TRANSFORMATIONS

One of the assumptions of using ANOVA to test for significance is that the errors should be independently and normally distributed.

Randomization is used to break up any correlation of experimental units.

A problem that may influence this assumption is that the errors may be heterogeneous.

There are two types of heterogeneity.

1. Irregular: certain treatments possess considerably more variability that others. e.g. In insecticide trials, the checks may contain considerably more insects that the treated experimental units; therefore, the checks contribute to the Error MS to a larger degree than the treated units. Consequently, the standard deviation will be too large for comparisons among treated experimental units.

   This portion of the experiment is not under statistical control.

   The best procedure to compensate for this problem is to omit certain portions of the data from the analysis or use orthogonal contrasts.

2. Regular: arises from some type of non-normality of the data in the experiment.

   This non-normality is caused by a relationship between the variability of several treatments and the mean.

   To correct the problem, the data can be transformed such that the transformed errors are normally distributed.

<u>Ways the Mean and Variance Can Be Related</u>

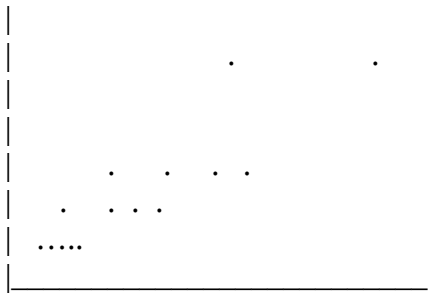
1. Count data: e.g. number of infested plants per plot, number of lesions per leaf, etc. These type of data may follow a Poisson distribution where the mean equals the variance.
2. Binomial data: data in which only two outcomes are possible. For example, susceptible vs. non-susceptible, present vs. not present, etc.

<u>Detecting the Presence of Variability Heterogeneity for a CRD</u>

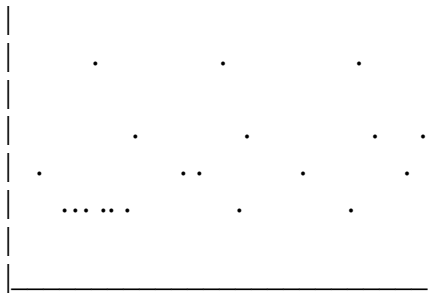
Step 1. For each treatment, compute the variance and the mean across replicates.

Step 2. Plot a scatter diagram of the treatment variances vs. the treatment means. The number of points in the scatter diagram equals the number of treatments.

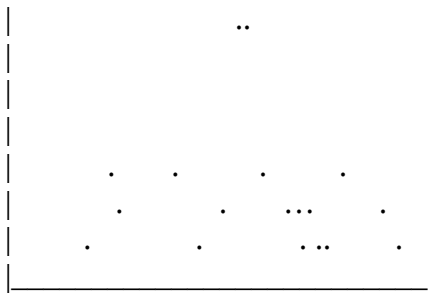
Step 3. Visually examine the scatter diagram to identify the patter of relationship if any.



Heterogeneous variance where the variance is proportional to the mean.



Homogeneous variance



Outliers – transformation will not work.

Causes of outliers

1. Mean(s) have high variability.
2. Errors in collecting data.

To determine if transformations are necessary for others designs, plot residual on the Y-axis and the predicted values on the X-axis.

Data Transformations

1. Logarithmic (Log_{10}) transformation

   Appropriate for data where the standard deviation is proportional to the mean.

   Helpful when the data are expressed as a percentage of change.

   These types of data may follow a multiplicative model instead of an additive model.

   If the data set includes small values (e.g. less than 10), use the transformation Log(Y+1) instead of Log Y (Y is the original data).

2. Square root transformation

   Useful for count data (data that follow a Poisson distribution).

   Appropriate for data consisting of small whole numbers.

   In both these cases the mean may be proportional to the variance.

   Examples are the number of infested plants per plot, the number of insects caught in a trap, the number of weeds per plot (i.e. data obtained in counting rare events).

   This transformation also may be appropriate for percentage data where the range is between 0 and 20% or between 80 and 100%.

   If most of the values in the data set are less than 10, especially if zeros are present, the transformation to use is $(Y+0.5)^{1/2}$ instead of $Y^{1/2}$.

3. Arc sine square root transformation - Arc Sine $(Y)^{1/2}$

   Appropriate for data on proportions, binomial data, and data expressed as percent of control.

   The value of 0% should be substituted by (1/4n) and the value 100% by (100-1/4n), where n is the number of units in which the percentage data were based (i.e. the denominator used in computing the percentage.

The following rules may be useful in choosing the proper transformation scale for the percentage data derived from count data.

Rule 1. For percentage data lying within the range of 20 - 80%, no transformation is needed.

Rule 2. For percentage data lying within a range of either 0 - 20% or 80 – 100%, but not both, the square root transformation could be useful.

Rule 3. For percentage data that do not follow the ranges specified in either Rule 1 or Rule 2 (e.g. percent control data), the Arc Sine square root transformation may be useful.

Determining if a Transformation is Needed

Perform the ANOVA on untransformed data.

Check the residual vs. predicted value plots to determine if a transformation is needed.

If a transformation is needed, transform the data using the appropriate method.

Determine if the transformation corrected the problem of non-normality of the errors.

If the transformation did not correct the problem, then analyze and discuss the nontransformed data.

Performing an ANOVA Using Transformed Data

Perform the ANOVA using the transformed data.

The LSD used to compare differences should be calculated using the transformed error mean square.

Mean separation should be done using the LSD calculated from the transformed data.

When presenting means, untransformed means can be used. However, somewhere in you presentation or paper, it should be mentioned that transformed data were used to perform the ANOVA.

Example of Producing Residual Plots Using SAS

SAS Commands

```
options pageno=1;
data example;
input PLOT  BLOC  ENTRY HDDT  HT    LODG  YIELD MOIST;
datalines;
3501  1     8     32    84.5  3     46.8  21.5
3502  1     30    32    82.5  3     78.9  19.8
3503  1     7     31    73.5  3     68.5  20.7
3504  1     26    36    64.5  1     64.5  16.7
3505  1     13    33    75.5  2     69.8  16.4
3506  1     18    31    76.0  2     74.5  16.7
3507  1     27    31    78.0  2     85.5  18.0
3508  1     4     34    81.5  4     67.3  16.4
3509  1     29    30    72.0  2     77.4  16.2
3510  1     19    30    80.5  2     55.5  15.3
3511  1     23    34    70.0  4     68.4  15.0
3512  1     5     33    85.0  5     64.2  13.8
3513  1     2     32    87.0  4     71.2  14.7
3514  1     22    35    79.0  4     62.0  13.3
3515  1     25    36    89.5  4     66.0  14.8
3516  1     6     31    83.0  2     77.3  13.6
3517  1     17    33    83.5  3     99.4  16.6
3518  1     3     32    84.0  3     79.9  16.2
3519  1     24    33    82.5  1     83.1  18.0
3520  1     21    32    80.5  1     84.1  19.4
3521  1     20    31    80.5  2     81.5  19.6
3522  1     16    31    75.5  1     65.1  16.0
3523  1     1     32    88.0  3     67.3  19.4
3524  1     14    33    82.0  2     72.9  18.5
3525  1     28    31    79.5  1     89.9  20.6
3526  1     10    31    85.0  3     82.6  20.8
3527  1     11    31    89.0  2     70.0  16.1
3528  1     15    33    75.5  1     77.3  18.9
3529  1     9     33    79.0  2     82.5  16.1
3530  1     12    32    105.0 2     57.4  16.2
3531  2     23    34    72.0  5     69.7  16.5
3532  2     8     32    88.5  3     79.7  16.4
3533  2     28    31    81.0  1     87.6  16.0
3534  2     6     32    81.5  2     70.3  15.8
3535  2     18    30    81.0  2     74.6  13.7
3536  2     2     33    84.5  3     70.7  15.3
3537  2     20    31    86.5  5     79.5  16.6
3538  2     9     32    79.5  3     80.0  13.4
3539  2     13    33    79.0  2     68.7  14.6
3540  2     27    31    73.5  3     78.2  15.4
3541  2     30    32    82.5  2     74.7  16.4
3542  2     21    33    77.0  2     72.5  16.1
3543  2     25    35    84.0  2     72.6  16.0
3544  2     12    32    93.5  3     60.1  16.0
3545  2     16    31    69.5  3     65.2  15.8
3546  2     29    30    72.5  1     82.7  18.4
3547  2     17    33    82.5  4     79.1  17.1
3548  2     14    33    80.0  2     74.5  19.4
```

```
3549  2     10    32    76.5  2     81.4  17.2
3550  2     26    36    66.5  1     50.7  22.6
3551  2     5     33    80.0  2     52.9  22.8
3552  2     7     32    77.0  2     75.1  21.3
3553  2     15    33    76.0  1     67.2  19.5
3554  2     24    33    86.5  4     77.9  18.3
3555  2     19    30    84.0  3     72.7  15.9
3556  2     3     33    85.0  3     73.9  17.4
3557  2     1     33    87.0  4     70.6  18.3
3558  2     4     34    86.0  5     70.1  16.0
3559  2     22    35    81.5  6     57.4  16.2
3560  2     11    31    92.0  3     63.3  15.1
3561  3     21    32    83.0  2     83.0  15.6
3562  3     22    34    85.0  6     56.6  13.7
3563  3     14    33    85.0  4     83.9  14.7
3564  3     7     32    86.5  4     80.6  15.5
3565  3     27    31    82.0  2     96.5  14.8
3566  3     6     32    82.5  2     70.4  15.6
3567  3     26    37    73.0  1     72.4  16.2
3568  3     4     35    85.0  4     80.1  16.0
3569  3     25    37    88.5  3     77.6  16.0
3570  3     9     33    88.0  2     80.5  15.6
3571  3     2     32    83.5  2     79.5  16.6
3572  3     16    31    73.5  1     70.0  16.1
3573  3     24    33    83.5  3     85.7  17.8
3574  3     18    31    82.5  2     73.9  17.4
3575  3     10    32    85.5  3     95.7  17.7
3576  3     15    33    78.5  2     78.8  19.9
3577  3     23    35    76.0  5     74.4  19.5
3578  3     17    33    82.0  3     77.3  18.9
3579  3     13    33    77.5  2     72.4  16.2
3580  3     1     33    92.0  4     67.4  16.2
3581  3     30    32    86.0  4     86.5  19.4
3582  3     28    32    75.5  2     89.4  16.7
3583  3     29    30    76.5  1     72.2  19.3
3584  3     11    31    86.5  2     55.6  15.2
3585  3     5     33    80.5  3     63.0  15.5
3586  3     8     32    79.5  3     74.2  14.1
3587  3     12    32    103.0 2     60.9  14.9
3588  3     3     33    83.0  3     72.9  15.7
3589  3     19    30    83.5  3     76.8  14.1
3590  3     20    30    89.0  4     80.4  15.7
;;
ods rtf file='residual plot SAS output.rtf';
proc print;
run;
proc reg;
model hddt=bloc entry/r p;
output out=new r=residual p=predicted;
run;
proc plot;
plot residual*predicted;
run;
ods rtf close;
```

SAS Output

Obs	PLOT	BLOC	ENTRY	HDDT	HT	LODG	YIELD	MOIST
1	3501	1	8	32	84.5	3	46.8	21.5
2	3502	1	30	32	82.5	3	78.9	19.8
3	3503	1	7	31	73.5	3	68.5	20.7
4	3504	1	26	36	64.5	1	64.5	16.7
5	3505	1	13	33	75.5	2	69.8	16.4
6	3506	1	18	31	76.0	2	74.5	16.7
7	3507	1	27	31	78.0	2	85.5	18.0
8	3508	1	4	34	81.5	4	67.3	16.4
9	3509	1	29	30	72.0	2	77.4	16.2
10	3510	1	19	30	80.5	2	55.5	15.3
11	3511	1	23	34	70.0	4	68.4	15.0
12	3512	1	5	33	85.0	5	64.2	13.8
13	3513	1	2	32	87.0	4	71.2	14.7
14	3514	1	22	35	79.0	4	62.0	13.3
15	3515	1	25	36	89.5	4	66.0	14.8
16	3516	1	6	31	83.0	2	77.3	13.6
17	3517	1	17	33	83.5	3	99.4	16.6
18	3518	1	3	32	84.0	3	79.9	16.2
19	3519	1	24	33	82.5	1	83.1	18.0
20	3520	1	21	32	80.5	1	84.1	19.4
21	3521	1	20	31	80.5	2	81.5	19.6
22	3522	1	16	31	75.5	1	65.1	16.0
23	3523	1	1	32	88.0	3	67.3	19.4
24	3524	1	14	33	82.0	2	72.9	18.5
25	3525	1	28	31	79.5	1	89.9	20.6
26	3526	1	10	31	85.0	3	82.6	20.8
27	3527	1	11	31	89.0	2	70.0	16.1
28	3528	1	15	33	75.5	1	77.3	18.9
29	3529	1	9	33	79.0	2	82.5	16.1

Obs	PLOT	BLOC	ENTRY	HDDT	HT	LODG	YIELD	MOIST
30	3530	1	12	32	105.0	2	57.4	16.2
31	3531	2	23	34	72.0	5	69.7	16.5
32	3532	2	8	32	88.5	3	79.7	16.4
33	3533	2	28	31	81.0	1	87.6	16.0
34	3534	2	6	32	81.5	2	70.3	15.8
35	3535	2	18	30	81.0	2	74.6	13.7
36	3536	2	2	33	84.5	3	70.7	15.3
37	3537	2	20	31	86.5	5	79.5	16.6
38	3538	2	9	32	79.5	3	80.0	13.4
39	3539	2	13	33	79.0	2	68.7	14.6
40	3540	2	27	31	73.5	3	78.2	15.4
41	3541	2	30	32	82.5	2	74.7	16.4
42	3542	2	21	33	77.0	2	72.5	16.1
43	3543	2	25	35	84.0	2	72.6	16.0
44	3544	2	12	32	93.5	3	60.1	16.0
45	3545	2	16	31	69.5	3	65.2	15.8
46	3546	2	29	30	72.5	1	82.7	18.4
47	3547	2	17	33	82.5	4	79.1	17.1
48	3548	2	14	33	80.0	2	74.5	19.4
49	3549	2	10	32	76.5	2	81.4	17.2
50	3550	2	26	36	66.5	1	50.7	22.6
51	3551	2	5	33	80.0	2	52.9	22.8
52	3552	2	7	32	77.0	2	75.1	21.3
53	3553	2	15	33	76.0	1	67.2	19.5
54	3554	2	24	33	86.5	4	77.9	18.3
55	3555	2	19	30	84.0	3	72.7	15.9
56	3556	2	3	33	85.0	3	73.9	17.4
57	3557	2	1	33	87.0	4	70.6	18.3
58	3558	2	4	34	86.0	5	70.1	16.0
59	3559	2	22	35	81.5	6	57.4	16.2

Obs	PLOT	BLOC	ENTRY	HDDT	HT	LODG	YIELD	MOIST
60	3560	2	11	31	92.0	3	63.3	15.1
61	3561	3	21	32	83.0	2	83.0	15.6
62	3562	3	22	34	85.0	6	56.6	13.7
63	3563	3	14	33	85.0	4	83.9	14.7
64	3564	3	7	32	86.5	4	80.6	15.5
65	3565	3	27	31	82.0	2	96.5	14.8
66	3566	3	6	32	82.5	2	70.4	15.6
67	3567	3	26	37	73.0	1	72.4	16.2
68	3568	3	4	35	85.0	4	80.1	16.0
69	3569	3	25	37	88.5	3	77.6	16.0
70	3570	3	9	33	88.0	2	80.5	15.6
71	3571	3	2	32	83.5	2	79.5	16.6
72	3572	3	16	31	73.5	1	70.0	16.1
73	3573	3	24	33	83.5	3	85.7	17.8
74	3574	3	18	31	82.5	2	73.9	17.4
75	3575	3	10	32	85.5	3	95.7	17.7
76	3576	3	15	33	78.5	2	78.8	19.9
77	3577	3	23	35	76.0	5	74.4	19.5
78	3578	3	17	33	82.0	3	77.3	18.9
79	3579	3	13	33	77.5	2	72.4	16.2
80	3580	3	1	33	92.0	4	67.4	16.2
81	3581	3	30	32	86.0	4	86.5	19.4
82	3582	3	28	32	75.5	2	89.4	16.7
83	3583	3	29	30	76.5	1	72.2	19.3
84	3584	3	11	31	86.5	2	55.6	15.2
85	3585	3	5	33	80.5	3	63.0	15.5
86	3586	3	8	32	79.5	3	74.2	14.1
87	3587	3	12	32	103.0	2	60.9	14.9
88	3588	3	3	33	83.0	3	72.9	15.7

Obs	PLOT	BLOC	ENTRY	HDDT	HT	LODG	YIELD	MOIST
89	3589	3	19	30	83.5	3	76.8	14.1
90	3590	3	20	30	89.0	4	80.4	15.7

The SAS System

The REG Procedure
Model: MODEL1
Dependent Variable: HDDT

Number of Observations Read	90
Number of Observations Used	90

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	2	1.20463	0.60232	0.24	0.7893
Error	87	220.89537	2.53903		
Corrected Total	89	222.10000			

Root MSE	1.59343	**R-Square**	0.0054
Dependent Mean	32.43333	**Adj R-Sq**	-0.0174
Coeff Var	4.91295		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	32.09655	0.53661	59.81	<.0001
BLOC	1	0.13333	0.20571	0.65	0.5186
ENTRY	1	0.00452	0.01941	0.23	0.8162

The SAS System

The REG Procedure
Model: MODEL1
Dependent Variable: HDDT

Output Statistics								
Obs	Dependent Variable	Predicted Value	Std Error Mean Predict	Residual	Std Error Residual	Student Residual	-2-1 0 1 2	Cook's D
1	32.0000	32.2661	0.3028	-0.2661	1.564	-0.170	| | |	0.000
2	32.0000	32.3656	0.3869	-0.3656	1.546	-0.237	| | |	0.001
3	31.0000	32.2615	0.3126	-1.2615	1.562	-0.807	| * | |	0.009
4	36.0000	32.3475	0.3347	3.6525	1.558	2.345	| |**** |	0.085
5	33.0000	32.2887	0.2700	0.7113	1.570	0.453	| | |	0.002
6	31.0000	32.3113	0.2700	-1.3113	1.570	-0.835	| * | |	0.007
7	31.0000	32.3520	0.3469	-1.3520	1.555	-0.869	| * | |	0.013
8	34.0000	32.2480	0.3469	1.7520	1.555	1.127	| |** |	0.021
9	30.0000	32.3611	0.3730	-2.3611	1.549	-1.524	| *** | |	0.045
10	30.0000	32.3158	0.2741	-2.3158	1.570	-1.475	| ** | |	0.022
11	34.0000	32.3339	0.3028	1.6661	1.564	1.065	| |** |	0.014
12	33.0000	32.2525	0.3347	0.7475	1.558	0.480	| | |	0.004
13	32.0000	32.2389	0.3730	-0.2389	1.549	-0.154	| | |	0.000
14	35.0000	32.3294	0.2940	2.6706	1.566	1.705	| |*** |	0.034
15	36.0000	32.3430	0.3233	3.6570	1.560	2.344	| |**** |	0.079
16	31.0000	32.2570	0.3233	-1.2570	1.560	-0.806	| * | |	0.009
17	33.0000	32.3068	0.2672	0.6932	1.571	0.441	| | |	0.002
18	32.0000	32.2435	0.3597	-0.2435	1.552	-0.157	| | |	0.000
19	33.0000	32.3385	0.3126	0.6615	1.562	0.423	| | |	0.002
20	32.0000	32.3249	0.2862	-0.3249	1.568	-0.207	| | |	0.000
21	31.0000	32.3204	0.2796	-1.3204	1.569	-0.842	| * | |	0.007
22	31.0000	32.3023	0.2657	-1.3023	1.571	-0.829	| * | |	0.007
23	32.0000	32.2344	0.3869	-0.2344	1.546	-0.152	| | |	0.000
24	33.0000	32.2932	0.2672	0.7068	1.571	0.450	| | |	0.002
25	31.0000	32.3565	0.3597	-1.3565	1.552	-0.874	| * | |	0.014
26	31.0000	32.2751	0.2862	-1.2751	1.568	-0.813	| * | |	0.007
27	31.0000	32.2796	0.2796	-1.2796	1.569	-0.816	| * | |	0.007
28	33.0000	32.2977	0.2657	0.7023	1.571	0.447	| | |	0.002
29	33.0000	32.2706	0.2940	0.7294	1.566	0.466	| | |	0.003

The SAS System

The REG Procedure
Model: MODEL1
Dependent Variable: HDDT

Output Statistics								
Obs	Dependent Variable	Predicted Value	Std Error Mean Predict	Residual	Std Error Residual	Student Residual	-2-1 0 1 2	Cook's D
30	32.0000	32.2842	0.2741	-0.2842	1.570	-0.181	| | |	0.000
31	34.0000	32.4673	0.2222	1.5327	1.578	0.971	| |* |	0.006
32	32.0000	32.3994	0.2222	-0.3994	1.578	-0.253	| | |	0.000
33	31.0000	32.4899	0.2950	-1.4899	1.566	-0.951	| *| |	0.011
34	32.0000	32.3904	0.2494	-0.3904	1.574	-0.248	| | |	0.001
35	30.0000	32.4446	0.1748	-2.4446	1.584	-1.544	| ***| |	0.010
36	33.0000	32.3723	0.3112	0.6277	1.563	0.402	| | |	0.002
37	31.0000	32.4537	0.1893	-1.4537	1.582	-0.919	| *| |	0.004
38	32.0000	32.4039	0.2101	-0.4039	1.580	-0.256	| | |	0.000
39	33.0000	32.4220	0.1748	0.5780	1.584	0.365	| | |	0.001
40	31.0000	32.4854	0.2793	-1.4854	1.569	-0.947	| *| |	0.009
41	32.0000	32.4989	0.3277	-0.4989	1.559	-0.320	| | |	0.002
42	33.0000	32.4582	0.1990	0.5418	1.581	0.343	| | |	0.001
43	35.0000	32.4763	0.2494	2.5237	1.574	1.604	| |*** |	0.022
44	32.0000	32.4175	0.1812	-0.4175	1.583	-0.264	| | |	0.000
45	31.0000	32.4356	0.1682	-1.4356	1.585	-0.906	| *| |	0.003
46	30.0000	32.4944	0.3112	-2.4944	1.563	-1.596	| ***| |	0.034
47	33.0000	32.4401	0.1705	0.5599	1.584	0.353	| | |	0.000
48	33.0000	32.4265	0.1705	0.5735	1.584	0.362	| | |	0.001
49	32.0000	32.4085	0.1990	-0.4085	1.581	-0.258	| | |	0.000
50	36.0000	32.4808	0.2641	3.5192	1.571	2.240	| |**** |	0.047
51	33.0000	32.3858	0.2641	0.6142	1.571	0.391	| | |	0.001
52	32.0000	32.3949	0.2354	-0.3949	1.576	-0.251	| | |	0.000
53	33.0000	32.4311	0.1682	0.5689	1.585	0.359	| | |	0.000
54	33.0000	32.4718	0.2354	0.5282	1.576	0.335	| | |	0.001
55	30.0000	32.4492	0.1812	-2.4492	1.583	-1.547	| ***| |	0.010
56	33.0000	32.3768	0.2950	0.6232	1.566	0.398	| | |	0.002
57	33.0000	32.3677	0.3277	0.6323	1.559	0.405	| | |	0.002
58	34.0000	32.3813	0.2793	1.6187	1.569	1.032	| |** |	0.011

The SAS System

The REG Procedure
Model: MODEL1
Dependent Variable: HDDT

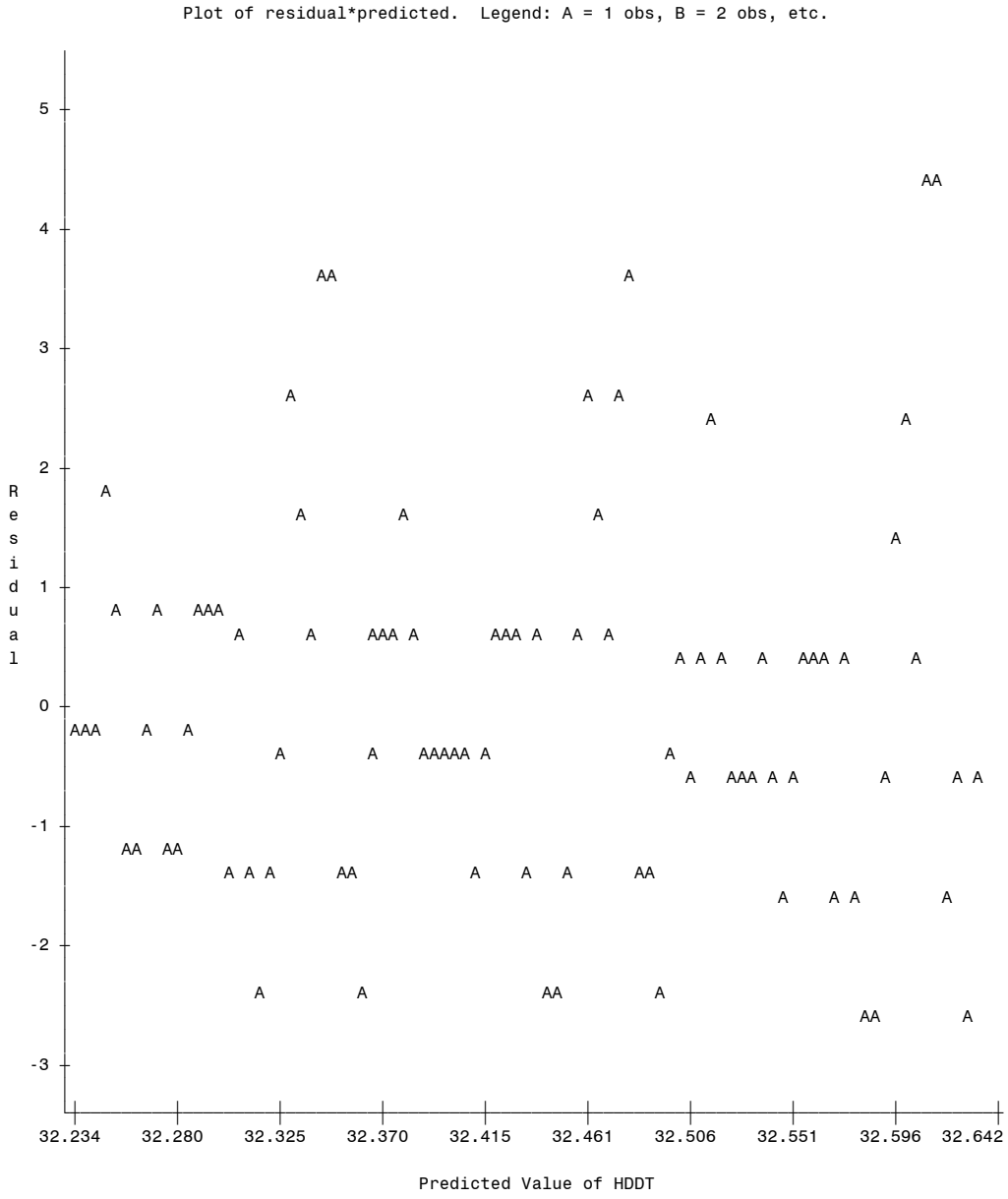
Output Statistics								
Obs	Dependent Variable	Predicted Value	Std Error Mean Predict	Residual	Std Error Residual	Student Residual	-2-1 0 1 2	Cook's D
59	35.0000	32.4627	0.2101	2.5373	1.580	1.606	| |*** |	0.015
60	31.0000	32.4130	0.1893	-1.4130	1.582	-0.893	| *| |	0.004
61	32.0000	32.5915	0.2862	-0.5915	1.568	-0.377	| | |	0.002
62	34.0000	32.5961	0.2940	1.4039	1.566	0.896	| |* |	0.009
63	33.0000	32.5599	0.2672	0.4401	1.571	0.280	| | |	0.001
64	32.0000	32.5282	0.3126	-0.5282	1.562	-0.338	| | |	0.002
65	31.0000	32.6187	0.3469	-1.6187	1.555	-1.041	| **| |	0.018
66	32.0000	32.5237	0.3233	-0.5237	1.560	-0.336	| | |	0.002
67	37.0000	32.6142	0.3347	4.3858	1.558	2.815	| |***** |	0.122
68	35.0000	32.5146	0.3469	2.4854	1.555	1.598	| |*** |	0.042
69	37.0000	32.6096	0.3233	4.3904	1.560	2.814	| |***** |	0.113
70	33.0000	32.5373	0.2940	0.4627	1.566	0.295	| | |	0.001
71	32.0000	32.5056	0.3730	-0.5056	1.549	-0.326	| | |	0.002
72	31.0000	32.5689	0.2657	-1.5689	1.571	-0.999	| *| |	0.010
73	33.0000	32.6051	0.3126	0.3949	1.562	0.253	| | |	0.001
74	31.0000	32.5780	0.2700	-1.5780	1.570	-1.005	| **| |	0.010
75	32.0000	32.5418	0.2862	-0.5418	1.568	-0.346	| | |	0.001
76	33.0000	32.5644	0.2657	0.4356	1.571	0.277	| | |	0.001
77	35.0000	32.6006	0.3028	2.3994	1.564	1.534	| |*** |	0.029
78	33.0000	32.5735	0.2672	0.4265	1.571	0.272	| | |	0.001
79	33.0000	32.5554	0.2700	0.4446	1.570	0.283	| | |	0.001
80	33.0000	32.5011	0.3869	0.4989	1.546	0.323	| | |	0.002
81	32.0000	32.6323	0.3869	-0.6323	1.546	-0.409	| | |	0.003
82	32.0000	32.6232	0.3597	-0.6232	1.552	-0.401	| | |	0.003
83	30.0000	32.6277	0.3730	-2.6277	1.549	-1.696	| ***| |	0.056
84	31.0000	32.5463	0.2796	-1.5463	1.569	-0.986	| *| |	0.010
85	33.0000	32.5192	0.3347	0.4808	1.558	0.309	| | |	0.001
86	32.0000	32.5327	0.3028	-0.5327	1.564	-0.341	| | |	0.001
87	32.0000	32.5508	0.2741	-0.5508	1.570	-0.351	| | |	0.001

The SAS System

The REG Procedure
Model: MODEL1
Dependent Variable: HDDT

Output Statistics								
Obs	Dependent Variable	Predicted Value	Std Error Mean Predict	Residual	Std Error Residual	Student Residual	-2-1 0 1 2	Cook's D
88	33.0000	32.5101	0.3597	0.4899	1.552	0.316	| | |	0.002
89	30.0000	32.5825	0.2741	-2.5825	1.570	-1.645	| ***| |	0.028
90	30.0000	32.5870	0.2796	-2.5870	1.569	-1.649	| ***| |	0.029

Sum of Residuals	0
Sum of Squared Residuals	220.89537
Predicted Residual SS (PRESS)	237.38998


Plot of residual*predicted. Legend: A = 1 obs, B = 2 obs, etc.
Residual
5
4
3
2
1
0
-1
-2
-3
32.234
32.280
32.325
32.370
32.415
32.461
32.506
32.551
32.596
32.642
Predicted Value of HDDT