these statements implicitly refit the model (that is, when you submit them, the new model is automatically fit, even though no output is printed).

These two new statements affect how you use the VAR statement. In Version 5, the VAR statement was useful if you wanted only to get the SSCP matrix and output it to a data set. In Version 6, the VAR statement lists all variables you may want to include in a later model or use in plots. In the VAR statement, you need to list variables that are not listed in MODEL statements before the first RUN statement.

The following statements give an example of using the ADD, DELETE, and VAR statements in Version 6:

```
proc reg;
var _numeric_;  
model y=x1 x2 x3 x4;  
rns;  
add x5 x6 x7;  
print anova;  
rns;  
delete x7;  
print;  
rns;
```

The statements above show use of the keyword _NUMERIC_ in the VAR statement. This is equivalent to listing all numeric variables in the VAR statement.

REWEIGHTING OBSERVATIONS

In some cases, you want to exclude certain observations from analysis or weight certain observations differently from others. With Version 5 software, you do this using the WEIGHT statement.

In Release 6.02, the DELOBS statement excludes observations from analysis. Just list the observation numbers to be excluded. Also, you can use the WEIGHT statement as in Version 5.
The REWEIGHT statement in Release 6.03 replaces the DELOBS statement and provides many enhancements. First, you can exclude observations from the analysis based on a condition you specify. Second, you can interactively reweight observations based on a condition. Third, you can get status listings that tell you the current weights for all observations used in the analysis. Fourth, you can undo either the last reweighting or all reweightings (thus restoring original weights to all observations).

Reweighting with Conditions

The following REWEIGHT statements give examples of valid conditions used to select observations. Note that you can have a simple condition or a compound condition (one that contains a logical operator like OR or AND).

- `reweight obs=12;`
- `reweight x1 lt 30;`
- `reweight x1 lt 30 / weight=0.5 noslist;`
- `reweight x1 50 or x2 gt 100;`

The first statement uses the keyword OBS. to specify an observation number and excludes observation 12 from analysis.

The second and third REWEIGHT statements select the same observations since the condition used in the two statements is the same. However, the second statement uses the default weight of 0, which excludes the observations from analysis. The third statement uses the specified weight of 0.5 and reweights the observations selected. This statement also uses the NOSLIST option, which suppresses the list of observations that meet the condition. This list is usually printed on the log.

The fourth statement contains the logical operator AND. Observations are not selected unless they meet both conditions. This statement also uses a statistic (the residual), calculated by PROC REG. To use statistics, you simply list their SAS name (as given in the OUTPUT statement) followed by a period. The final REWEIGHT statement uses the logical operator OR to exclude observations with X1 less than 10 or greater than 100.

Reweight Status

PROC REG remembers previous REWEIGHT statements. This allows you to use the STATUS keyword to list all reweighted observations. Simply type

```sas`
reweight status;
```
to get the list.

Restoring Original Weights (Undoing Reweights)

You can undo the most recent REWEIGHT statement with the UNDO keyword. For example, in these statements

```sas`
reweight x1square gt 1000 / weight=6;
reweight undo;
```
The UNDO term in the second REWEIGHT statement undoes the effect of the first REWEIGHT statement. To restore original weights to all observations, use the ALLOBS term in combination with the RESET option as follows:

```sas`
reweight allobs / reset;
```
The RESET option can also be used without ALLOBS; in this case, the observations selected in the most recent REWEIGHT statement are restored to their original weights. For example,

```sas`
reweight student. gt 2 or student. lt -2 / weight=6.5;
reweight student. gt 3 or student. lt -3 / weight=0.5;
reweight / reset;
```
Observations selected by the second REWEIGHT statement now have weights restored to their original values (either to 1 or to the value of the WEIGHT variable). Observations that meet the first condition (studentized residuals greater than 2 or less than -2) but do not meet the second condition have weights of 0.75.

Reweight and Refit Statement

The ability of PROC REG to remember previous REWEIGHT statements provides a powerful tool, as seen above. This tool also allows you to specify several REWEIGHT statements before refitting the model with the reweighted observations. The REWEIGHT statement does not refit the model. This is different from other interactive statements in PROC REG, which implicitly refit the model. With the REWEIGHT statement, you explicitly refit the model using the REFIT statement. The statements below illustrate using REWEIGHT and REFIT statements.

```sas`
reweight obs=13 and obs=37;
reweight x1 gt 1000;
refit;
```

Plotting in PROC REG

In regression analysis, you often fit a model and then want to produce a plot that shows the data, fitted line, and confidence limits for the mean. This was possible with Version 5 software using a combination of the REG and PLOT procedures. In Release 6.03, the REG procedure contains a PLOT statement that allows you to produce plots of data and of statistics calculated by the procedure. For example, the statements on the left below can be run in both Version 5 and Version 6; statements on the right can be run in Release 6.03.

```sas`
proc reg;
model y=x1 x1square;
output out=new p=yhat
u95m=upper 195m=lower;
run;
proc plot;
plot y=x1 p=x1
overlay;
run;
```

By default, the PLOT statement produces one plot for each plot request and uses the default symbols 1, 2, ... 9, * (for values larger than 10). and? (for differing values that overlap or are negative). The sections below discuss options that modify these defaults.

Requesting Plots

If you have used PROC PLOT or PROC G PLOT before, plot requests should look familiar. Simply list the y-variable, an asterisk, and the x-variable. Optionally, you can specify a list of y- or x-variables, and enclose the list in parentheses. Also, you can specify a plotting symbol, or another variable whose values are to be used as plotting symbols. Several examples of plot requests are shown below.

```sas`
plot y=x*;
plot y=x1 x2 x3;
plot y1 y2 y3 x1 x2 x3=group;
```
The first plot request uses an asterisk instead of the default symbol. The second plot request produces three plots, one for X1, one for X2, and one for X3. The third plot request produces six plots and uses the values of the variable GROUP to identify points on the plots. (Only the left-most character of the value of the variable appears on the plot.)
Changing the Default Symbol
To modify the default symbols, use the SYMBOL = option as follows:

```
plot y*x / symbol='A';
```

The SYMBOL = option changes the default symbols, but it is overruled by an explicit symbol in a plot request. In the following statements,

```
plot y*p.*x / symbol='a';
```

the plot of raw data (Y*X) uses an asterisk, but the plot of the fitted line (P.*X) uses the letter P.

Producing Several Plots on a Page
By default, the PLOT statement prints each plot you request on a separate page. You can use the HPLOTS= and VPLOTS= options to modify these defaults. To print two rows of three plots use HPLOTS=3 and VPLOTS=2.

PROC REG remembers the settings for these two options. Once you have modified the default values of 1, all future plots use the modified values. Of course, you can always reset these options to their defaults, for example:

```
plot y*x / hplots=1 vplots=1;
```

Overlaying Plots
Again, the OVERLAY option will be familiar to you if you have used PROC PLOT. Simply follow your plot request with a slash and the option as follows:

```
plot y*x / overlay;
```

The OVERLAY option scales both axes to include data for all variables in plot requests. This is different from the COLLECT option, described below.

Collecting Plots
The CLEAR, COLLECT, and NOCOLLECT options allow you to collect plots across PLOT statements, clear collected plots, and end the process of collecting plots. These options can be especially useful if you want to show plots produced by fitting different models to the data.

To start a collection of plots with the current plot, use the COLLECT option in the PLOT statement:

```
plot y*x / collect;
```

PROC REG scales the axes to include all data associated with this first PLOT statement. With the COLLECT option, the axes are not rescaled as future plots are added to the collection. Be careful how you collect plots; start a collection with a plot that is associated with the full model and then add plots associated with a reduced model, for example.

To clear the collection of plots and start a new collection, use the CLEAR option. To end the collection of plots, use the NOCOLLECT option.

HIGHLIGHTING PLOTS
You may want to highlight or “paint” points in a plot. The PAINT statement paints points that meet a condition you specify and gives you a list of observations that are painted.

To paint points, you first specify a condition. Several examples of conditions are shown below.

```
paint obs=-12;
paint temp='hi';
paint x=gt 2 or student. It -2;
paint x1 gt 12 x 2 gt 35;
```

The second and third PAINT statements in the list above have different effects. The statement is case-sensitive; if you give a lower-case value in the condition, only points with lower-case values are painted. The second and third statements could be combined into one statement with an OR operator as follows:

```
paint temp='hi' or temp='H1';
```

The statements below give examples of using the PAINT statement.

```
plot y*x;
run;
paint x gt 10;
plot;
run;
```

These statements illustrate a basic rule: PAINT statements do not produce plots. To see the results of a PAINT statement, follow it with a PLOT statement. Note also that the PLOT statement remembers previous plots; the second PLOT statement above produces a plot of Y by X.

Additional Features
Additional terms allow you to list the status of painted points, undo the effects of a previous PAINT statement, and paint all observations. Options allow you to specify a default symbol, reset the current paint symbol back to the default, and suppress the list of observations painted. These terms and options are the same as those for the REWEIGHT statement.

PRINTING MODEL INFORMATION
When you change the model by adding or deleting variables, or when you change the observations used to fit the model, you will want to see the effects of your actions. The ADD, DELETE, and REWEIGHT statements do not produce printed output.

In another situation, you fit a model and then decide you want to look at an analysis of residuals. You can submit another MODEL statement and use the R option, but you can also use the PRINT statement in Version 6.

The PRINT statement prints information from the most recent model. To see the test for a significant model and parameter estimates, type

```
print nobs;
run;
```

To see information on residuals for the current model, type

```
print r;
run;
```

The PRINT statement remembers previous requests. This provides a powerful tool when changing the model or observations used to fit it. In the following statements, the second PRINT statement gives model parameters for the model with X1, X2, X3, X4, and X5 as independent variables.
The PRINT statement accepts most MODEL statement options that produce output and are available with all model-selection methods. In addition, the ANOVA option prints parameter estimates and general model information. In Release 6.03, the MODELDATA option prints the data for variables used in the current model.

ADDITIONAL FEATURES

This section briefly summarizes several additional features in Version 6.

The RESTRICT statement was not available in Release 6.02 but is available in Release 6.03.

The following MODEL statement options were not available in Release 6.02 but are available in Release 6.03: ACOV, PCORR1, PCORR2, SCORR1, SCORR2, SEQB, and SPEC. In Release 6.03, the ALL option includes the options in this list.

In Release 6.03, the SELECTION= option replaces the METHOD= option in the MODEL statement.

In Release 6.03, the new GROUPNAMES= option provides names for variable groups. The BACKWARD, FORWARD, and STEPWISE methods allow you to specify groups of variables that enter or exit the model together, and the GROUPNAMES= option gives names to the groups. For example:

```sas
model y=x1 x2 x3; run;
add x4; print above; run;
add x5; print; run;
```

The PRINT statement accepts most MODEL statement options that produce output and are available with all model-selection methods. In addition, the ANOVA option prints parameter estimates and general model information. In Release 6.03, the MODELDATA option prints the data for variables used in the current model.

**EXAMPLE**

The following program and output illustrate many of the new features in PROC REG.

```sas
options ps=39 nodate;
title 'Kilowatts, Air Conditioners, Dryers and Regression'; /* needed to interactively use variables that don't appear in MODEL statements before the first RUN statement */
model kwh=ac;
run;
```

**Kilowatts, Air Conditioners, Dryers and Regression**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean</th>
<th>F Value</th>
<th>Prob &gt; F</th>
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<td>203.88194</td>
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<tr>
<td>C Total</td>
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<td>8678.1793</td>
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<td></td>
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</table>

**Parameter Estimates**

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<thead>
<tr>
<th>Variable</th>
<th>DF</th>
<th>Parameter Estimates</th>
</tr>
</thead>
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<tr>
<td>Intercept</td>
<td>1</td>
<td>27.551712</td>
</tr>
<tr>
<td>AC</td>
<td>1</td>
<td>2.941968 (0.0416)</td>
</tr>
</tbody>
</table>

```sas
plot kwh=ac p=ac=' / overlay;
plot r.('ac dryer) hplots=2; run;
```

Statistics need a period after their SAS name. */

The following program and output illustrate many of the new features in PROC REG.

```sas
options ps=39 nodate;
title 'Kilowatts, Air Conditioners, Dryers and Regression'; /* needed to interactively use variables that don't appear in MODEL statements before the first RUN statement */
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run;
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plot kwh=ac p=ac=' / overlay;
plot r.('ac dryer) hplots=2; run;
```

Statistics need a period after their SAS name. */

The following program and output illustrate many of the new features in PROC REG.

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options ps=39 nodate;
title 'Kilowatts, Air Conditioners, Dryers and Regression'; /* needed to interactively use variables that don't appear in MODEL statements before the first RUN statement */
model kwh=ac;
run;
```
Kilowatts, Air Conditioners, Dryers and Regression

Model: RECEP
Dependent Variable: KWH

Analysis of Variance

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<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
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<td>Error</td>
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<td>15.98722</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9578.5714</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Root MSE: 3.91538
R-square: 0.9709
Dep Hun: 64.85714
Adj R-sq: 0.9677
C.V.: 6.06777

Parameter Estimates

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Standard Error</th>
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<td>15.046</td>
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plot;
/* repeats last-requested plot(s) for most recent model */
run;

Kilowatts, Air Conditioners, Dryers and Regression 6

RESIDUAL

| 5 | 1 | 1 |
| 3 | 1 | 1 |
| -5 | 1 | 1 |

Predicted Value of KWH vs. PRED

plot x.*p. / plots=1;
/* resets to one plot per page */
run;

Kilowatts, Air Conditioners, Dryers and Regression 5

plot x.*p. / plots=1;
/* resets to one plot per page */
run;

Kilowatts, Air Conditioners, Dryers and Regression 4

Model: RECEP
Dependent Variable: KWH

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/* plots last-requested plot(s) for most recent model */
run;

Kilowatts, Air Conditioners, Dryers and Regression

Model: RECEP
Dependent Variable: KWH

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plot;
/* plots last-requested plot(s) for most recent model */
run;
Kilowatts, Air Conditioners, Dryers and Regression

---

RESIDUALS

---

--t-----t-----t-----t-----t-----t- ____ t _____ + _____ + _

H

---

-10.0 t +

---

10 ~ ~ ~ ~ ~ ~ H

---

Predicted Value of KWH

---

Kilowatts, Air Conditioners, Dryers and Regression

---

MODEL: WREXS

---

dependent Variable: KWH

---

Analysis of Variance

---

Table:

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<th>MS</th>
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<tr>
<td>Total</td>
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<td>8512.95000</td>
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</tbody>
</table>

Root MSE 3.47553, R-sq 1 - 0.9740, Adj R-sq 0.9730, C.V. 5.23030

---

Parameter Estimates

---

| Variable | Parameter Estimate | Standard Error | T for H0: Parameter = 0 | Prob > |T| |
|----------|-------------------|----------------|-------------------------|--------|---|
| INTERCEP | 9.86566           | 0.24877239     |                         | 4.267  | 0.0001 |
| AC       | 5.45062           | 0.13077125     |                         | 40.42  | 0.0001 |
| DRYER    | 12.58532          | 0.32887169     |                         | 7.58   | 0.0001 |

---

reweight student.^2 or student. - 2;

---

/* excludes observations with large studentized residuals from analysis--does not refit the model */

---

print above;

---

/* refits model and prints new information. PRN statement implicitly refits model */

---

run;

---

REFERENCES


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