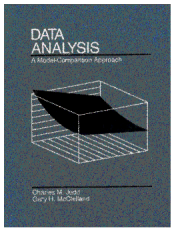

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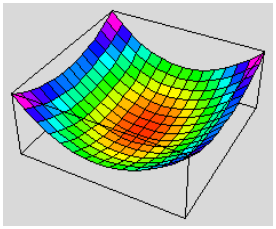


Final Exam
Spring 1996

Bread-and-Butter Edition

An advantage of the general linear model approach or the neoclassical approach used in Judd & McClelland (1989) is the ability to generate and test complex models which ask sophisticated questions of data. However, we should not forget that the approach also facilitates the basic analyses used in many social science studies. This final exam focuses on those basic analyses and serves as a final review of the general linear model approach applied to bread-and-butter analyses.

Question 1

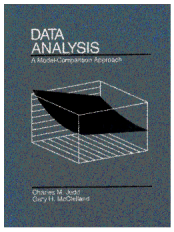
In this study of memory, there are two independent variables: subject mood and emotionality of words. Subjects are randomly assigned to one of 3 mood conditions: sad, neutral, or pleasant. To induce these moods the experiment has the subjects read a series of statements that are either sad, neutral, or pleasant, respectively. Within each mood condition, subjects are further randomly divided into groups asked to memorize either emotional words (such as "love" and "hate") or unemotional words (such as "shoe" and "tree"). The dependent variable is the number of words recalled on a test administered 30 minutes later. There are 18 subjects in this 3 x 2 design. [based on Glenberg (1988), p. 382]

A. Your advisor asks you to do a two-way ANOVA. Specify the SAS commands you would use to do the analysis using contrasts.

B. Layout the source table, being sure to include rows for all main effects, interactions, and appropriate one-df tests. Fill in the df column.

Question 2

[from Kirk (1982), p. 565]. The performance of fifteen clerks on three date-sorting tasks was compared at two times of day: 10 A.M. and 4 P.M. Each clerk completed the date-sorting tasks at each time, but on different days (with the order of the times randomly determined). The task involved



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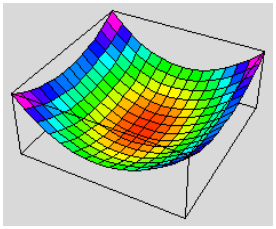


sorting a list of random dates written in European form (e.g., 30 1 74 for January 30, 1974). Clerks were randomly assigned to sort the dates into either two, three, or four accounting periods. The dependent variable was the number of dates sorted in a fixed time. (Experiment suggested by Monk, T.H., & Conrad, M.C. (1979). Time of day effects in a range of clerical tasks. *Human Factors*, *21*, 191-194).

A. Using the SAS input and output below, construct a complete source table.

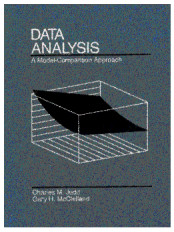
B. Write a *brief* summary of the results.

C. The periods variable is numeric so instead of using contrast codes, we could have used the SAS command:

```
proc glm;
        btwn:  model w0 = periods periods*periods;
        wthn: model w1 = periods periods*periods;
```

Put a star, check, or other mark by the rows in your source table which would be different if the above SAS code had been used instead of the `proc reg` commands which were used in the output below.

```
data clerks;
   input subj periods am pm;
   w0 = (am + pm)/sqrt(2);
   w1 = (am - pm)/sqrt(2);
   lin = (1/2)*(periods=2) + 0*(periods=3) -(1/2)*(periods=4);
   quad =(-1/3)*(periods=2) +(2/3)*(periods=3)-(1/3)*(periods=4);
   label w0 = "Combined Score am + pm"
          w1 = "Difference Score am - pm"
          lin = "linear effect of periods"
          quad = "quadratic effect of periods";
cards;
 1 2 171 189
 2 2 183 204
 3 2 145 154
 4 2 158 166
 5 2 196 179
 6 3 213 249
 7 3 224 237
 8 3 198 224
 9 3 182 198
10 3 172 214
11 4 200 212
12 4 226 224
13 4 213 196
```



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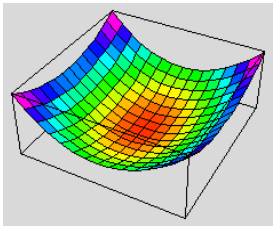


```
14 4 251 259
15 4 238 239
;;
proc reg;
   btwn: model w0 = lin quad/ss2;
   wthn: model w1 = lin quad/ss2;
```

The SAS System

Model: BTWN
Dependent Variable: W0 Combined Score am + pm

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	2	13957.80000	6978.90000	8.821	0.0044
Error	12	9494.00000	791.16667		
C Total	14	23451.80000			

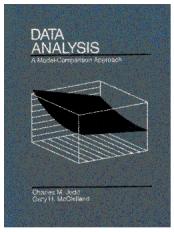
Root MSE	28.12769	R-square	0.5952
Dep Mean	288.21672	Adj R-sq	0.5277
C.V.	9.75921		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	288.216724	7.26253705	39.685	0.0001
LIN	1	-72.549156	17.78951002	-4.078	0.0015
QUAD	1	15.485639	15.40616760	1.005	0.3347

Variable	DF	Type II SS	Squared Partial Corr Type II
INTERCEP	1	1246033	.
LIN	1	13158	0.58088419
QUAD	1	799.350000	0.07765693

Variable	DF	Variable Label
INTERCEP	1	Intercept
LIN	1	linear effect of periods
QUAD	1	quadratic effect of periods



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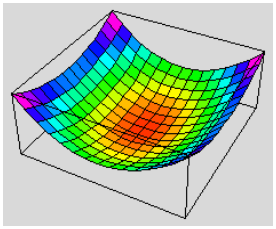


The SAS System

Model: WTHN
Dependent Variable: W1 Difference Score am - pm

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	2	912.20000	456.10000	5.421	0.0210
Error	12	1009.60000	84.13333		
C Total	14	1921.80000			

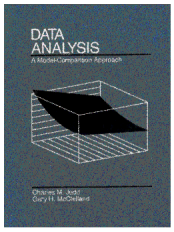
Root MSE	9.17242	R-square	0.4747
Dep Mean	-8.20244	Adj R-sq	0.3871
C.V.	-111.82555		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-8.202439	2.36830929	-3.463	0.0047
LIN	1	-5.232590	5.80114931	-0.902	0.3848
QUAD	1	-15.909903	5.02394267	-3.167	0.0081

Variable	DF	Type II SS	Squared Partial Corr Type II
INTERCEP	1	1009.200000	.
LIN	1	68.450000	0.06349427
QUAD	1	843.750000	0.45525670

Variable	DF	Variable Label
INTERCEP	1	Intercept
LIN	1	linear effect of periods
QUAD	1	quadratic effect of periods



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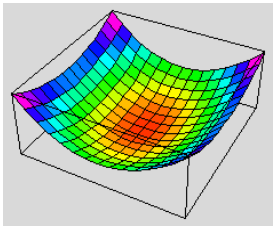


Question 3

[And now a problem for our students from business; from Neter, Wasserman, & Kutner (1983), p. 330]

An economist was interested in the speed with which a particular insurance innovation was adopted. Of particular interest was whether stock companies adopted innovations slower or faster than mutual companies. Also available was information on the size of the company (in millions of dollars of insurance policies in force). Relevant SAS input commands and output folllow the questions.

A. Without controlling for size of firm, is there a difference between the time to adopt the innovation for mutual as compared to stock companies? Give the appropriate PRE, F*, and p.

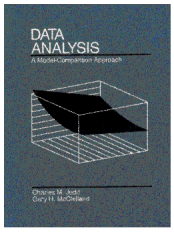
B. Using ANCOVA, is there a difference between the time to adopt the innovation for mutual as compared to stock companies when controlling for size of firm? Give the appropriate PRE, F*, and p. Give the adjusted means that are compared in this analysis.

C. Explain in non-technical terms, such as in a memo to a CEO, why questions A and B have different answers.

D. Is there any evidence for a violation of the heterogeneity of regression assumption? Give the appropriate PRE, F*, and p.

E. Is the relationship between size and time to adopt the innovation different for mutual and stock companies? Give the appropriate PRE, F*, and p.

```
data firms;
   input time size type$;
   MvsS = (1/2)*(type="Mutual") - (1/2)*(type="Stock");
   SizeMvsS = size * MvsS;
   label time = "Months to Adopt"
          size = "Size of Firm ($1,000,000s)"
          MvsS = "Mutual vs. Stock Contrast"
          SizeMvsS ="Size by Mutual vs. Stock Interaction";
cards;
17 151 Mutual
26  92 Mutual
21 175 Mutual
30  31 Mutual
22 104 Mutual
 0 277 Mutual
12 210 Mutual
```



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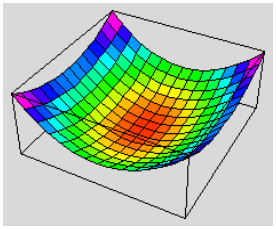


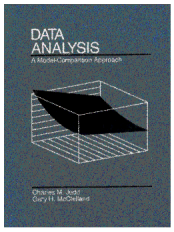
```
19 120 Mutual
 4 290 Mutual
16 238 Mutual
28 164 Stock
15 272 Stock
11 295 Stock
38  68 Stock
31  85 Stock
21 224 Stock
20 166 Stock
13 305 Stock
30 124 Stock
14 246 Stock
;;
proc means;
   var time size;
   by type;

proc reg;  title 'Simple Comparison';
   model time = MvsS;
proc reg; title 'ANCOVA Comparison';
   model time = MvsS size/ss2 pcorr2 tol;
   output out=temp h=lever r=resid p=timehat rstudent=rstudent
            cookd=cookd;
proc reg data=firms; title2 'with Interaction Added';
   model time = MvsS size SizeMvsS/ss2 pcorr2 tol;

The SAS System
 TYPE=Mutual

Variable  Label                          N          Mean       Std Dev
-----------------------------------------------------------------------
TIME      Months to Adopt               10    16.7000000     9.2981480
SIZE      Size of Firm ($1,000,000s)    10   168.8000000    84.7909848
-----------------------------------------------------------------------
Variable  Label                                Minimum       Maximum
-----------------------------------------------------------------------
TIME      Months to Adopt                            0    30.0000000
SIZE      Size of Firm ($1,000,000s)     31.0000000   290.0000000
-----------------------------------------------------------------------

 TYPE=Stock
Variable  Label                          N          Mean       Std Dev
-----------------------------------------------------------------------
TIME      Months to Adopt               10    22.1000000     9.1706052
SIZE      Size of Firm ($1,000,000s)    10   194.9000000    85.9863684
-----------------------------------------------------------------------
Variable  Label                                Minimum       Maximum
-----------------------------------------------------------------------
TIME      Months to Adopt                 11.0000000    38.0000000
SIZE      Size of Firm ($1,000,000s)      68.0000000   305.0000000
-----------------------------------------------------------------------
```



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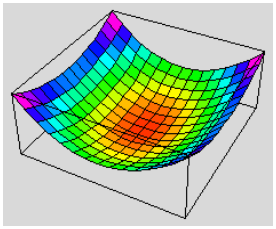
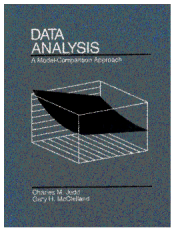


```
Simple Comparison
Model: MODEL1
Dependent Variable: TIME       Months to Adopt

Analysis of Variance

                          Sum of          Mean
Source           DF      Squares        Square      F Value       Prob>F

Model             1    145.80000     145.80000        1.710       0.2075
Error            18   1535.00000      85.27778
C Total          19   1680.80000

    Root MSE       9.23460     R-square       0.0867
    Dep Mean      19.40000     Adj R-sq       0.0360
    C.V.          47.60101

Parameter Estimates

                 Parameter       Standard    T for H0:
Variable  DF      Estimate          Error   Parameter=0    Prob > |T|

INTERCEP   1     19.400000    2.06491862         9.395        0.0001
MVSS       1     -5.400000    4.12983723        -1.308        0.2075

              Variable
Variable  DF     Label

INTERCEP   1  Intercept
MVSS       1  Mutual vs. Stock Contrast
```



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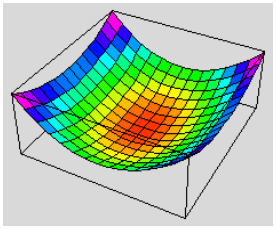


ANCOVA Comparison
Model: MODEL1
Dependent Variable: TIME Months to Adopt

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	2	1504.41333	752.20667	72.497	0.0001
Error	17	176.38667	10.37569		
C Total	19	1680.80000			

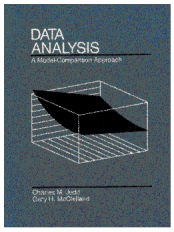
Root MSE	3.22113	R-square	0.8951
Dep Mean	19.40000	Adj R-sq	0.8827
C.V.	16.60377		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	37.901804	1.77004130	21.413	0.0001
MVSS	1	-8.055469	1.45910570	-5.521	0.0001
SIZE	1	-0.101742	0.00889122	-11.443	0.0001

Variable	DF	Type II SS	Squared Partial Corr Type II	Tolerance
INTERCEP	1	4757.401281	.	.
MVSS	1	316.245973	0.64195091	0.97470527
SIZE	1	1358.613335	0.88509012	0.97470527

Variable	DF	Variable Label
INTERCEP	1	Intercept
MVSS	1	Mutual vs. Stock Contrast
SIZE	1	Size of Firm ($1,000,000s)



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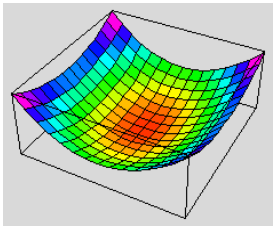


ANCOVA Comparison
with Interaction Added

Model: MODEL1
Dependent Variable: TIME Months to Adopt

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	3	1504.41904	501.47301	45.490	0.0001
Error	16	176.38096	11.02381		
C Total	19	1680.80000			

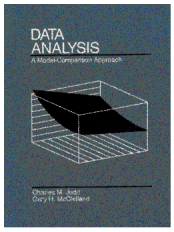
Root MSE	3.32021	R-square	0.8951
Dep Mean	19.40000	Adj R-sq	0.8754
C.V.	17.11450		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	37.903995	1.82702585	20.746	0.0001
MVSS	1	-8.131250	3.65405169	-2.225	0.0408
SIZE	1	-0.101739	0.00916561	-11.100	0.0001
SIZEMVSS	1	0.000417	0.01833121	0.023	0.9821

Variable	DF	Type II SS	Squared Partial Corr Type II	Tolerance
INTERCEP	1	4744.738605	.	.
MVSS	1	54.587974	0.23634336	0.16512481
SIZE	1	1358.269138	0.88506764	0.97451427
SIZEMVSS	1	0.005708	0.00003236	0.16555219

Variable	DF	Variable Label
INTERCEP	1	Intercept
MVSS	1	Mutual vs. Stock Contrast
SIZE	1	Size of Firm ($1,000,000s)
SIZEMVSS	1	Size by Mutual vs. Stock Interaction



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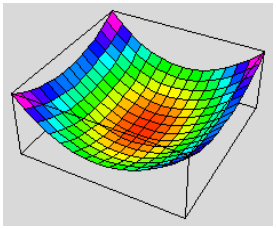


F. The following SAS output of residuals and plots was for a preliminary analysis like the one above. Comment on how well the assumptions were satisfied for this preliminary analysis and comment on any outliers. What next step would you recommend?

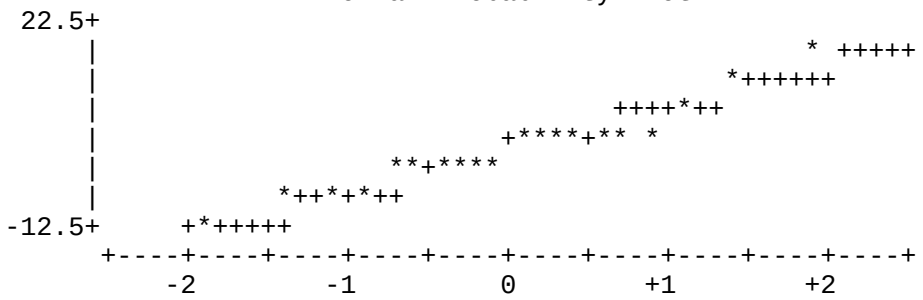
ANCOVA Comparison

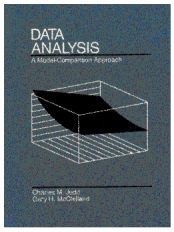
OBS	MVSS	SIZE	SIZEMVSS	TIME	TIMEHAT	RESID	LEVER	RSTUDENT	COOKD
1	0.5	151	75.5	17	19.0997	-2.0997	0.11192	-0.27543	0.00337
2	0.5	92	46.0	26	21.5492	4.4508	0.14869	0.60159	0.02189
3	0.5	575	287.5	21	1.4964	19.5036	0.57858	9.83323	6.67537
4	0.5	31	15.5	30	24.0818	5.9182	0.21282	0.84060	0.06480
5	0.5	104	52.0	22	21.0510	0.9490	0.13920	0.12620	0.00091
6	0.5	277	138.5	0	13.8685	-13.8685	0.11660	-2.04340	0.15479
7	0.5	210	105.0	12	16.6502	-4.6502	0.10001	-0.61153	0.01438
8	0.5	120	60.0	19	20.3867	-1.3867	0.12814	-0.18335	0.00175
9	0.5	290	145.0	4	13.3288	-9.3288	0.12353	-1.29132	0.07538
10	0.5	238	119.0	16	15.4877	0.5123	0.10304	0.06672	0.00018
11	-0.5	164	-82.0	28	23.3829	4.6171	0.10341	0.60826	0.01477
12	-0.5	272	-136.0	15	18.8990	-3.8990	0.12121	-0.51721	0.01285
13	-0.5	295	-147.5	11	17.9441	-6.9441	0.13576	-0.94664	0.04721
14	-0.5	68	-34.0	38	27.3685	10.6315	0.15747	1.52923	0.13506
15	-0.5	85	-42.5	31	26.6628	4.3372	0.14310	0.58396	0.01975
16	-0.5	224	-112.0	21	20.8918	0.1082	0.10302	0.01408	0.00001
17	-0.5	166	-83.0	20	23.2998	-3.2998	0.10298	-0.43218	0.00751
18	-0.5	305	-152.5	13	17.5289	-4.5289	0.14326	-0.61041	0.02156
19	-0.5	124	-62.0	30	25.0436	4.9564	0.11794	0.65962	0.02006
20	-0.5	246	-123.0	14	19.9785	-5.9785	0.10932	-0.79657	0.02653

ANCOVA Comparison
Normal-Normal Quantile Plot

Variable=RESID Residual

Normal Probability Plot





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Univ of Colorado
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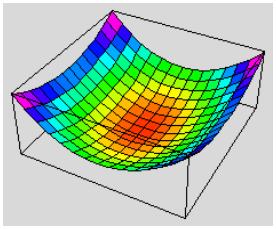
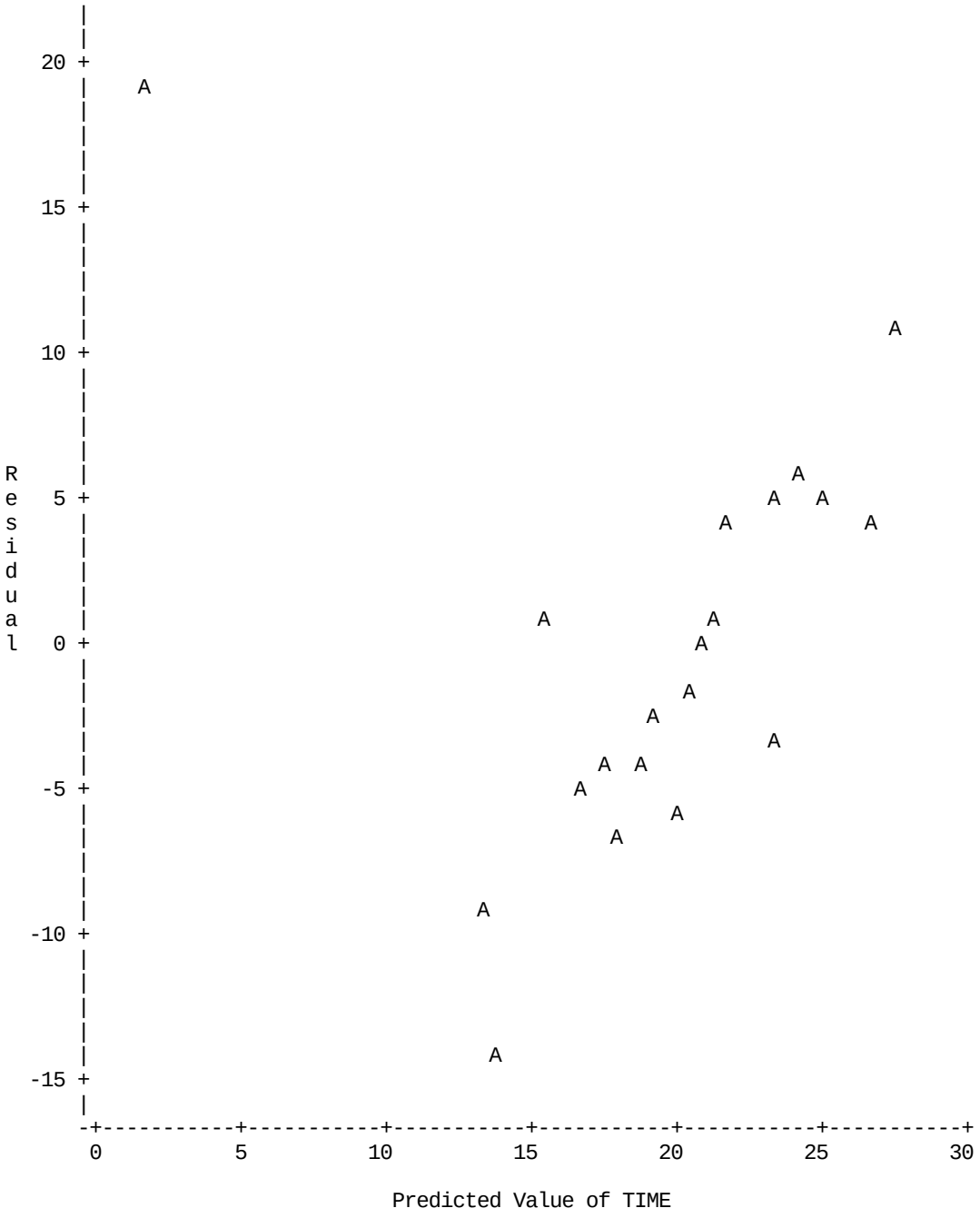
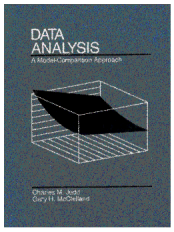
Judd, C.M., & McClelland, G.H. (1989).
Data Analysis: A Model Comparison Approach. HBJ.



ANCOVA Comparison
Plot of Residuals vs. Predicted

Plot of RESID*TIMEHAT. Legend: A = 1 obs, B = 2 obs, etc.





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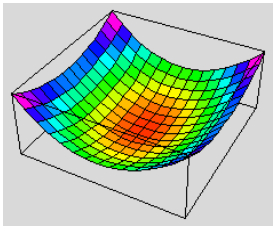


Question 4

[also from Neter, et al., p. 364] In a study of the effectiveness of coupons offering a price reduction on a given product, 1000 homes were selected and a coupon and advertising material for the product were mailed to each. The coupons offered different price reductions (5, 10, 15, 20, and 30 percent) for specific automobile maintenance services; 200 homes were randomly assigned to each of the price reduction categories. The response variable was whether the coupon was redeemed within six months.

A. Is the price reduction percentage related to the rate at which coupons were redeemed? Give the appropriate test statistic and p.

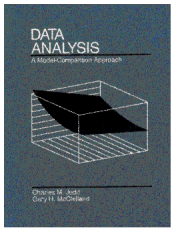
B. Is there any evidence that the effectiveness of the price reduction did not increase linearly (in terms of logits)? Give the appropriate test statistic and p.

C. Your boss decides that a 25% price reduction is the most your firm can afford. What is the expected proportion of coupons that would be redeemed if a 25% reduction were offered?

```
data coupons;
   input reduce count redeem;
   reducesq = reduce * reduce;

cards;
 5   32  1
 5  168  0
10   51  1
10  149  0
15   70  1
15  130  0
20  103  1
20   97  0
30  148  1
30   52  0
;;

proc logistic;
   model redeem = reduce;
   weight count;
proc logistic;
   model redeem = reduce reducesq;
   weight count;
```



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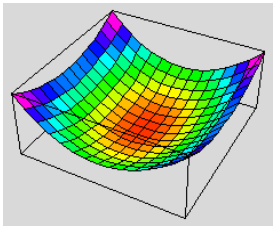


The LOGISTIC Procedure

Data Set: WORK.COUPONS
Response Variable: REDEEM
Response Levels: 2
Number of Observations: 10
Weight Variable: COUNT
Sum of Weights: 1000
Link Function: Logit

Response Profile

Ordered Value	REDEEM	Count	Total Weight
1	0	5	596.00000
2	1	5	404.00000

Criteria for Assessing Model Fit

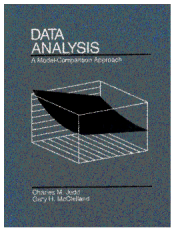
Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1351.200	1172.763	.
SC	1351.503	1173.368	.
-2 LOG L	1349.200	1168.763	180.437 with 1 DF (p=0.0001)
Score	.	.	173.057 with 1 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	2.1855	0.1647	176.1542	0.0001	.	8.895
REDUCE	1	-0.1087	0.00884	151.1552	0.0001	-5.435146	0.897

Association of Predicted Probabilities and Observed Responses

Concordant	= 40.0%	Somers' D	= 0.000
Discordant	= 40.0%	Gamma	= 0.000
Tied	= 20.0%	Tau-a	= 0.000
(25 pairs)		c	= 0.500



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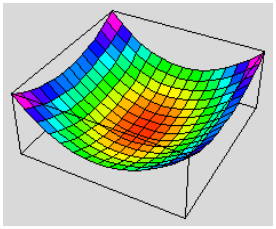

The SAS System

The LOGISTIC Procedure

Data Set: WORK.COUPONS
Response Variable: REDEEM
Response Levels: 2
Number of Observations: 10
Weight Variable: COUNT
Sum of Weights: 1000
Link Function: Logit

Response Profile

Ordered Value	REDEEM	Count	Total Weight
1	0	5	596.00000
2	1	5	404.00000

Criteria for Assessing Model Fit

Criterion	Intercept Only	Intercept and Covariates	Chi-Square for Covariates
AIC	1351.200	1174.722	.
SC	1351.503	1175.629	.
-2 LOG L	1349.200	1168.722	180.479 with 2 DF (p=0.0001)
Score	.	.	173.339 with 2 DF (p=0.0001)

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
INTERCPT	1	2.2428	0.3267	47.1399	0.0001	.	9.420
REDUCE	1	-0.1167	0.0400	8.5032	0.0035	-5.832308	0.890
REDUCESQ	1	0.00022	0.00108	0.0415	0.8385	0.398600	1.000

Association of Predicted Probabilities and Observed Responses

Concordant = 40.0%	Somers' D = 0.000
Discordant = 40.0%	Gamma = 0.000
Tied = 20.0%	Tau-a = 0.000
(25 pairs)	c = 0.500