

Printout

Saturday, March 25, 2023

11:09 AM

Section 1

MANE 6313

Subsection 1

Week 11, Module F

Student Learning Outcome

- Select an appropriate experimental design with one or more factors,
- Select an appropriate model with one or more factors,
- Evaluate statistical analyses of experimental designs,
- Assess the model adequacy of any experimental design, and
- Interpret model results.

Module Learning Outcome

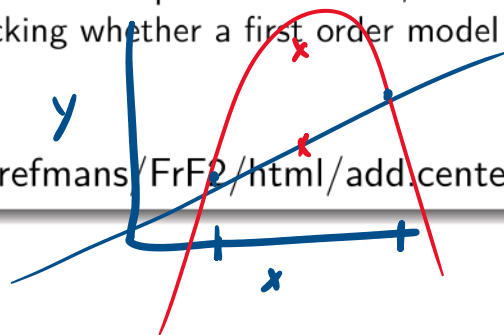
Describe sequential analysis and addition of center points.

Center Points for Fractional Factorial

- Same concept as introduced in Chapter 6.8 - The Addition of Center Points to the 2^k Design
- R documentation provides the following reasons to add center points to fractional factorial designs
 - “Provide a repeated benchmark run that can alert the experiment to unplanned changes in experimental conditions,”
 - “Provide an independent estimate of experimental error,” and
 - “Provide a possibility for checking whether a first order model is sufficient”

Source:

<https://search.r-project.org/CRAN/refmans/FrF2/html/add.center.html>



Example Problem

- Devore, Chang and Sutherland provided an example
 - One-eighth fraction of a seven factor design (16 runs)
 - 7 center points are added

2^{7-3}

Base Design

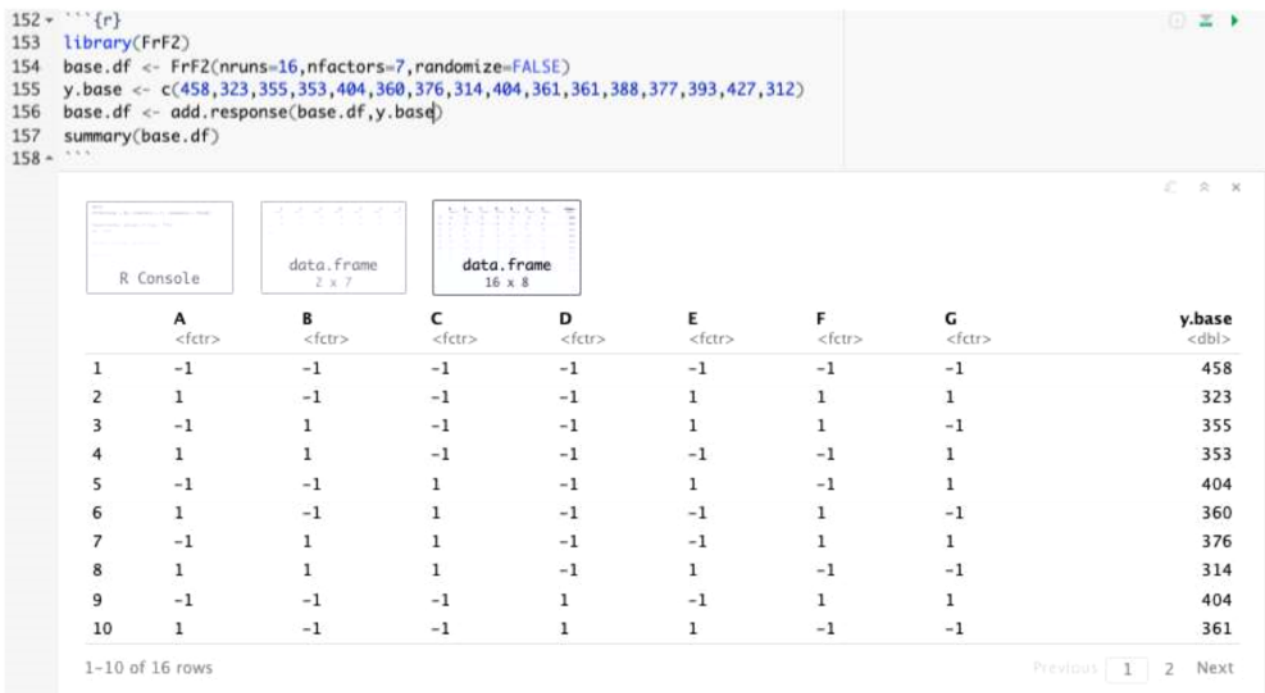


Figure 1: Example Problem - Base Design

Combined Design

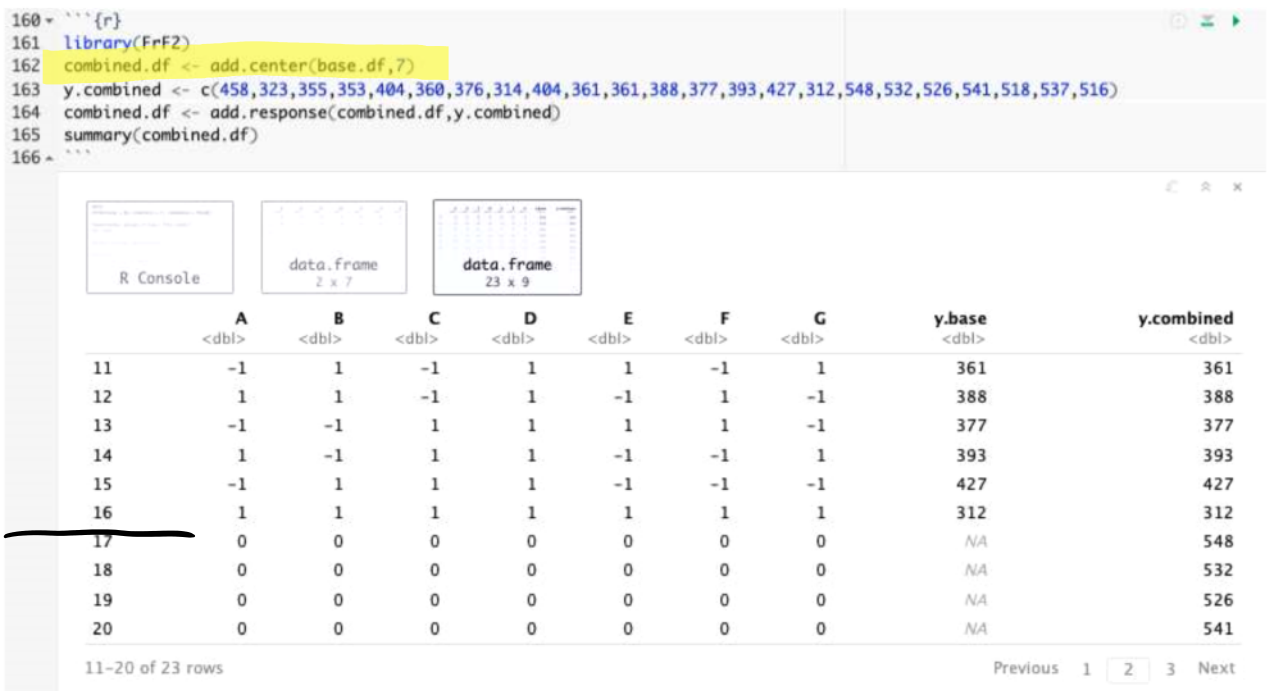


Figure 2: Combined Design

Design Details for Combined Design

```

160 > ``{r}
161 library(FrF2)
162 combined.df <- add.center(base.df,7)
163 y.combined <- c(458,323,355,353,404,360,376,314,404,361,361,388,377,393,427,312,548,532,526,541,518,537,516)
164 combined.df <- add.response(combined.df,y.combined)
165 summary(combined.df)
166 >

```

R Console

data.frame
2 x 7

data.frame
23 x 9

```
FrF2(nruns = 16, nfactors = 7, randomize = FALSE)
```

```
Experimental design of type FrF2.center
23 runs
```

```
Factor settings (scale ends):
```

```
Responses:
```

```
[1] y.base y.combined
```

```
Design generating information:
```

```
$legend
```

```
[1] A=A B=B C=C D=D E=E F=F G=G
```

```
$generators
```

```
[1] E=ABC F=ABD G=ACD
```

```
Alias structure:
```

```
$fi2
```

```
[1] AB=CE=DF AC=BE=DG AD=BF=CG AE=BC=FG AF=BD=EG AG=CD=EF BG=CF=DE
```

Half Normal Plot

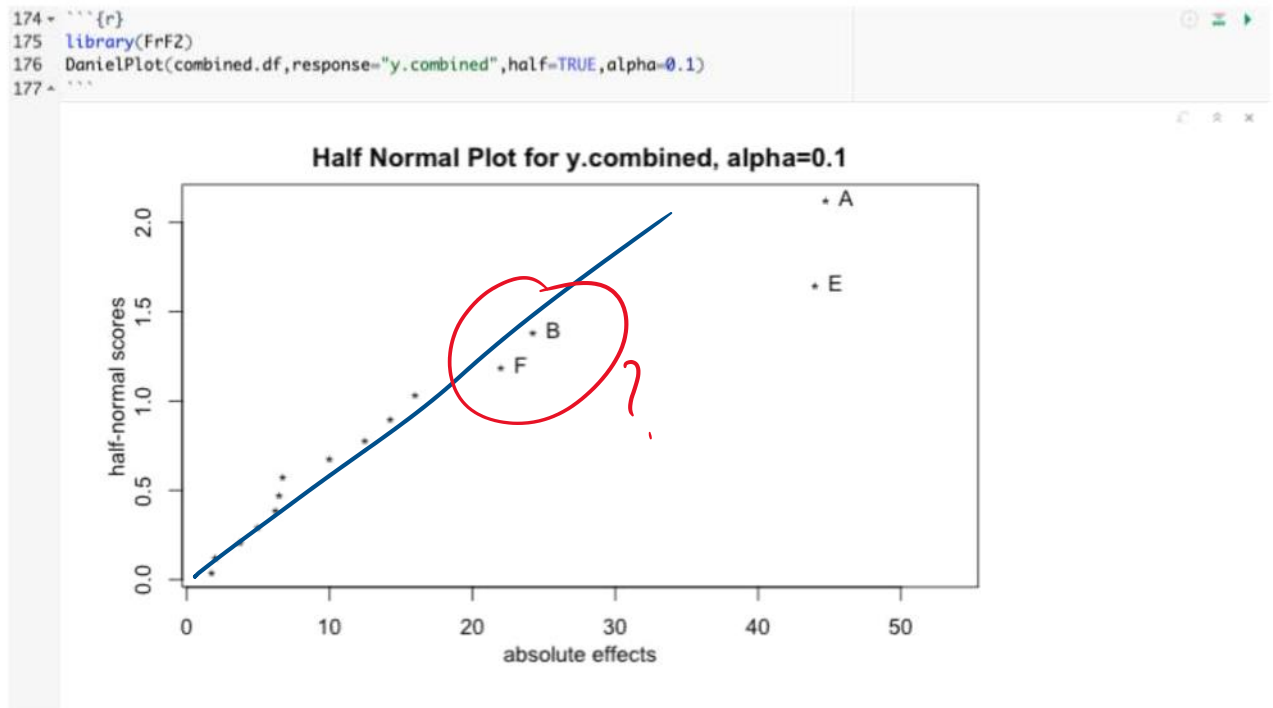


Figure 5: Half-Normal Plot for Combined Data

Initial Model

```
179 > ```{r}  
180 combined.model1 <- aov(y.combined~A+B+E+F,data=combined.df)  
181 summary(combined.model1)  
182 > ```
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
A	1	8010	8010	1.141	0.300
B	1	2352	2352	0.335	0.570
E	1	7744	7744	1.103	0.308
F	1	1936	1936	0.276	0.606
Residuals	18	126374	7021		

Figure 6: Initial Model

all terms are
~~NOT~~ statistically
significant.
No model needed
use average to
predicted

Test for Pure Quadratic Curvature

- See Week Seven - Module G

Programmed everything in R

```

185 ~ ```{r}
186 y.cp <- c(548,532,526,541,518,537,516)
187 n_f=nrow(base.df)
188 ybar_f=mean(y.base)
189 n_c=nrow(combined.df)-nrow(base.df)
190 ybar_c=mean(y.cp)
191 ss_pq=n_c*n_f*(ybar_f-ybar_c)^2/(n_c+n_f)
192 sprintf("Factorial Statistics: n_f=%i, ybar_f=%f",n_f,ybar_f)
193 sprintf("Center point Statistics: n_c=%i, ybar_c=%f",n_c,ybar_c)
194 sprintf("SS_Pure Quadratic=%f",ss_pq)
195 ms_residual=7021
196 F_0=ss_pq/ms_residual
197 sprintf("F0=%f",F_0)
198 df_resid = 18
199 criticalValue = qf(0.05,1,df_resid,lower.tail = FALSE)
200 sprintf("Reject the null hypothesis if F0>%f",criticalValue)
201 sprintf("Since %f > %f, the null hypothesis is rejected and quadratic curvature is present.",F_0,criticalValue)
202 ~ ```

```

```

[1] "Factorial Statistics: n_f=16, ybar_f=372.875000"
[1] "Center point Statistics: n_c=7, ybar_c=531.142857"
[1] "SS_Pure Quadratic=121976.349379"
[1] "F0=17.373074"
[1] "Reject the null hypothesis if F0>4.413873"
[1] "Since 17.373074 > 4.413873, the null hypothesis is rejected and quadratic curvature is present."

```

Figure 7: Test for Pure Quadratic Curvature

Plot of A vs. Y

```
219 ~ ``{r}  
220 plot(combined.df$A,combined.df$y,combined,xlab="Factor A",ylab="y",main="Factor A vs. y")  
221 ~ ``
```

