SAS Lab 13 For Statistics 514

Topics:
Chapter 31. Exploratory Experiments–Two-Level Factorial and Fractional Factorial Designs

```
*Attendance 13, 31.2 2^3 full factorial, mice;
*interaction error variance;
DATA OXYGENCONSUMPTION;
  INPUT ROC X1 X2 X3;
        X12 = X1 * X2;
        X13 = X1 * X3;
        X23 = X2 * X3;
        X123 = X1 * X2 * X3;
DATALINES;
9.8  -1 -1 -1
10.2   1 -1 -1
10.4 -1  1 -1
8.5    1  1 -1
11.1 -1 -1  1
10.7   1 -1  1
10.7 -1  1  1
9.9    1  1  1
;
PROC REG DATA=OXYGENCONSUMPTION;
        TITLE '31.2, 2^3 full factorial, mice roc, no error variance';
        MODEL ROC = X1 X2 X3 X12 X13 X23 X123;
        OUTPUT OUT=OXYGENCONSUMPTION2 PREDICTED=OXYGENCONSUMPTIONPRED RESIDUAL=RESID;
RUN;
PROC REG DATA=OXYGENCONSUMPTION;
        TITLE '31.2, 2^3 full factorial, using X123 as error';
        MODEL ROC = X1 X2 X3 X12 X13 X23;
        OUTPUT OUT=OXYGENCONSUMPTION2 PREDICTED=OXYGENCONSUMPTIONPRED RESIDUAL=RESID;
RUN;
PROC REG DATA=OXYGENCONSUMPTION;
        TITLE '31.2, 2^3 full factorial, using X12,X13, X23, X123 as error';
        MODEL ROC = X1 X2 X3;
        OUTPUT OUT=OXYGENCONSUMPTION2 PREDICTED=OXYGENCONSUMPTIONPRED RESIDUAL=RESID;
RUN;
*center point replications error variance;
DATA OXYGENCONSUMPTION;
  INPUT ROC X1 X2 X3;
        X12 = X1 * X2;
        X13 = X1 * X3;
        X23 = X2 * X3;
        X123 = X1 * X2 * X3;
DATALINES;
9.8  -1 -1 -1
10.2   1 -1 -1
10.4 -1  1 -1
8.5    1  1 -1
11.1 -1 -1  1
10.7   1 -1  1
10.7 -1  1  1
9.9    1  1  1
10.3  0  0  0
9.7   0  0  0
10.0  0  0  0
;
PROC REG DATA=OXYGENCONSUMPTION outest=est;
        TITLE '31.2, 2^3 full factorial, center point replications';
        MODEL ROC = X1 X2 X3 X12 X13 X23 X123;
        output out=oxygenconsumptionout predicted=pred residual=resid;
RUN;
PROC GPLOT DATA=oxygenconsumptionout;
        TITLE '31.2 residuals vs fitted, center point replications ';
        PLOT RESID*PRED;
RUN;
proc capability data=oxygenconsumptionout noprint graphics;
        title '31.2 normal probability plot for residuals';
        probplot resid;
run;
* correlation test for normality;
PROC SORT DATA=oxygenconsumptionout;
        BY RESID;
RUN;
DATA oxygenconsumptionout;
        SET oxygenconsumptionout NOBS=NOBS;
        QUANTILE = PROBIT( (_N_- (3/8)) / (NOBS + (1/4)) );
RUN;
DATA oxygenconsumptionout2;
        IF _N_ = 1 THEN SET EST;
        SET oxygenconsumptionout;
        EXPRESIDUAL = _RMSE_*QUANTILE;
RUN;
PROC CORR DATA=oxygenconsumptionout2;
        TITLE '31.2 correlation of normal prob plot of residualc';
        VAR RESID EXPRESIDUAL;
RUN;
proc sort data=oxygenconsumption;
        by x1;
run;
proc means data=oxygenconsumption noprint;
        title 'treatment means plot';
        var roc;
        by x1;
        output out=rocmn mean=rmn;
run;
proc gplot data=rocmn;
        title '31.2 roc versus temperature (x1)';
        plot rmn*x1;
run;
proc sort data=oxygenconsumption;
        by x3;
run;
proc means data=oxygenconsumption noprint;
        title 'treatment means plot';
        var roc;
        by x3;
        output out=rocmn mean=rmn;
run;
proc gplot data=rocmn;
        title '31.2 roc versus humidity (x3)';
        plot rmn*x3;
run;
proc sort data=oxygenconsumption;
        by x1 x3;
run;
proc means data=oxygenconsumption noprint;
        title 'treatment means plot';
        var roc;
        by x1 x3;
        output out=rocmn mean=rmn;
run;
proc gplot data=rocmn;
        title '31.2 roc versus (x1), sorted by (x3)';
        plot rmn*x1=x3;
run;
*using 1, 3, 12 and 123 only;
DATA OXYGENCONSUMPTION;
  INPUT ROC X1 X2 X3;
        X12 = X1 * X2;
        X13 = X1 * X3;
        X23 = X2 * X3;
        X123 = X1 * X2 * X3;
DATALINES;
9.8  -1 -1 -1
10.2   1 -1 -1
10.4 -1  1 -1
8.5    1  1 -1
11.1 -1 -1  1
10.7   1 -1  1
10.7 -1  1  1
9.9    1  1  1
;
PROC REG DATA=OXYGENCONSUMPTION outest=est;
        TITLE '31.2, 2^3 full factorial, using 1 and 3 only';
        MODEL ROC = X1 X3;
        output out=oxygenconsumptionout predicted=pred residual=resid;
RUN;
PROC GPLOT DATA=oxygenconsumptionout;
        TITLE '31.2 residuals vs fitted, using 1 and 3 only';
        PLOT RESID*PRED;
RUN;
proc capability data=oxygenconsumptionout noprint graphics;
        title '31.2 normal probability plot for residuals, using 1 and 3 only';
        probplot resid;
run;
* correlation test for normality;
PROC SORT DATA=oxygenconsumptionout;
        BY RESID;
RUN;
DATA oxygenconsumptionout;
        SET oxygenconsumptionout NOBS=NOBS;
        QUANTILE = PROBIT( (_N_- (3/8)) / (NOBS + (1/4)) );
RUN;
DATA oxygenconsumptionout2;
        IF _N_ = 1 THEN SET EST;
        SET oxygenconsumptionout;
        EXPRESIDUAL = _RMSE_*QUANTILE;
RUN;
PROC CORR DATA=oxygenconsumptionout2;
        TITLE '31.2 correlation of normal prob plot of residuals, using 1 and 3 only';
        VAR RESID EXPRESIDUAL;
RUN;
PROC RSREG DATA=oxygenconsumption;
        TITLE '31.2 lack of fit test, using 1 and 3 only';
        MODEL ROC = X1 X3 / covar=2 LACKFIT;
RUN;
proc sort data=oxygenconsumption;
        by x1;
run;
proc means data=oxygenconsumption noprint;
        title 'treatment means plot, using 1 and 3 only';
        var roc;
        by x1;
        output out=rocmn mean=rmn;
run;
proc gplot data=rocmn;
        title '31.2 roc versus temperature (x1), using 1 and 3 only';
        plot rmn*x1;
run;
proc sort data=oxygenconsumption;
        by x3;
run;
proc means data=oxygenconsumption noprint;
        title 'treatment means plot, using 1 and 3 only';
        var roc;
        by x3;
        output out=rocmn mean=rmn;
run;
proc gplot data=rocmn;
        title '31.2 roc versus humidity (x3), using 1 and 3 only';
        plot rmn*x3;
run;
QUIT;
```

```
*Attendance 13, 31.3, 2^{5-1} fractional factorial;
proc factex;
        title '2^{5-1} fractional factorial design';
        factors x1 x2 x3 x4 x5;
        size design=16;
        model resolution=max;
        examine design;
        examine aliasing;
run;
proc factex;
        title '2^{5-2} fractional factorial design';
        factors x1 x2 x3 x4 x5;
        size design=8;
        model resolution=max;
        examine design;
        examine aliasing;
run;
proc factex;
        title '2^{6-3} fractional factorial design';
        factors x1 x2 x3 x4 x5 x6;
        size design=16;
        model resolution=max;
        examine design;
        examine aliasing;
run;
proc factex;
        title '2^{9-3} fractional factorial design';
        factors x1 x2 x3 x4 x5 x6 x7 x8 x9;
        size design=64;
        model resolution=max;
        examine design;
        examine aliasing;
run;
quit;
```

```
*Homework 7, 31.9, 2^4 full factorial;
*Computer monitors, residuals;
DATA COMPUTERMONITORS;
  INPUT FAILRATES X1 X2 X3
                X4 X12 X13 X14
                X23 X24 X34 X123
                X124 X134 X234 X1234;
DATALINES;
3.88  -1  -1  -1  -1   1   1   1   1   1   1  -1  -1  -1  -1   1
3.17   1  -1  -1  -1  -1  -1  -1  -1   1   1   1   1   1  -1  -1
4.07  -1   1  -1  -1  -1   1   1  -1  -1   1   1   1  -1   1  -1
3.22   1   1  -1  -1   1  -1  -1  -1  -1   1  -1  -1   1   1   1
4       -1  -1   1  -1   1  -1   1  -1   1  -1   1  -1   1   1  -1
3.65   1  -1   1  -1  -1   1  -1  -1   1  -1  -1   1  -1   1   1
3.93  -1   1   1  -1  -1  -1   1   1  -1  -1  -1   1   1  -1   1
3.33   1   1   1  -1   1   1  -1   1  -1  -1   1  -1  -1  -1  -1
4.45  -1  -1  -1   1   1   1  -1   1  -1  -1  -1   1   1   1  -1
3.7      1  -1  -1   1  -1  -1   1   1  -1  -1   1  -1  -1   1   1
4.55  -1   1  -1   1  -1   1  -1  -1   1  -1   1  -1   1  -1   1
4.05   1   1  -1 1   1  -1   1  -1   1  -1  -1   1  -1  -1  -1
3.92  -1  -1   1   1   1  -1  -1  -1  -1   1   1   1  -1  -1   1
3.2      1  -1   1   1  -1   1   1  -1  -1   1  -1  -1   1  -1  -1
3.61  -1   1     1   1  -1  -1  -1   1   1   1  -1  -1  -1   1  -1
3.11   1   1     1   1   1   1   1   1   1   1   1   1   1   1   1
3.8      0    0      0  0  0  0  0  0  0  0  0  0  0  0  0  0
3.99   0      0      0  0  0  0  0  0  0  0  0  0  0  0  0  0
4.16   0      0      0  0  0  0  0  0  0  0  0  0  0  0  0  0
;
PROC REG DATA=COMPUTERMONITORS;
        TITLE '31.9, 2^4 full factorial, monitors, residuals';
        MODEL FAILRATES = X1 X2 X3
                X4 X12 X13 X14
                X23 X24 X34 X123
                X124 X134 X234 X1234;
RUN;
QUIT;
```

```
*Homework 7, 31.10, 2^4 full factorial;
*Computer monitors, REDUCED model;
DATA COMPUTERMONITORS;
  INPUT FAILRATES X1 X2 X3
                X4 X12 X13 X14
                X23 X24 X34 X123
                X124 X134 X234 X1234;
DATALINES;
3.88  -1 -1 -1 -1  1  1  1  1  1 -1 -1 -1 -1  1
3.17   1 -1 -1 -1 -1 -1 -1  1  1  1  1  1 -1 -1
4.07  -1  1 -1 -1 -1  1  1 -1 -1  1  1  1 -1  1 -1
3.22   1  1 -1 -1  1 -1 -1 -1 -1  1 -1 -1  1  1  1
4       -1 -1  1 -1  1 -1  1 -1  1 -1  1 -1  1  1 -1
3.65   1 -1  1 -1 -1  1 -1  1 -1  1 -1 -1  1 -1  1  1
3.93  -1  1  1 -1 -1 -1  1  1 -1 -1 -1  1  1 -1  1
3.33   1  1  1 -1  1  1 -1  1 -1 -1  1 -1 -1 -1 -1
4.45  -1 -1 -1  1  1  1 -1  1 -1 -1 -1  1  1  1 -1
3.7      1 -1 -1  1 -1 -1  1  1 -1 -1  1 -1 -1  1  1
4.55  -1  1 -1 1 -1  1 -1 -1  1 -1  1 -1  1 -1  1
4.05   1  1 -11  1 -1  1 -1  1 -1 -1  1 -1 -1 -1
3.92  -1 -1  1  1  1 -1 -1 -1 -1  1  1  1 -1 -1  1
3.2      1 -1  1  1 -1  1  1 -1 -1  1 -1 -1  1 -1 -1
3.61  -1  1     1  1 -1 -1 -1  1  1  1 -1 -1 -1  1 -1
3.11  1  1      1  1  1  1  1  1  1  1  1  1  1  1  1
3.8       0     0       0  0  0  0  0  0  0  0  0  0  0  0  0
3.99   0        0       0  0  0  0  0  0  0  0  0  0  0  0  0
4.16   0        0       0  0  0  0  0  0  0  0  0  0  0  0  0
;
PROC REG DATA=COMPUTERMONITORS outest=est;
        TITLE '31.10(a) 2^4 full factorial, reduced model';
        MODEL FAILRATES = X1 X3 X4 X34;
        OUTPUT OUT=COMPUTERMONITORsout PREDICTED=PRED RESIDUAL=RESID;
RUN;
PROC PRINT DATA=COMPUTERMONITORsout;
        TITLE '31.10(a) residuals, 2^4 full factorial';
        VAR FAILRATES PRED RESID;
RUN;
PROC GPLOT DATA=COMPUTERMONITORsout;
        TITLE '31.10(a) residuals vs fitted, 2^4 full factorial';
        PLOT RESID*PRED;
RUN;
proc capability data=computermonitorsout noprint graphics;
        title '31.10(b) normal probability plot for residuals';
        probplot resid;
run;
* correlation test for normality;
PROC SORT DATA=computermonitorsout;
        BY RESID;
RUN;
DATA computermonitorsout;
        SET computermonitorsout NOBS=NOBS;
        QUANTILE = PROBIT( (_N_- (3/8)) / (NOBS + (1/4)) );
RUN;
DATA computermonitorsout2;
        IF _N_ = 1 THEN SET EST;
        SET computermonitorsout;
        EXPRESIDUAL = _RMSE_*QUANTILE;
RUN;
PROC CORR DATA=computermonitorsout2;
        TITLE '31.10(b) correlation of normal prob plot of residuals';
        VAR RESID EXPRESIDUAL;
RUN;
PROC RSREG DATA=COMPUTERMONITORS;
        TITLE '31.10(d) lack of fit test';
        MODEL FAILRATES = X1 X3 X4 X34 / covar=4 LACKFIT;
RUN;
proc sort data=computermonitors;
        by x1;
run;
proc means data=computermonitors noprint;
        title 'treatment means plot';
        var failrates;
        by x1;
        output out=computermn mean=mn;
run;
proc gplot data=computermn;
        title '31.10(e) failrate versus base clearance (x1)';
        plot mn*x1;
run;
proc sort data=computermonitors;
        by x3;
run;
proc means data=computermonitors noprint;
        title 'treatment means plot';
        var failrates;
        by x3;
        output out=computermn mean=mn;
run;
proc gplot data=computermn;
        title '31.10(e) failrate versus side vent size (x3)';
        plot mn*x3;
run;
proc sort data=computermonitors;
        by x4;
run;
proc means data=computermonitors noprint;
        title 'treatment means plot';
        var failrates;
        by x4;
        output out=computermn mean=mn;
run;
proc gplot data=computermn;
        title '31.10(e) failrate versus interface board angle (x4)';
        plot mn*x4;
run;
proc sort data=computermonitors;
        by x3 x4;
run;
proc means data=computermonitors noprint;
        title 'treatment means plot';
        var failrates;
        by x3 x4;
        output out=computermn mean=mn;
run;
proc gplot data=computermn;
        title '31.10(e) failrate versus (x3), sorted by (x4)';
        plot mn*x3=x4;
run;
QUIT;
```

```
*Homework 7, 31.20, fractional factorial;
*Fiber optics, residuals;
DATA FIBEROPTICS;
  INPUT VISCOSITY X1 X2 X3
              X4 X5 X6 X7
              X8 X9;
DATALINES;
101.2  1    1    1    1    -1   1    -1   -1   1
92.9   -1   -1   -1   -1   -1   -1   -1   -1   1
129.9  1    1    1    1    1    -1   -1   -1   -1
54.1   -1   -1   1    1    1    -1   1    -1   1
26.2   -1   -1   1    1    -1   1    1    -1   -1
68.6   -1   1    -1   1    -1   -1   -1   1    -1
84.1   1    1    -1   -1   1    1    1    -1   1
99.6   1    -1   -1   1    1    1    1    1    -1
31.4   -1   1    1    -1   -1   1    1    1    1
73.4   1    -1   1    -1   -1   1    -1   1    -1
27.6   1    -1   -1   1    -1   -1   1    1    1
33.6   -1   1    1    -1   1    -1   1    1    -1
72.5   -1   1    -1   1    1    1    -1   1    1
73.4   -1   -1   -1   -1   1    1    -1   -1   -1
31.6   1    1    -1   -1   -1   -1   1    -1   -1
121.6  1    -1   1    -1   1    -1   -1   1    1
;
PROC REG DATA=FIBEROPTICS;
        TITLE '31.20 2^4 full factorial, fiber';
        MODEL VISCOSITY = X1 X2 X3
              X4 X5 X6 X7
              X8 X9;
RUN;
QUIT;
```

```
*Homework 7, 31.21, fractional factorial;
*Fiber optics, reduced model;
DATA FIBEROPTICS;
  INPUT VISCOSITY X1 X2 X3
                X4 X5 X6 X7
                X8 X9;
        X15 = X1*X5;
        X17 = X1*X7;
        X57 = X5*X7;
        X157 = X1*X5*X7;
DATALINES;
101.2  1    1    1    -1   1    -1   -1   1
92.9   -1   -1   -1   -1   -1   -1   -1   1
129.9  1    1    1    1    1    -1   -1   -1   -1
54.1   -1   -1   1    1    1    -1   1    -1   1
26.2   -1   -1   1    1    -1   1    1    -1   -1
68.6   -1   1    -1   1    -1   -1   -1   1    -1
84.1   1    1    -1   -1   1    1    1    -1   1
99.6   1    -1   -1   1    1    1    1    1    -1
31.4   -1   1    1    -1   -1   1    1    1    1
73.4   1    -1   1    -1   -1   1    -1   1    -1
27.6   1    -1   -1   1    -1   -1   1    1    1
33.6   -1   1    1    -1   1    -1   1    1    -1
72.5   -1   1    -1   1    1    1    -1   1    1
73.4   -1   -1   -1   -1   1    1    -1   -1   -1
31.6   1    1    -1   -1   -1   -1   1    -1   -1
121.6  1    -1   1    -1   1    -1   -1   1    1
;
PROC REG DATA=FIBEROPTICS;
        TITLE '31.21 replicated 2^3 full factorial, reduced model';
        MODEL VISCOSITY = X1 X5 X7;
        OUTPUT OUT=FIBEROPTICout PREDICTED=PRED RESIDUAL=RESID;
RUN;
PROC PRINT DATA=fiberopticout;
        TITLE '30.21(a) residuals, replicated full factorial, reduced model';
        VAR x1 x5 x7 viscosity pred resid;
RUN;
PROC GPLOT DATA=fiberopticout;
        TITLE '30.21(a) residuals vs fitted';
        PLOT resid*pred;
RUN;
proc capability data=fiberopticout noprint graphics;
        title '31.21(b) normal probability plot for residuals';
        probplot resid;
run;
PROC RSREG DATA=fiberoptics;
        TITLE '31.21(c) lack of fit test';
        MODEL VISCOSITY = X1 X5 X7 / covar=3 LACKFIT;
RUN;
QUIT;
```

```
*Homework 7, 31.22, fractional factorial;
*Fiber optics, another reduced model;
DATA FIBEROPTICS;
  INPUT VISCOSITY X1 X2 X3
                X4 X5 X6 X7
                X8 X9;
        X15 = X1*X5;
        X17 = X1*X7;
        X57 = X5*X7;
        X157 = X1*X5*X7;
DATALINES;
101.2  1     1     1     1     -1    1     -1    -1    1
92.9   -1    -1    -1    -1    -1    -1    -1    -1    1
129.9  1     1     1     1     1     -1    -1    -1    -1
54.1   -1    -1    1     1     1     -1    1     -1    1
26.2   -1    -1    1     1     -1    1     1     -1    -1
68.6   -1    1     -1    1     -1    -1    -1    1     -1
84.1   1     1     -1    -1    1     1     1     -1    1
99.6   1     -1    -1    1     1     1     1     1     -1
31.4   -1    1     1     -1    -1    1     1     1     1
73.4   1     -1    1     -1    -1    1     -1    1     -1
27.6   1     -1    -1    1     -1    -1    1     1     1
33.6   -1    1     1     -1    1     -1    1     1     -1
72.5   -1    1     -1    1     1     1     -1    1     1
73.4   -1    -1    -1    -1    1     1     -1    -1    -1
31.6   1     1     -1    -1    -1    -1    1     -1    -1
121.6  1     -1    1     -1    1     -1    -1    1     1
;
PROC REG DATA=FIBEROPTICS;
        TITLE '31.22(a) replicated 2^3 full factorial, (less) reduced model';
        MODEL VISCOSITY = X1 X5 X7 X15 X17 X57 X157;
        OUTPUT OUT=FIBEROPTICout PREDICTED=PRED RESIDUAL=RESID;
RUN;
proc capability data=fiberopticout noprint graphics;
        title '31.22(b) normal probability plot for residuals';
        probplot resid;
run;
proc sort data=fiberoptics;
        by x1;
run;
proc means data=fiberoptics noprint;
        title '31.22(c) treatment means plot';
        var viscosity;
        by x1;
        output out=fibermn mean=mn;
run;
proc gplot data=fibermn;
        title '31.22(c) viscosity versus silica particle size (x1)';
        plot mn*x1;
run;
proc sort data=fiberoptics;
        by x5;
run;
proc means data=fiberoptics noprint;
        title '31.22(c) treatment means plot';
        var viscosity;
        by x5;
        output out=fibermn mean=mn;
run;
proc gplot data=fibermn;
        title '31.22(c) viscosity versus stabilizer level (x5)';
        plot mn*x5;
run;
proc sort data=fiberoptics;
        by x1 x5;
run;
proc means data=fiberoptics noprint;
        title '31.22(c) treatment means plot';
        var viscosity;
        by x1 x5;
        output out=fibermn mean=mn;
run;
proc gplot data=fibermn;
        title '31.22(c) viscosity versus (x1), sorted by (x5)';
        plot mn*x1=x5;
run;
proc sort data=fiberoptics;
        by x7;
run;
proc means data=fiberoptics noprint;
        title '31.22(c) treatment means plot';
        var viscosity;
        by x7;
        output out=fibermn mean=mn;
run;
proc gplot data=fibermn;
        title '31.22(c) viscosity versus postmix time (x7)';
        plot mn*x7;
run;
QUIT;
```