

Regression Analysis Using Statgraphics Centurion

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Outline

- Regression Models
- Examples – Single X
 - Simple regression
 - Nonlinear models
 - Calibration
 - Comparison of regression lines
- Examples – Multiple X
 - Regression model selection (stepwise, all possible)
 - Logistic regression
 - Poisson regression



Regression Model Setup

- Dependent variable: Y
- Independent variable(s): X_1, X_2, \dots, X_k
- Error term: ε

Model: $Y = f(X_1, X_2, \dots, X_k) + \varepsilon$



Types of Regression Models (#1)

Procedure	Dependent variable	Independent variables
Simple Regression	continuous	1 continuous
Polynomial Regression	continuous	1 continuous
Box-Cox Transformations	continuous	1 continuous
Calibration Models	continuous	1 continuous
Comparison of Regression Lines	continuous	1 continuous and 1 categorical

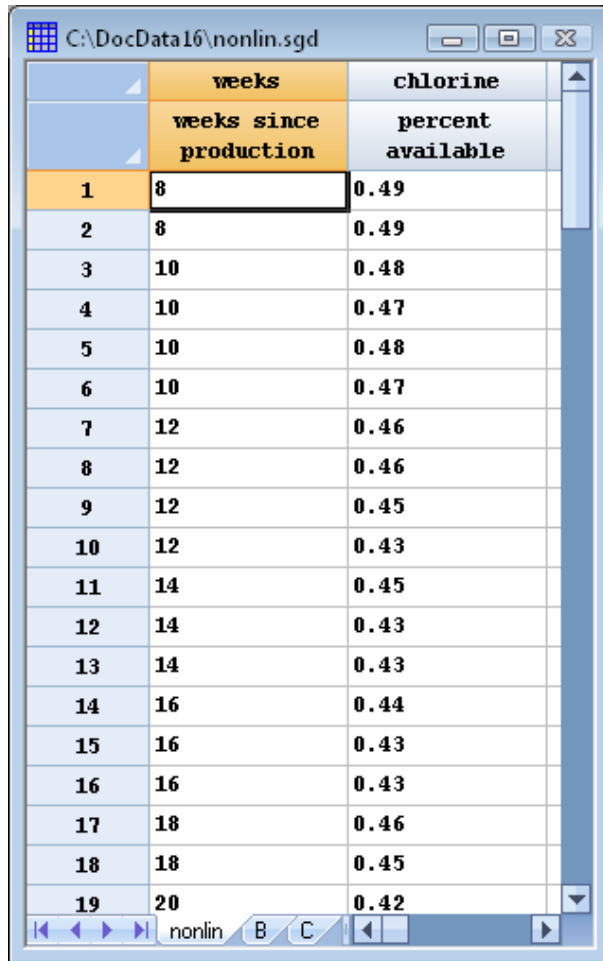
Types of Regression Models (#2)

Procedure	Dependent variable	Independent variables
Multiple Regression	continuous	2+ continuous
Regression Model Selection	continuous	2+ continuous
Nonlinear Regression	continuous	1+ continuous
Ridge Regression	continuous	2+ continuous
Partial Least Squares	continuous	2+ continuous
General Linear Models	1+ continuous	2+ continuous or categorical variables

Types of Regression Models (#3)

Procedure	Dependent variable	Independent variables
Logistic Regression	proportions	1+ continuous or categorical
Probit Analysis	proportions	1+ continuous or categorical
Poisson Regression	counts	1+ continuous or categorical
Negative Binomial Regression	counts	1+ continuous or categorical
Life Data - Parametric Models	failure times	1+ continuous or categorical

Example 1: Stability study



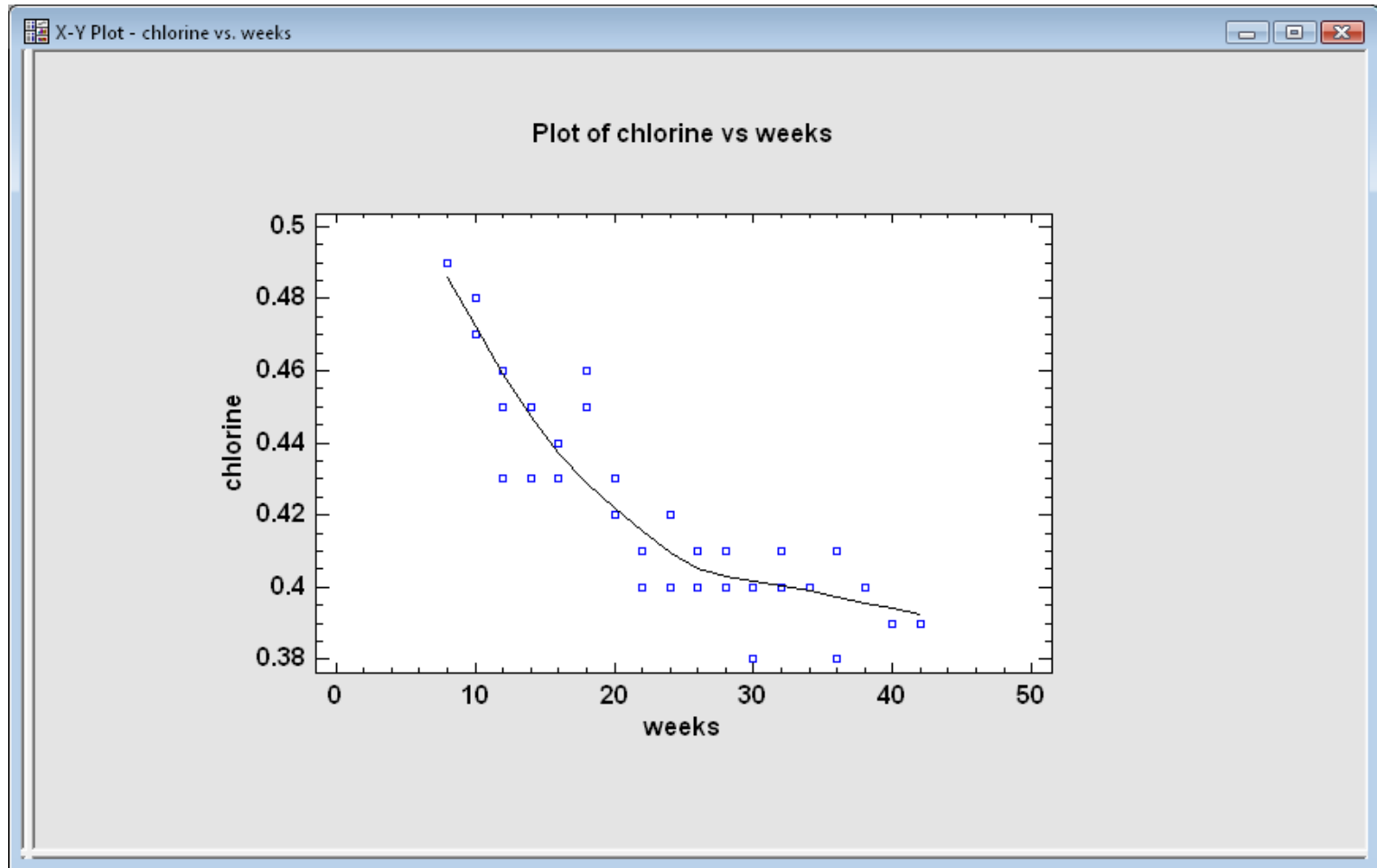
	weeks	chlorine
	weeks since production	percent available
1	8	0.49
2	8	0.49
3	10	0.48
4	10	0.47
5	10	0.48
6	10	0.47
7	12	0.46
8	12	0.46
9	12	0.45
10	12	0.43
11	14	0.45
12	14	0.43
13	14	0.43
14	16	0.44
15	16	0.43
16	16	0.43
17	18	0.46
18	18	0.45
19	20	0.42

Y: percent of available chlorine

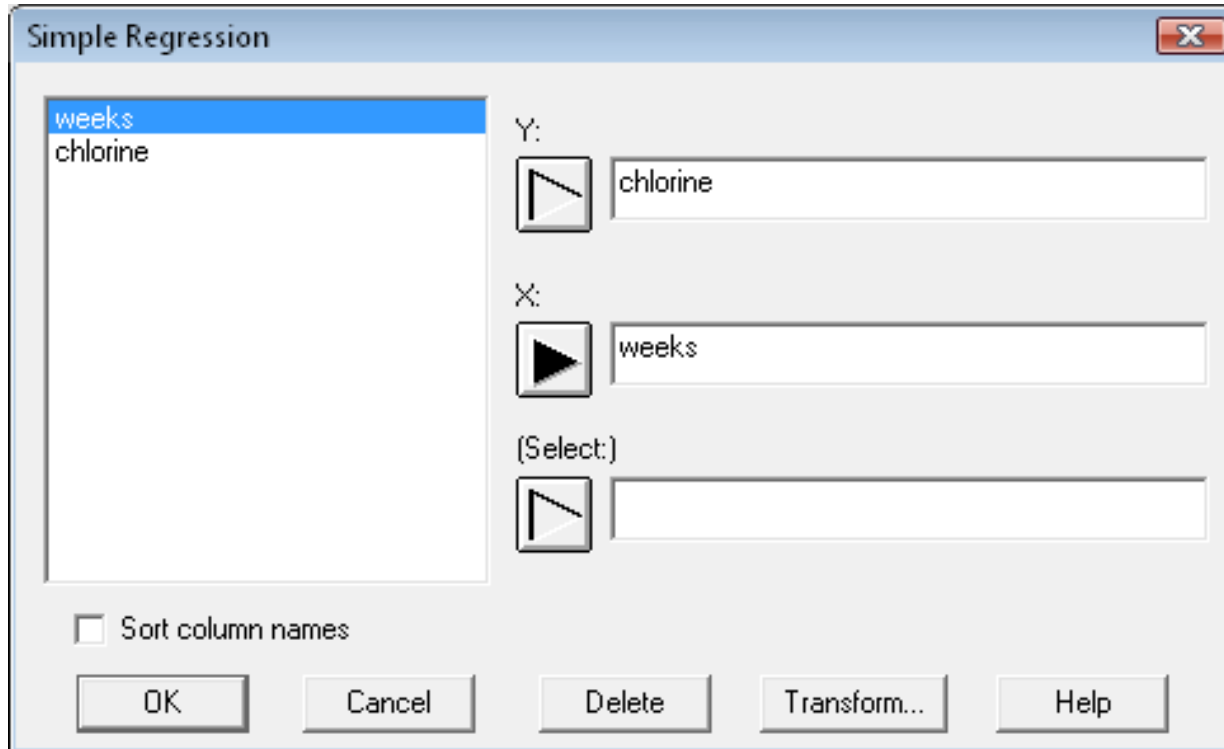
X: number of weeks since production

Lower acceptable limit for Y: 0.40

X-Y Scatterplot with Smooth



Simple Regression



Analysis Options

Simple Regression Options

Type of Model

<input checked="" type="radio"/> Linear	<input type="radio"/> Squared-Y Square Root-X	<input type="radio"/> Double Reciprocal
<input type="radio"/> Square Root-Y	<input type="radio"/> Logarithmic-X	<input type="radio"/> Squared-Y Reciprocal-X
<input type="radio"/> Exponential	<input type="radio"/> Square Root-Y Log-X	<input type="radio"/> Squared-X
<input type="radio"/> Reciprocal-Y	<input type="radio"/> Multiplicative	<input type="radio"/> Square Root-Y Squared-X
<input type="radio"/> Squared-Y	<input type="radio"/> Reciprocal-Y Log-X	<input type="radio"/> Log-Y Squared-X
<input type="radio"/> Square Root-X	<input type="radio"/> Squared-Y Log-X	<input type="radio"/> Reciprocal-Y Squared-X
<input type="radio"/> Double Square Root	<input type="radio"/> Reciprocal-X	<input type="radio"/> Double Squared
<input type="radio"/> Log-Y Square Root-X	<input type="radio"/> Square Root-Y Reciprocal-X	<input type="radio"/> Logistic
<input type="radio"/> Reciprocal-Y Square Root-X	<input type="radio"/> S-Curve	<input type="radio"/> Log Probit

Include constant

Alternative Fit

<input checked="" type="radio"/> None (least squares only)
<input type="radio"/> Minimize absolute deviations
<input type="radio"/> Use medians of 3 groups

OK Cancel Help



Tables and Graphs

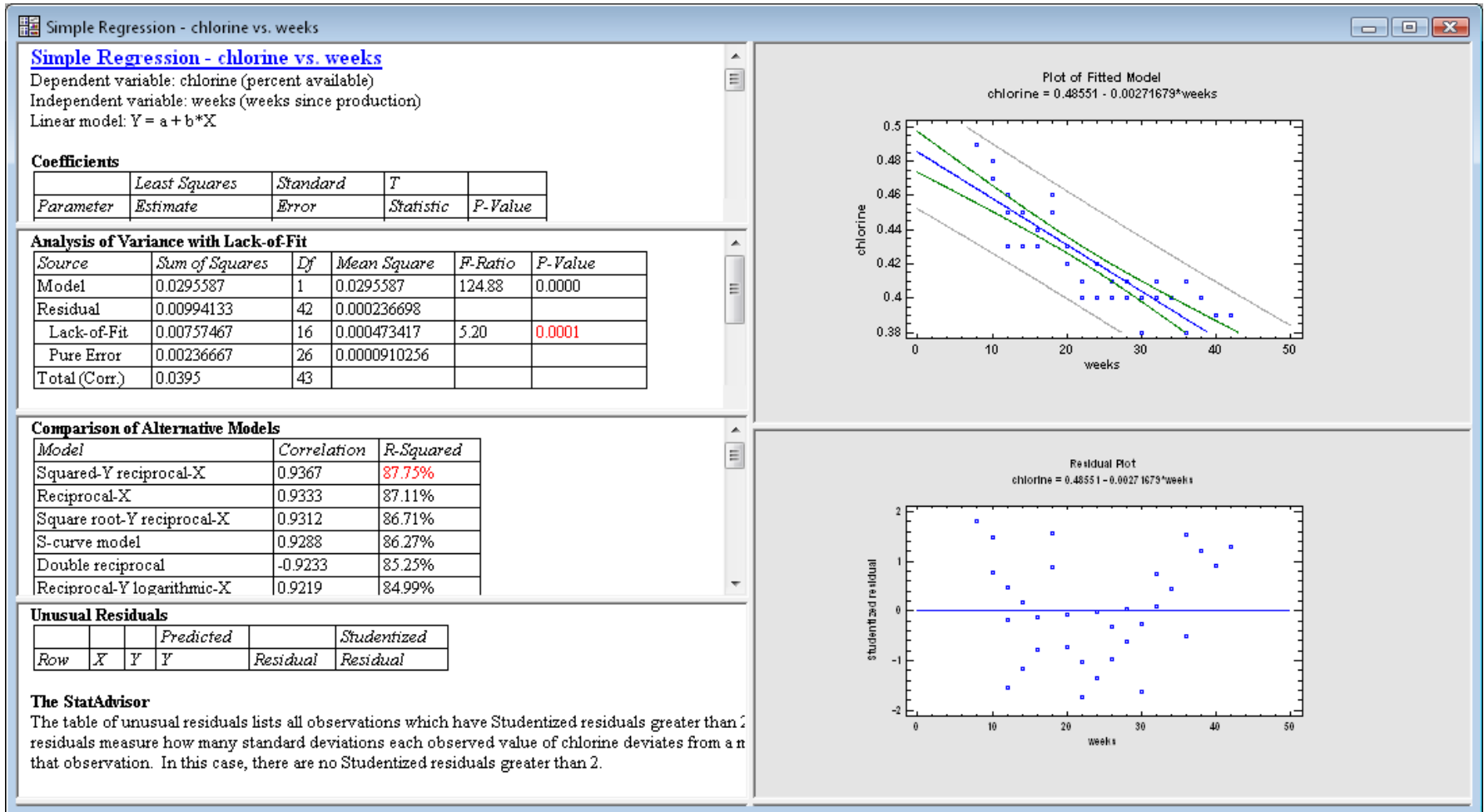
Tables and Graphs

TABLES	GRAPHS
<input checked="" type="checkbox"/> Analysis Summary	<input checked="" type="checkbox"/> Plot of Fitted Model
<input checked="" type="checkbox"/> Lack-of-Fit Test	<input type="checkbox"/> Observed versus Predicted
<input type="checkbox"/> Forecasts	<input checked="" type="checkbox"/> Residuals versus X
<input checked="" type="checkbox"/> Comparison of Alternative Models	<input type="checkbox"/> Residuals versus Predicted
<input checked="" type="checkbox"/> Unusual Residuals	<input type="checkbox"/> Residuals versus Row Number
<input type="checkbox"/> Influential Points	

OK
Cancel
All
Store
Help



Analysis Window



Analysis Summary

Simple Regression - chlorine vs. weeks

Simple Regression - chlorine vs. weeks
Dependent variable: chlorine (percent available)
Independent variable: weeks (weeks since production)
Linear model: $Y = a + b \cdot X$

Coefficients

	<i>Least Squares</i>	<i>Standard</i>	<i>T</i>	
<i>Parameter</i>	<i>Estimate</i>	<i>Error</i>	<i>Statistic</i>	<i>P-Value</i>
Intercept	0.48551	0.00589066	82.4204	0.0000
Slope	-0.00271679	0.000243115	-11.1749	0.0000

Analysis of Variance

<i>Source</i>	<i>Sum of Squares</i>	<i>Df</i>	<i>Mean Square</i>	<i>F-Ratio</i>	<i>P-Value</i>
Model	0.0295587	1	0.0295587	124.88	0.0000
Residual	0.00994133	42	0.000236698		
Total (Corr.)	0.0395	43			

Correlation Coefficient = -0.865055
R-squared = 74.8321 percent
R-squared (adjusted for d.f.) = 74.2328 percent
Standard Error of Est. = 0.015385
Mean absolute error = 0.012834
Durbin-Watson statistic = 0.992081 (P=0.0001)
Lag 1 residual autocorrelation = 0.451981

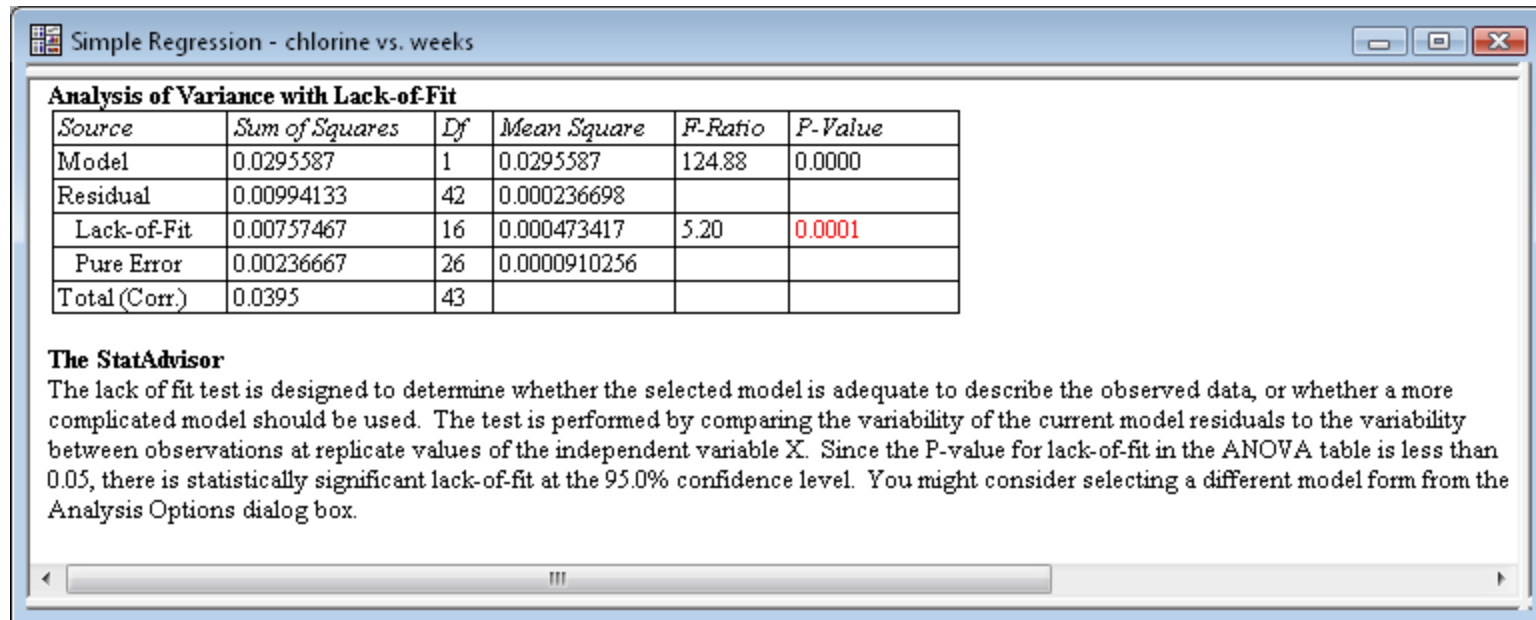
The StatAdvisor
The output shows the results of fitting a linear model to describe the relationship between chlorine and weeks. The equation of the fitted model is

$$\text{chlorine} = 0.48551 - 0.00271679 \cdot \text{weeks}$$

Since the P-value in the ANOVA table is less than 0.05, there is a statistically significant relationship between chlorine and weeks at the 95.0% confidence level.



Lack-of-Fit Test



The screenshot shows a software window titled "Simple Regression - chlorine vs. weeks". Inside the window, there is a table titled "Analysis of Variance with Lack-of-Fit". The table has six columns: Source, Sum of Squares, Df, Mean Square, F-Ratio, and P-Value. The rows are Model, Residual, Lack-of-Fit, Pure Error, and Total (Corr.). The P-value for Lack-of-Fit is highlighted in red as 0.0001. Below the table, there is a section titled "The StatAdvisor" with a paragraph of text explaining the lack-of-fit test.

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0.0295587	1	0.0295587	124.88	0.0000
Residual	0.00994133	42	0.000236698		
Lack-of-Fit	0.00757467	16	0.000473417	5.20	0.0001
Pure Error	0.00236667	26	0.0000910256		
Total (Corr.)	0.0395	43			

The StatAdvisor
The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is less than 0.05, there is statistically significant lack-of-fit at the 95.0% confidence level. You might consider selecting a different model form from the Analysis Options dialog box.

Comparison of Alternative Models

Simple Regression - chlorine vs. weeks

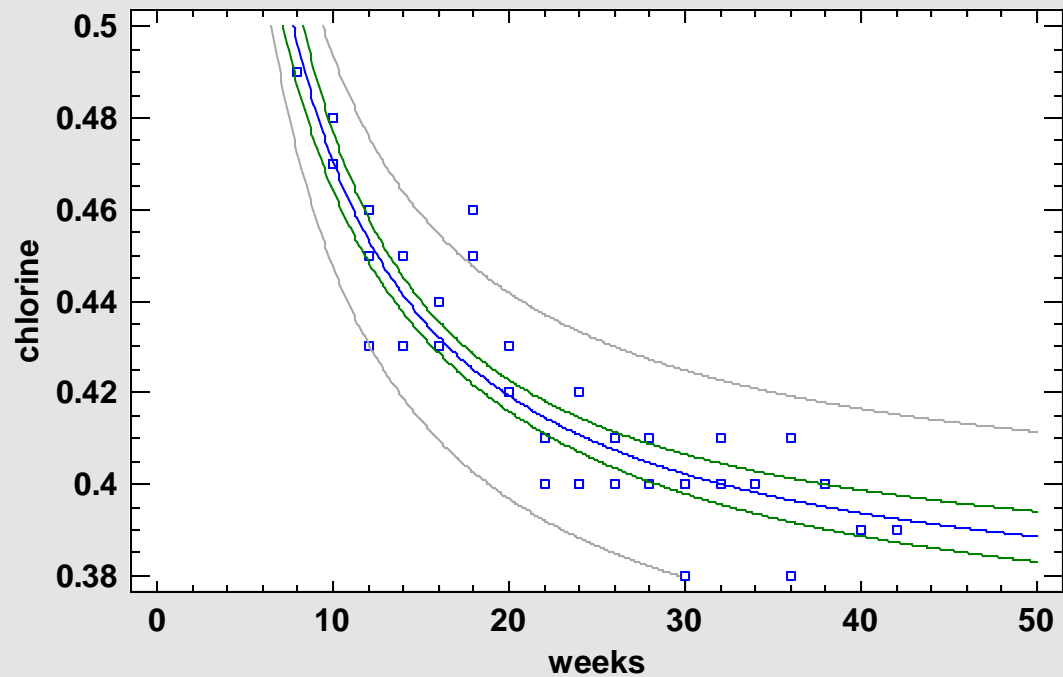
Comparison of Alternative Models

Model	Correlation	R-Squared
Squared-Y reciprocal-X	0.9367	87.75%
Reciprocal-X	0.9333	87.11%
Square root-Y reciprocal-X	0.9312	86.71%
S-curve model	0.9288	86.27%
Double reciprocal	-0.9233	85.25%
Reciprocal-Y logarithmic-X	0.9219	84.99%
Multiplicative	-0.9218	84.98%
Logarithmic-X	-0.9207	84.77%
Squared-Y logarithmic-X	-0.9185	84.36%
Reciprocal-Y square root-X	0.9038	81.69%
Logarithmic-Y square root-X	-0.9012	81.21%
Square root-X	-0.8974	80.54%
Squared-Y square root-X	-0.8926	79.68%
Reciprocal-Y	0.8759	76.73%
Exponential	-0.8710	75.87%
Square root-Y	-0.8682	75.37%
Logistic	-0.8665	75.08%
Log probit	-0.8662	75.03%
Linear	-0.8651	74.83%
Squared-Y	-0.8581	73.63%
Reciprocal-Y squared-X	0.8023	64.37%
Logarithmic-Y squared-X	-0.7941	63.05%
Square root-Y squared-X	-0.7896	62.34%
Squared-X	-0.7849	61.60%
Double squared	-0.7748	60.04%
Double square root	<no fit>	
Square root-Y logarithmic-X	<no fit>	



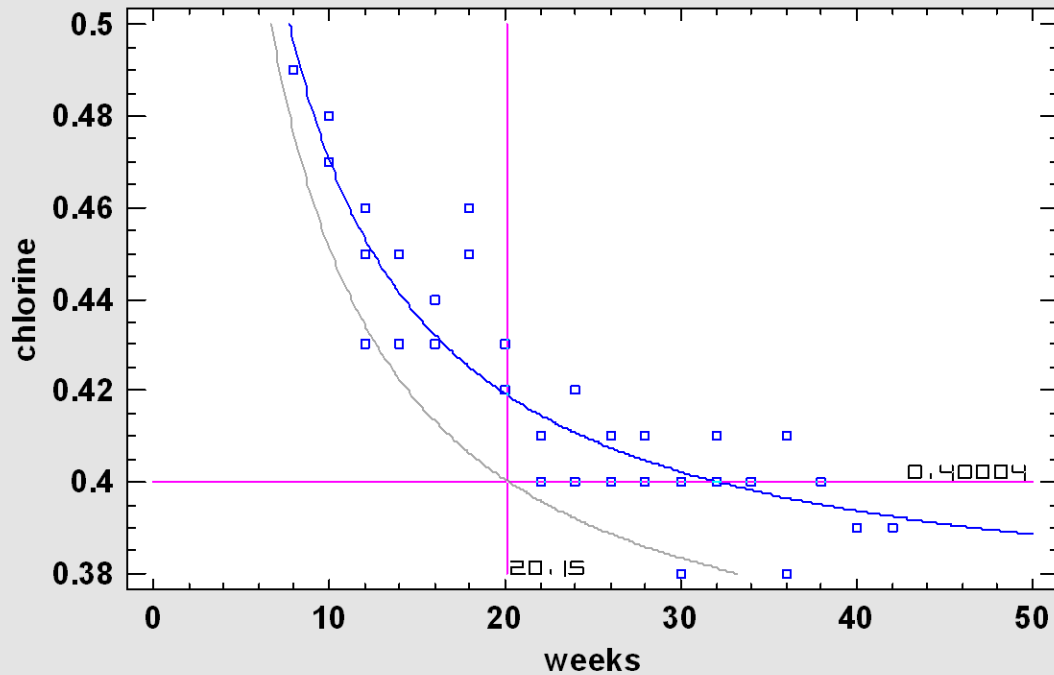
Fitted Reciprocal-X Model

Plot of Fitted Model
 $\text{chlorine} = 0.368053 + 1.02553/\text{weeks}$



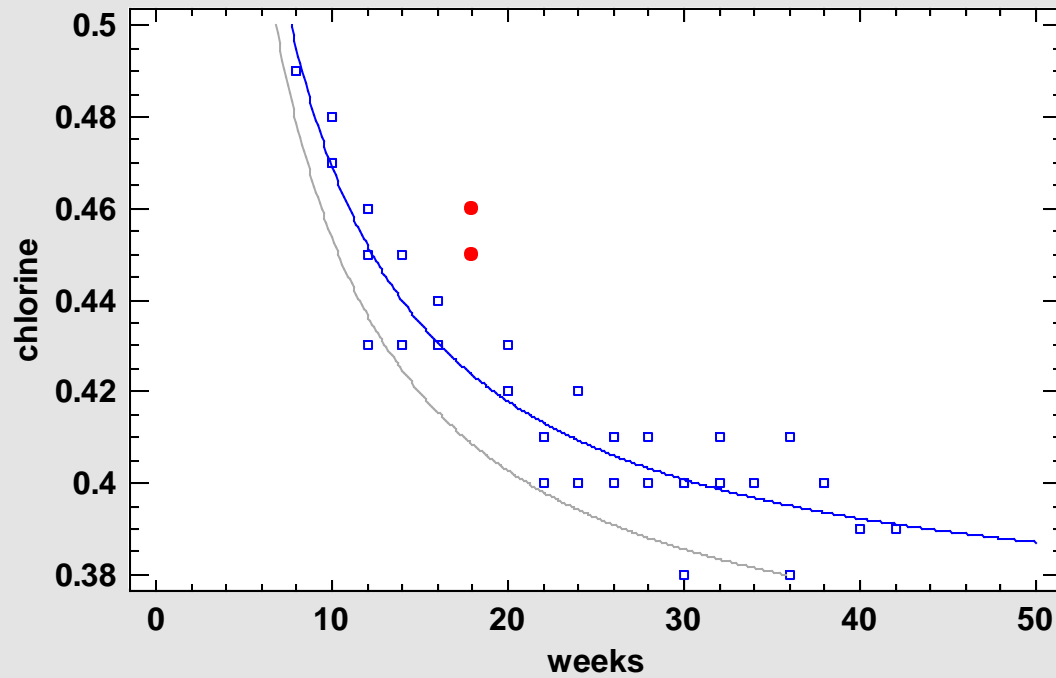
Lower 95% Prediction Limit

Plot of Fitted Model
 $\text{chlorine} = 0.368053 + 1.02553/\text{weeks}$



Outlier Removal

Plot of Fitted Model
 $\text{chlorine} = 0.366628 + 1.02548/\text{weeks}$



Example 2: Nonlinear Regression

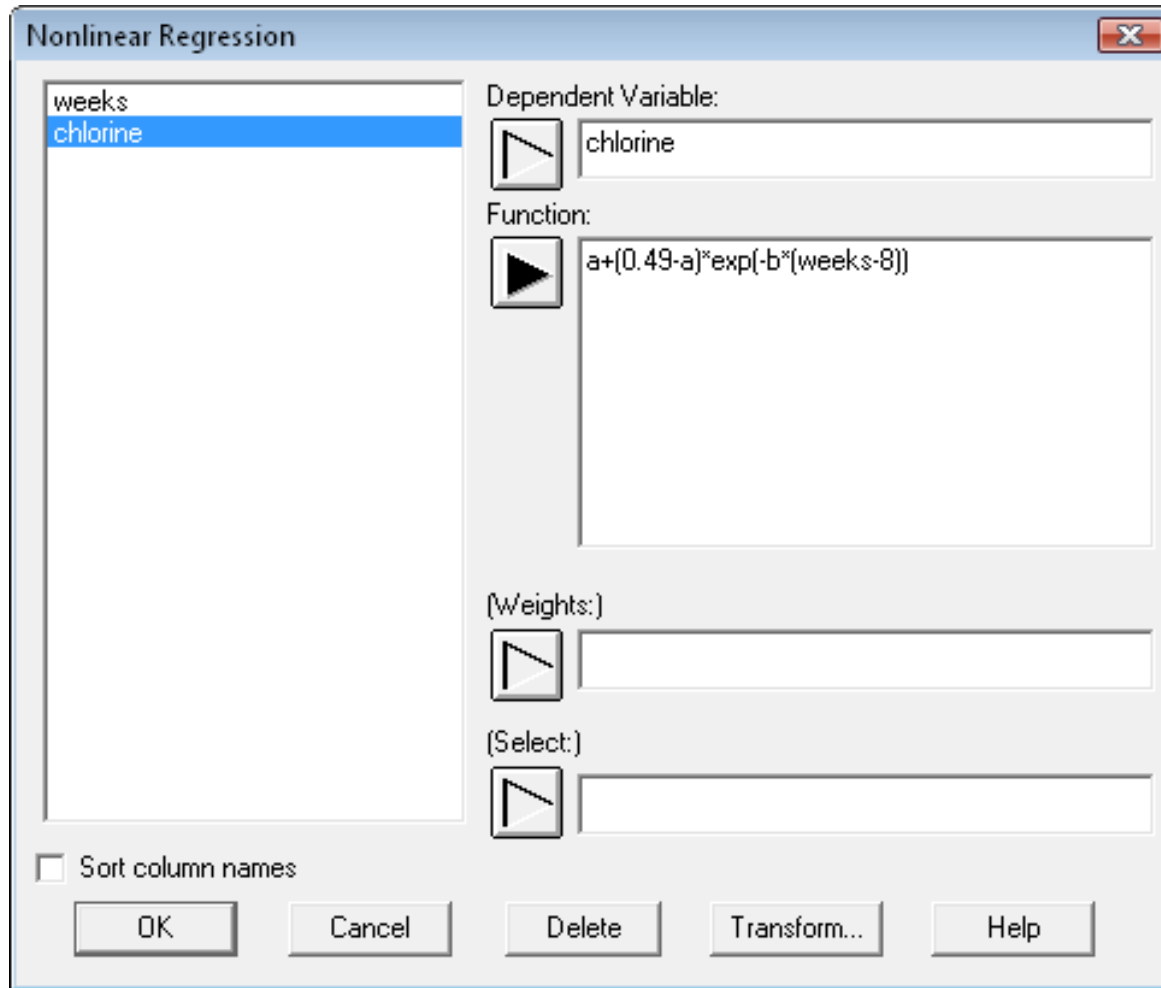
Draper and Smith in Applied Regression Analysis suggest fitting a model of the form

$$Y = a + (0.49-a)\exp[-b(x-8)]$$

Since the model is nonlinear in the parameters, it requires a search procedure to find the best solution.



Data Input Dialog Box



Initial Parameter Estimates

Initial Parameter Estimates

a:

0.1

b:

0.1

OK

Cancel

Help



Analysis Options

Nonlinear Regression Options [X]

Estimation

Stopping Criterion 1:

Stopping Criterion 2:

Maximum Iterations:

Maximum Function Calls:

Confidence Level:

Method

Marquardt
 Gauss-Newton
 Steepest Descent

Marquardt Parameter

Initial Value:

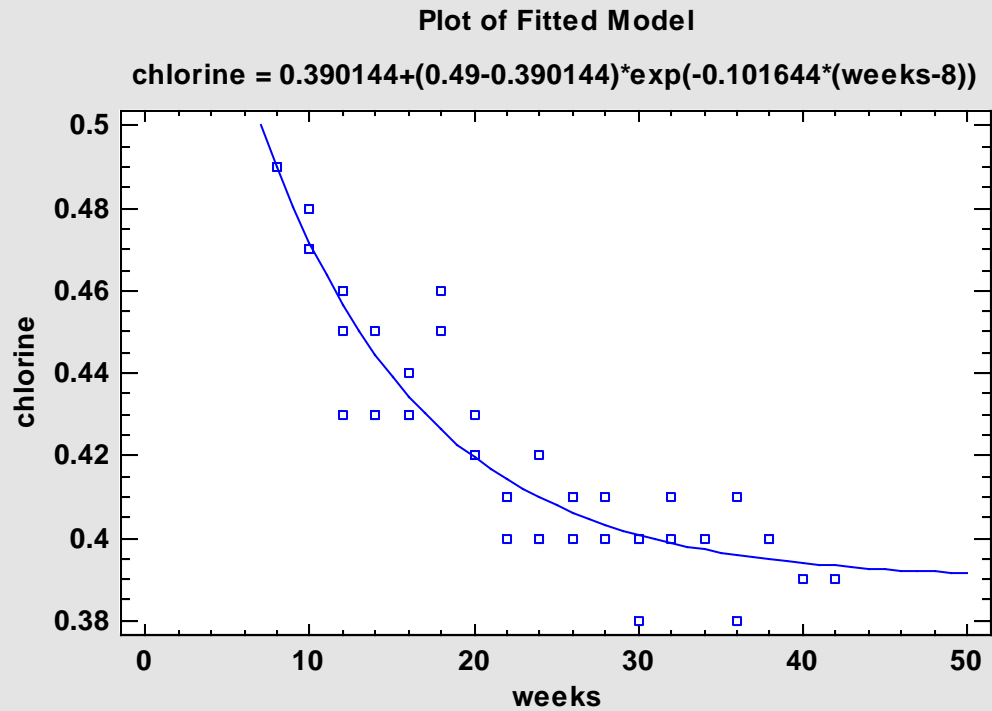
Scaling Factor:

Maximum Value:

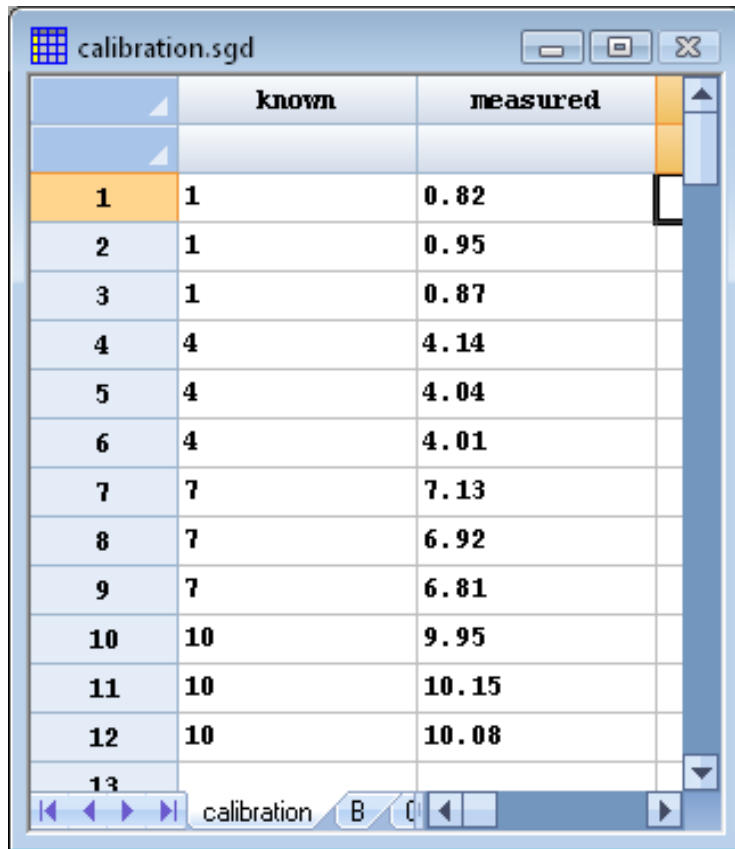
OK
Cancel
Help



Plot of Fitted Model



Example 3: Calibration



The screenshot shows a spreadsheet window titled "calibration.sgd" with a table containing 13 rows of data. The first two columns are labeled "known" and "measured". The data points are as follows:

	known	measured
1	1	0.82
2	1	0.95
3	1	0.87
4	4	4.14
5	4	4.04
6	4	4.01
7	7	7.13
8	7	6.92
9	7	6.81
10	10	9.95
11	10	10.15
12	10	10.08
13		

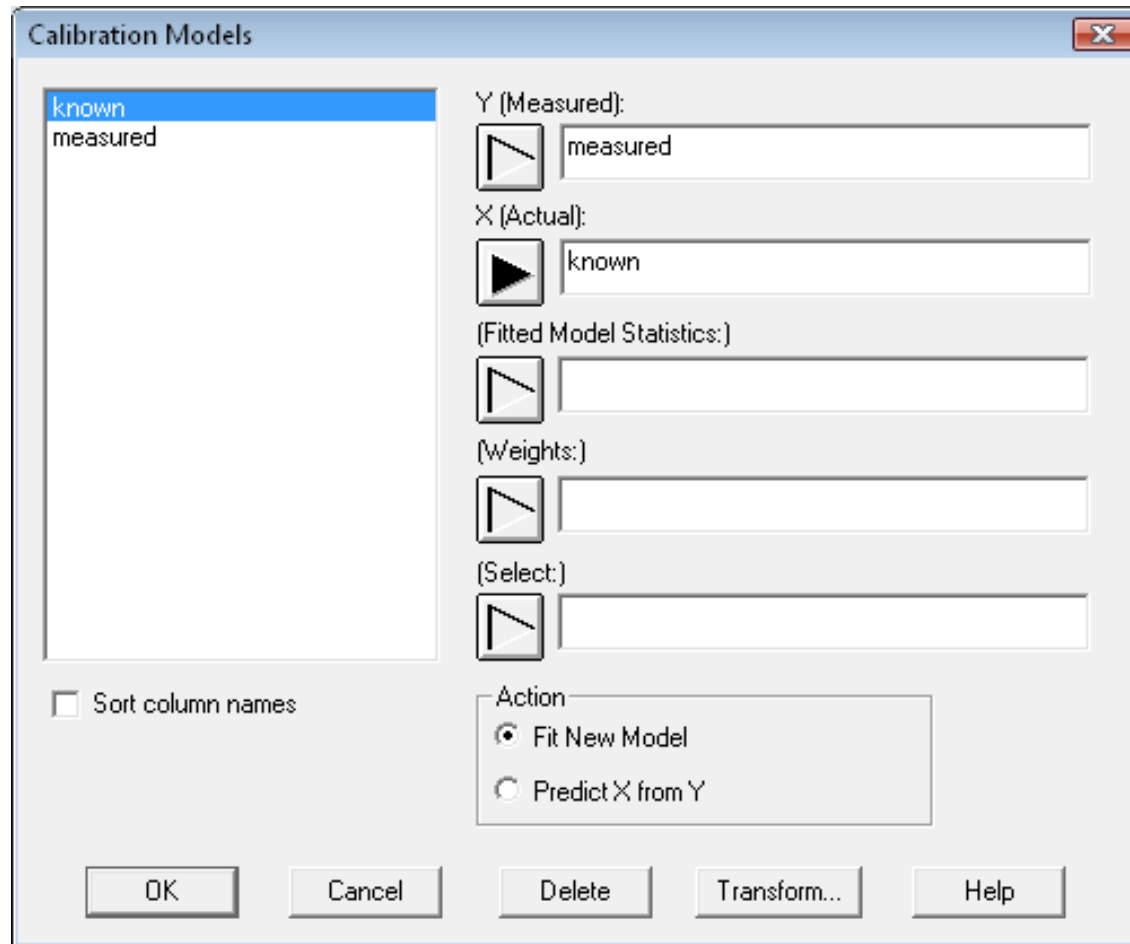
The general calibration problem is that of determining the likely value of X given an observed value of Y .

Typically: X = item characteristic, Y = measured value

Step 1: Build a regression model using samples with known values of X (“golden samples”).

Step 2: For another sample with unknown X , predict X from Y .

Data Input Dialog Box



Reverse Prediction

Plot of Fitted Model Options

Prediction Limits
 Confidence Limits

Confidence Level:
95.0

Predict
 Y
 X

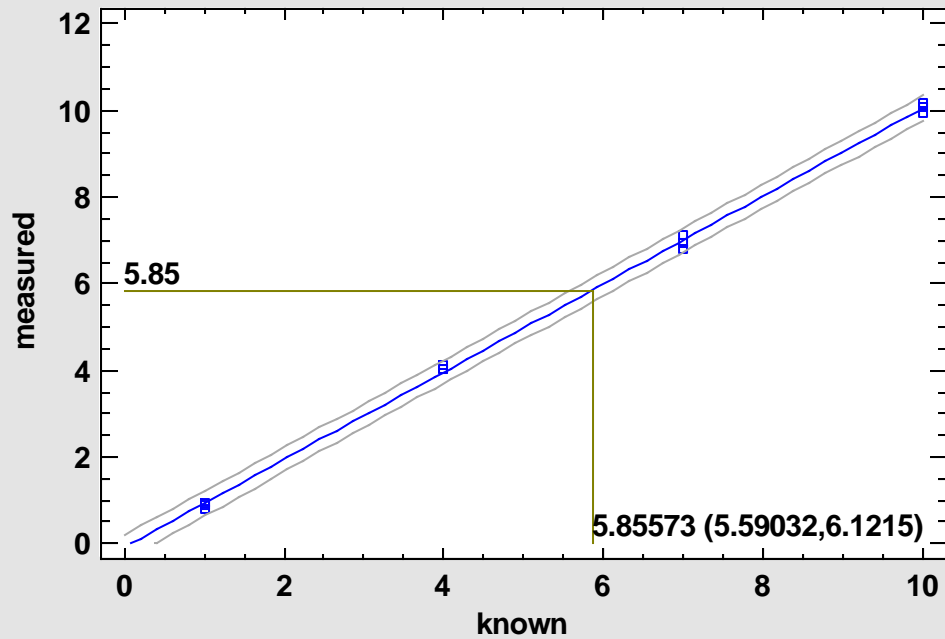
At:
5.85

Mean Size or Weight:
1.0

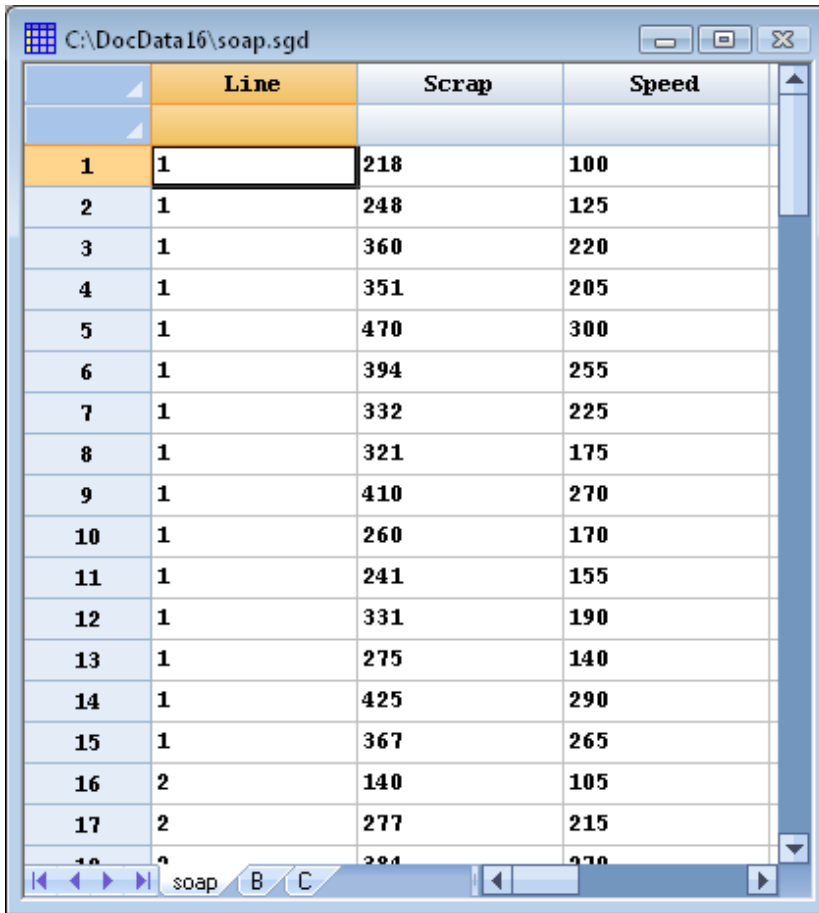
OK
Cancel
Help

Plot of Fitted Model

Plot of Fitted Model
 $\text{measured} = -0.0896667 + 1.01433 \cdot \text{known}$



Example 4: Comparison of Regression Lines



The screenshot shows a spreadsheet window titled 'C:\DocData16\soap.sgd'. The spreadsheet contains data for 18 rows, grouped into two levels (Line 1 and Line 2). The columns are 'Line', 'Scrap', and 'Speed'. The data is as follows:

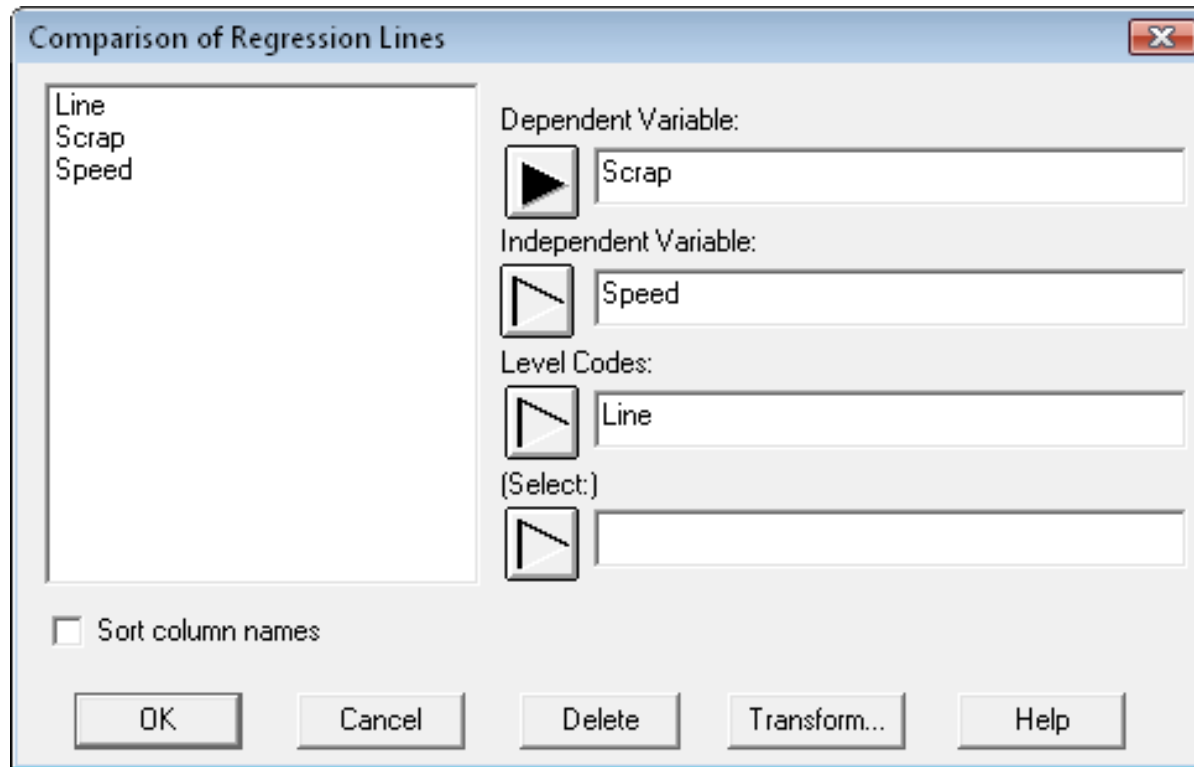
	Line	Scrap	Speed
1	1	218	100
2	1	248	125
3	1	360	220
4	1	351	205
5	1	470	300
6	1	394	255
7	1	332	225
8	1	321	175
9	1	410	270
10	1	260	170
11	1	241	155
12	1	331	190
13	1	275	140
14	1	425	290
15	1	367	265
16	2	140	105
17	2	277	215
18	2	284	270

Y: amount of scrap produced

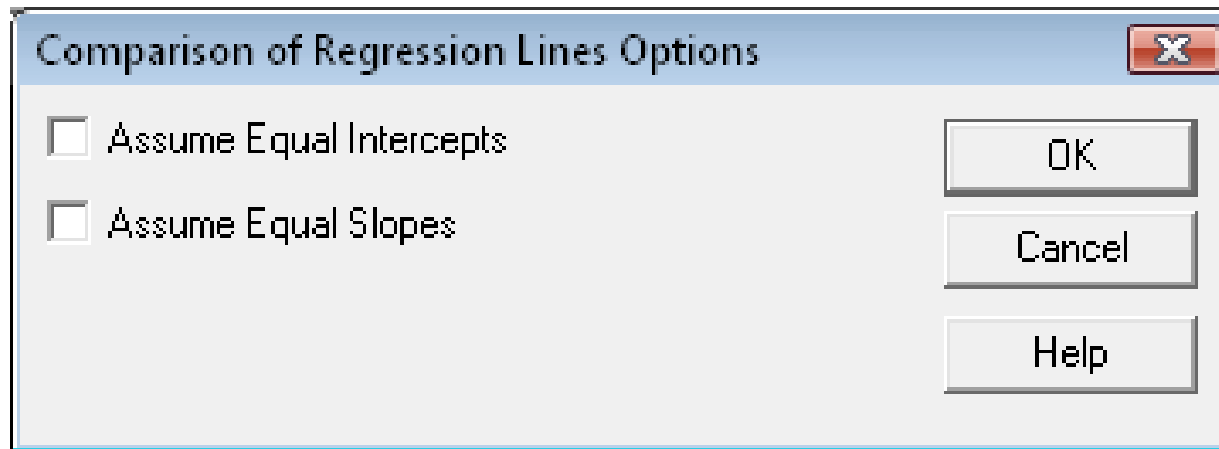
X: production line speed

Levels: line number

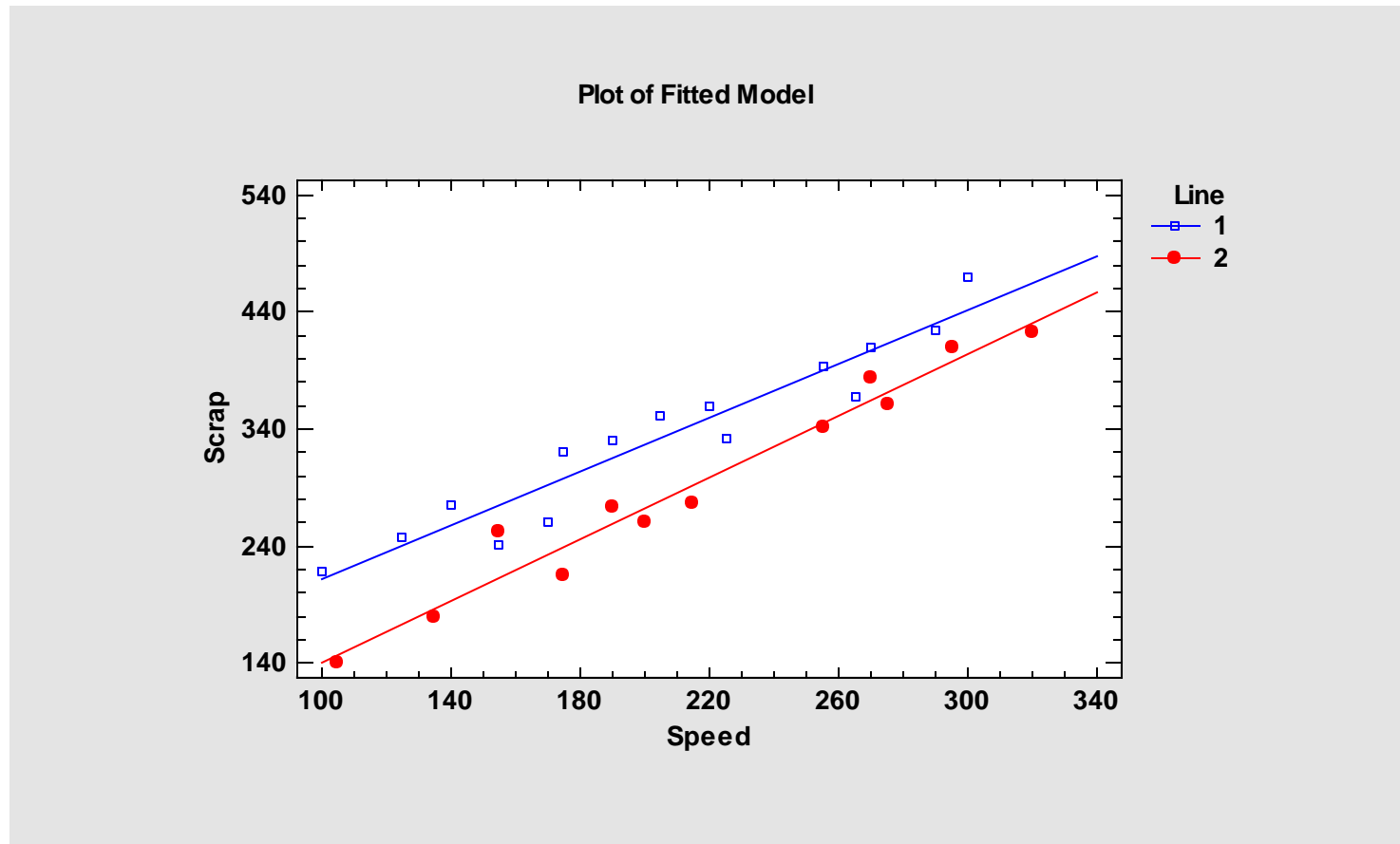
Data Input Dialog Box



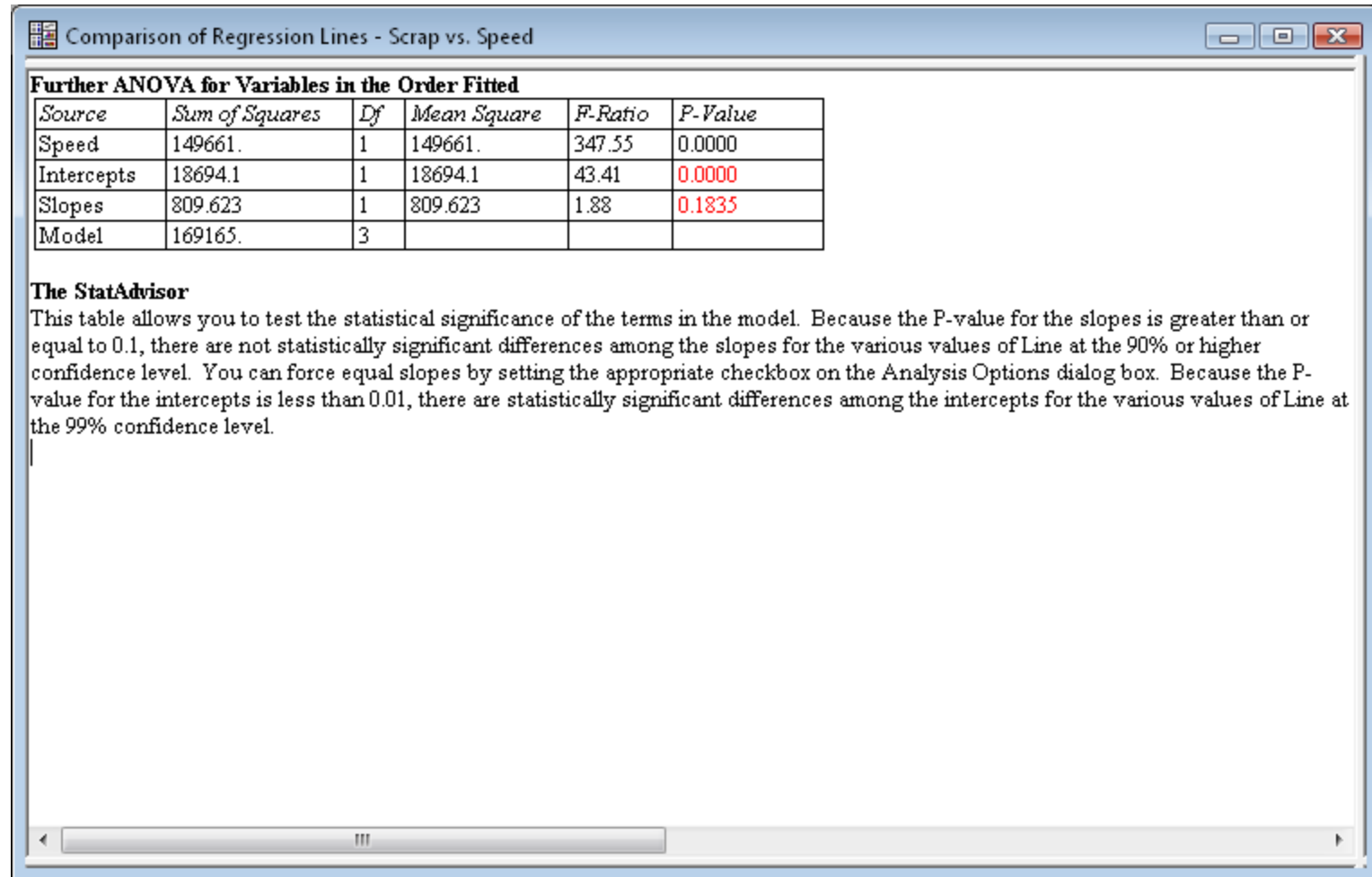
Analysis Options



Plot of Fitted Model



Significance Tests



Comparison of Regression Lines - Scrap vs. Speed

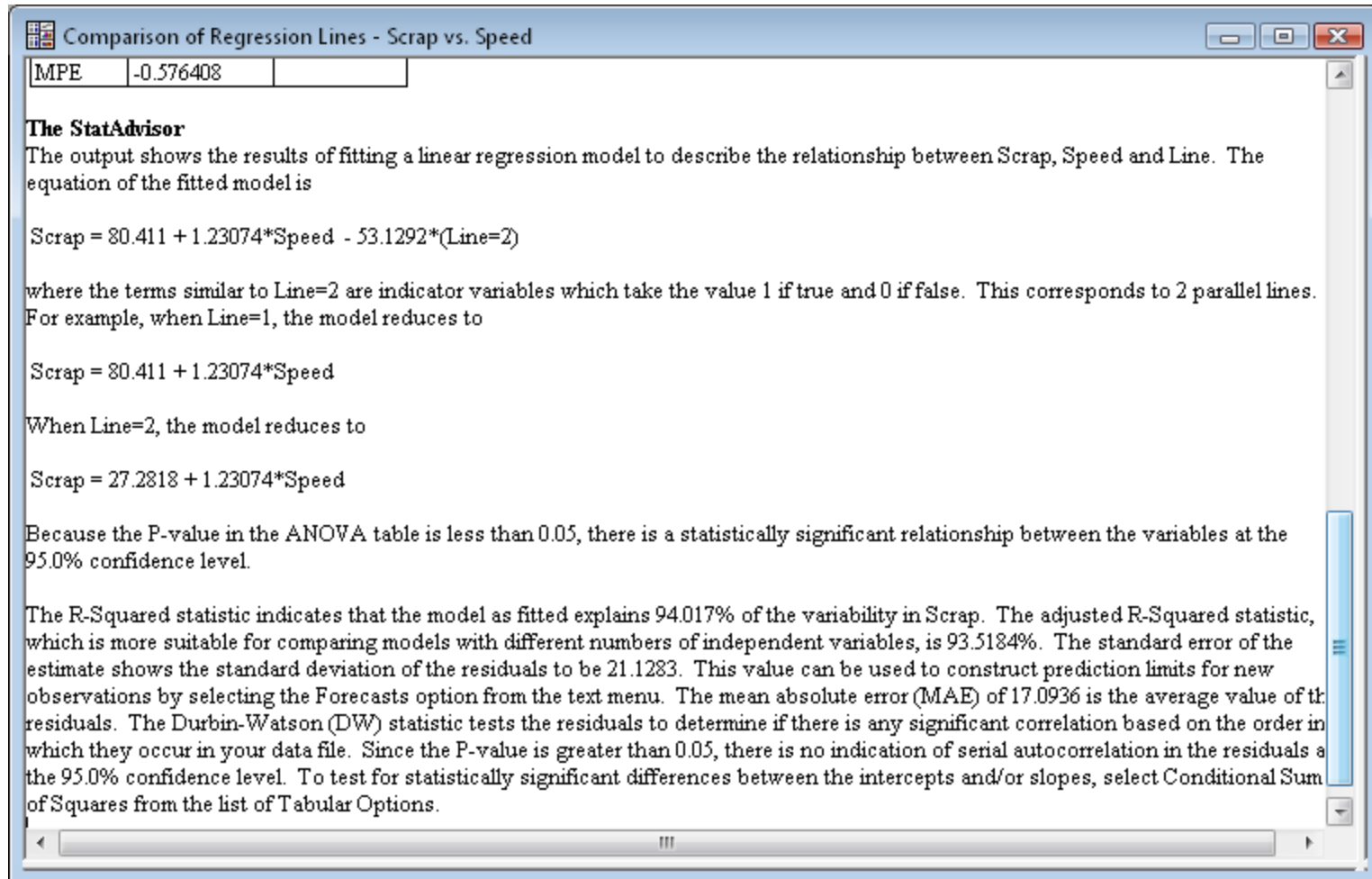
Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Speed	149661.	1	149661.	347.55	0.0000
Intercepts	18694.1	1	18694.1	43.41	0.0000
Slopes	809.623	1	809.623	1.88	0.1835
Model	169165.	3			

The StatAdvisor

This table allows you to test the statistical significance of the terms in the model. Because the P-value for the slopes is greater than or equal to 0.1, there are not statistically significant differences among the slopes for the various values of Line at the 90% or higher confidence level. You can force equal slopes by setting the appropriate checkbox on the Analysis Options dialog box. Because the P-value for the intercepts is less than 0.01, there are statistically significant differences among the intercepts for the various values of Line at the 99% confidence level.

Parallel Slope Model



MPE -0.576408

The StatAdvisor

The output shows the results of fitting a linear regression model to describe the relationship between Scrap, Speed and Line. The equation of the fitted model is

$$\text{Scrap} = 80.411 + 1.23074 * \text{Speed} - 53.1292 * (\text{Line}=2)$$

where the terms similar to Line=2 are indicator variables which take the value 1 if true and 0 if false. This corresponds to 2 parallel lines. For example, when Line=1, the model reduces to

$$\text{Scrap} = 80.411 + 1.23074 * \text{Speed}$$

When Line=2, the model reduces to

$$\text{Scrap} = 27.2818 + 1.23074 * \text{Speed}$$

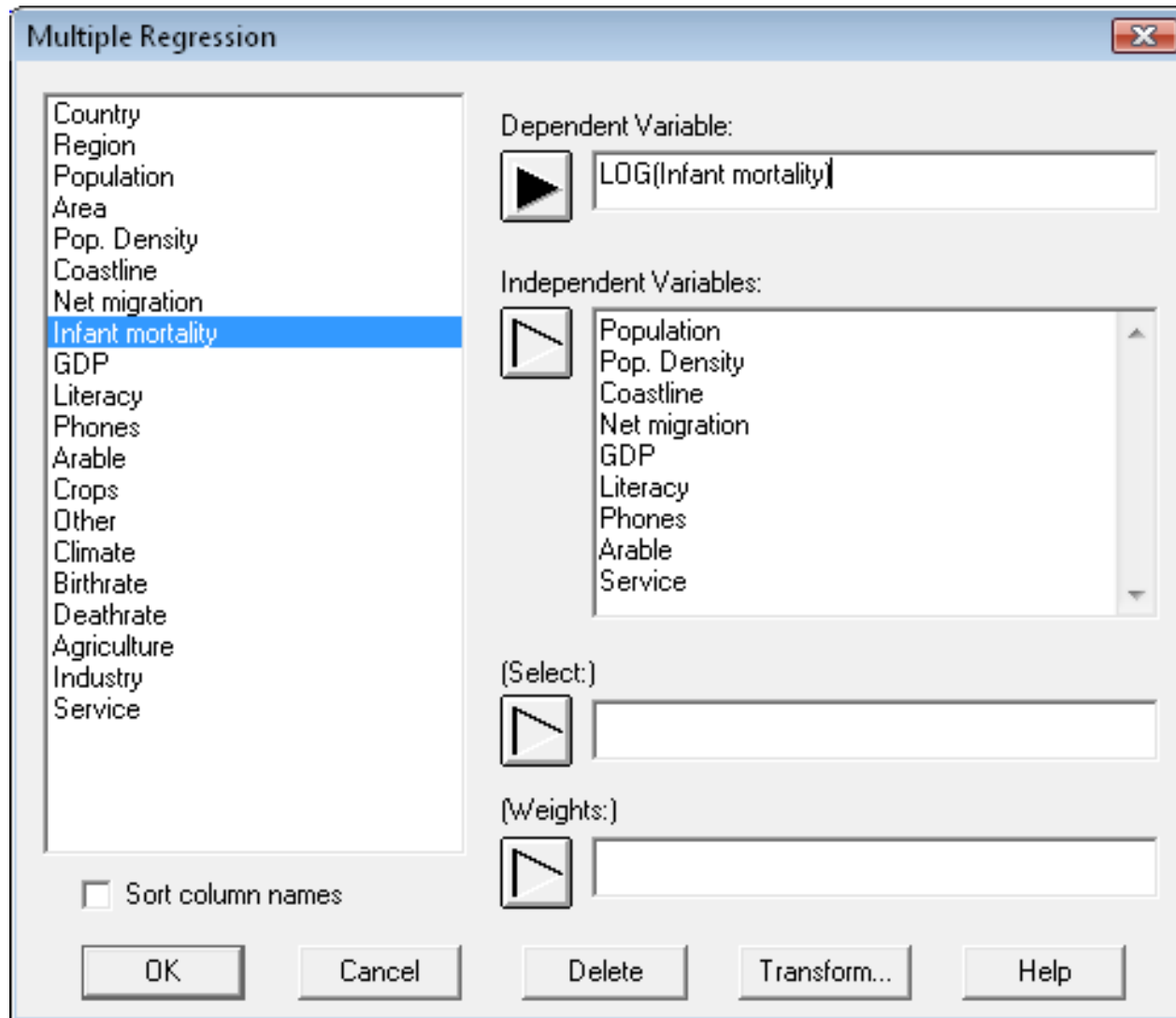
Because the P-value in the ANOVA table is less than 0.05, there is a statistically significant relationship between the variables at the 95.0% confidence level.

The R-Squared statistic indicates that the model as fitted explains 94.017% of the variability in Scrap. The adjusted R-Squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 93.5184%. The standard error of the estimate shows the standard deviation of the residuals to be 21.1283. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu. The mean absolute error (MAE) of 17.0936 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals at the 95.0% confidence level. To test for statistically significant differences between the intercepts and/or slopes, select Conditional Sum of Squares from the list of Tabular Options.

Example 5: Multiple Regression

	Country	Region	Population	Area	Pop. Density	Coastline	Net migration	Infant mortality	
				sq. mi.	per sq. mi.	coast/area ratio		per 1000 births	\$ P
1	Afghanistan	ASIA (EX. NEAR	31056997	647500	48.0	0.00	23.06	163.07	700
2	Albania	EASTERN EUROPE	3581655	28748	124.6	1.26	-4.93	21.52	4500
3	Algeria	NORTHERN AFRICA	32930091	2381740	13.8	0.04	-0.39	31	6000
4	American Samoa	OCEANIA	57794	199	290.4	58.29	-20.71	9.27	8000
5	Andorra	WESTERN EUROPE	71201	468	152.1	0.00	6.6	4.05	1900
6	Angola	SUB-SAHARAN AFRICA	12127071	1246700	9.7	0.13	0	191.19	1900
7	Anguilla	LATIN AMER. & CARIBBEAN	13477	102	132.1	59.80	10.76	21.03	8600
8	Antigua & Barbuda	LATIN AMER. & CARIBBEAN	69108	443	156.0	34.54	-6.15	19.46	1100
9	Argentina	LATIN AMER. & CARIBBEAN	39921833	2766890	14.4	0.18	0.61	15.18	1120
10	Armenia	C.W. OF INDEPENDENT STATES	2976372	29800	99.9	0.00	-6.47	23.28	3500
11	Aruba	LATIN AMER. & CARIBBEAN	71891	193	372.5	35.49	0	5.89	2800
12	Australia	OCEANIA	20264082	7686850	2.6	0.34	3.98	4.69	2900
13	Austria	WESTERN EUROPE	8192880	83870	97.7	0.00	2	4.66	3000
14	Azerbaijan	C.W. OF INDEPENDENT STATES	7961619	86600	91.9	0.00	-4.9	81.74	3400
15	Bahamas, The	LATIN AMER. & CARIBBEAN	303770	13940	21.8	25.41	-2.2	25.21	1670
16	Bahrain	NEAR EAST	698585	665	1050.5	24.21	1.05	17.27	1690
17	Bangladesh	ASIA (EX. NEAR EAST)	147365352	144000	1023.4	0.40	-0.71	62.6	1900
18	Barbados	LATIN AMER. & CARIBBEAN	279912	431	649.5	22.51	-0.31	12.5	1570
19	Belarus	C.W. OF INDEPENDENT STATES	10293011	207600	49.6	0.00	2.54	13.37	6100
20	Belgium	WESTERN EUROPE	10379067	30528	340.0	0.22	1.23	4.68	2910

Stepwise Regression



Analysis Options

Multiple Regression Options

Ordinary Least Squares

Forward Stepwise Selection

Backward Stepwise Selection

Box-Cox Optimization

Cochrane-Orcutt Optimization

Constant in Model

Transformations

Power: 1.0

Addend: 0

Autocorrelation: 0

Stepwise Regression

Selection Criterion

F-Ratio

P-Value

Max. Steps: 50

Display all steps

F-to-Enter: 4.0

F-to-Remove: 4.0

P-to-Enter: 0.05

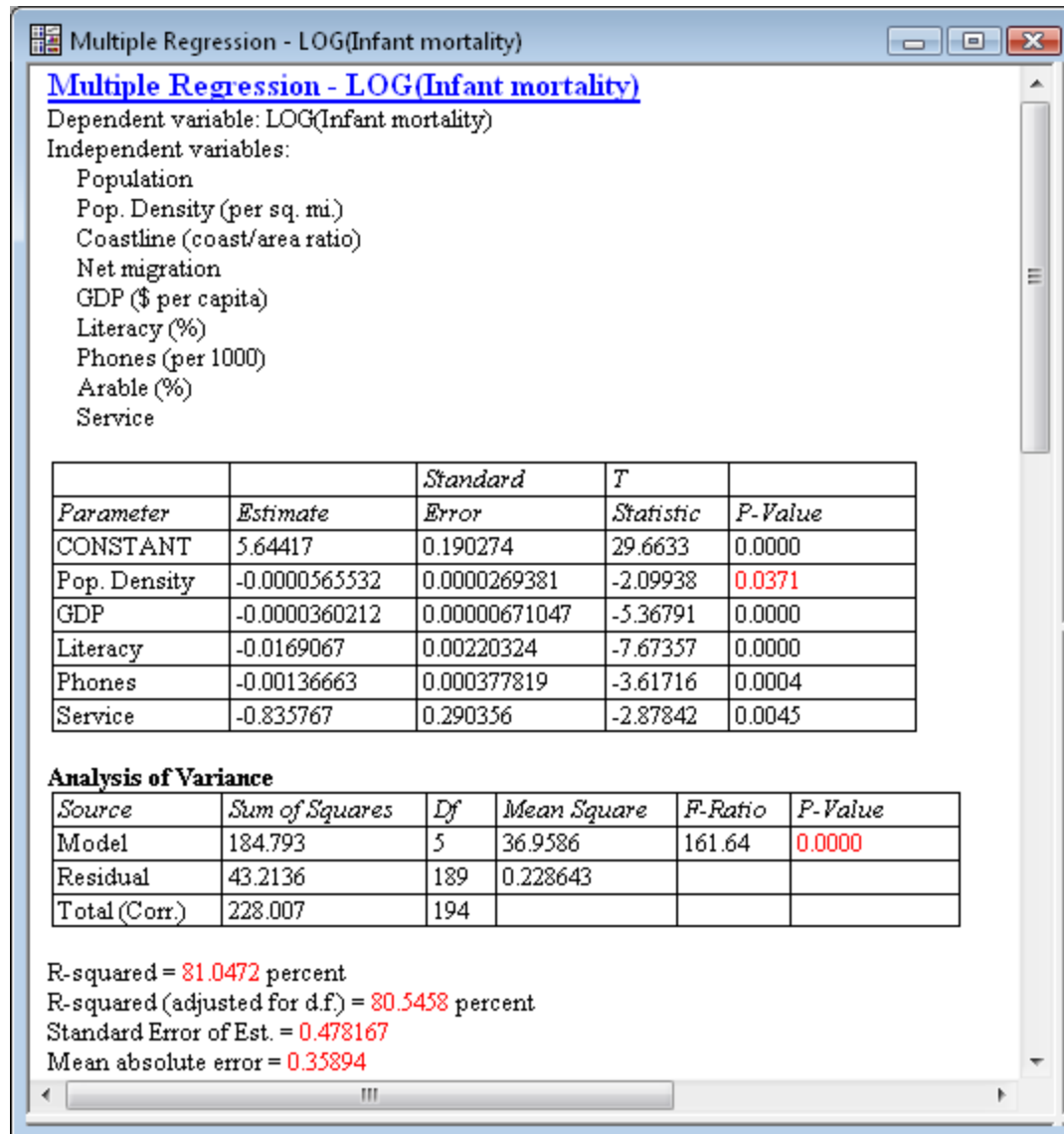
P-to-Remove: 0.05

OK

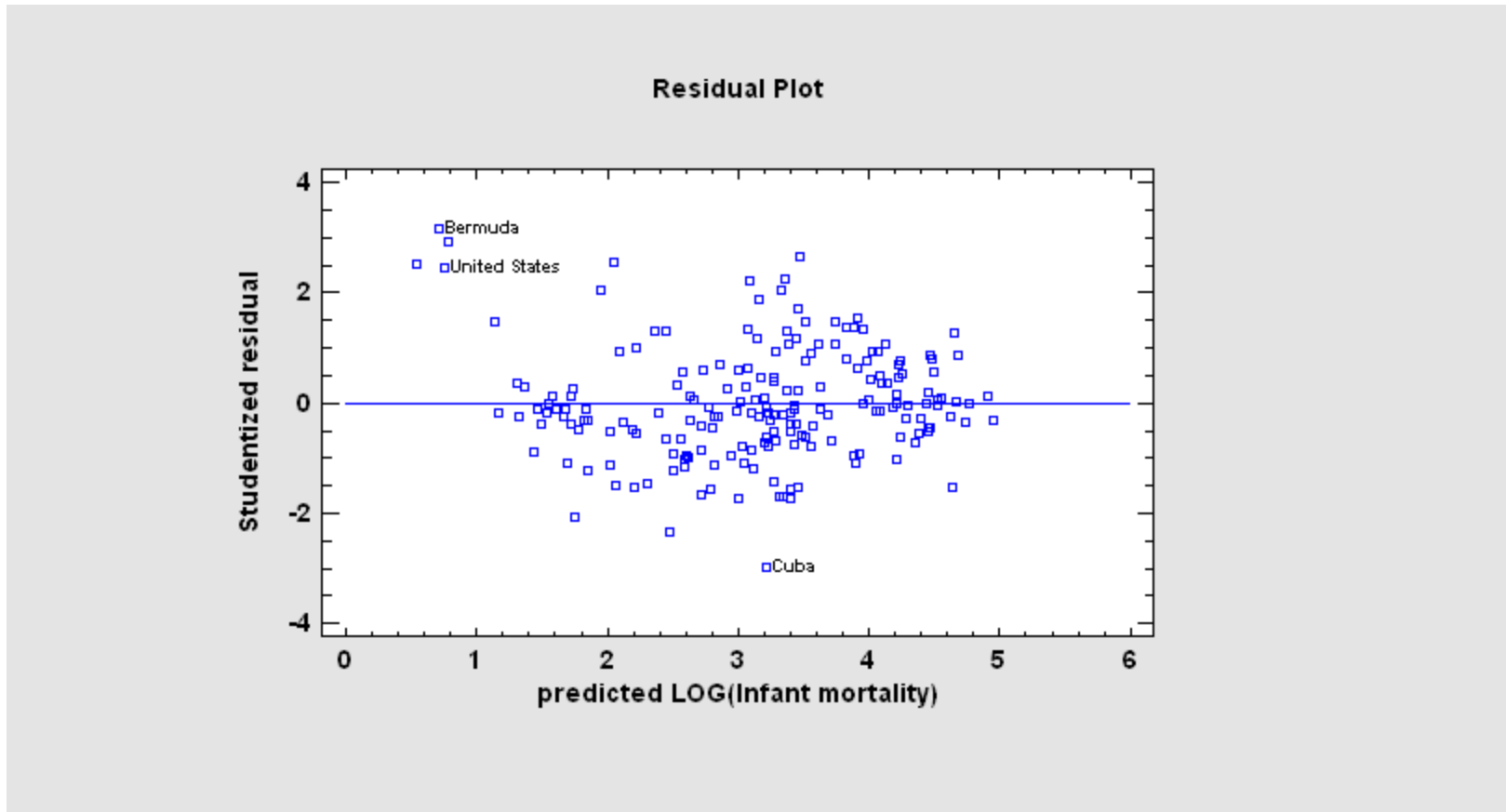
Cancel

Help

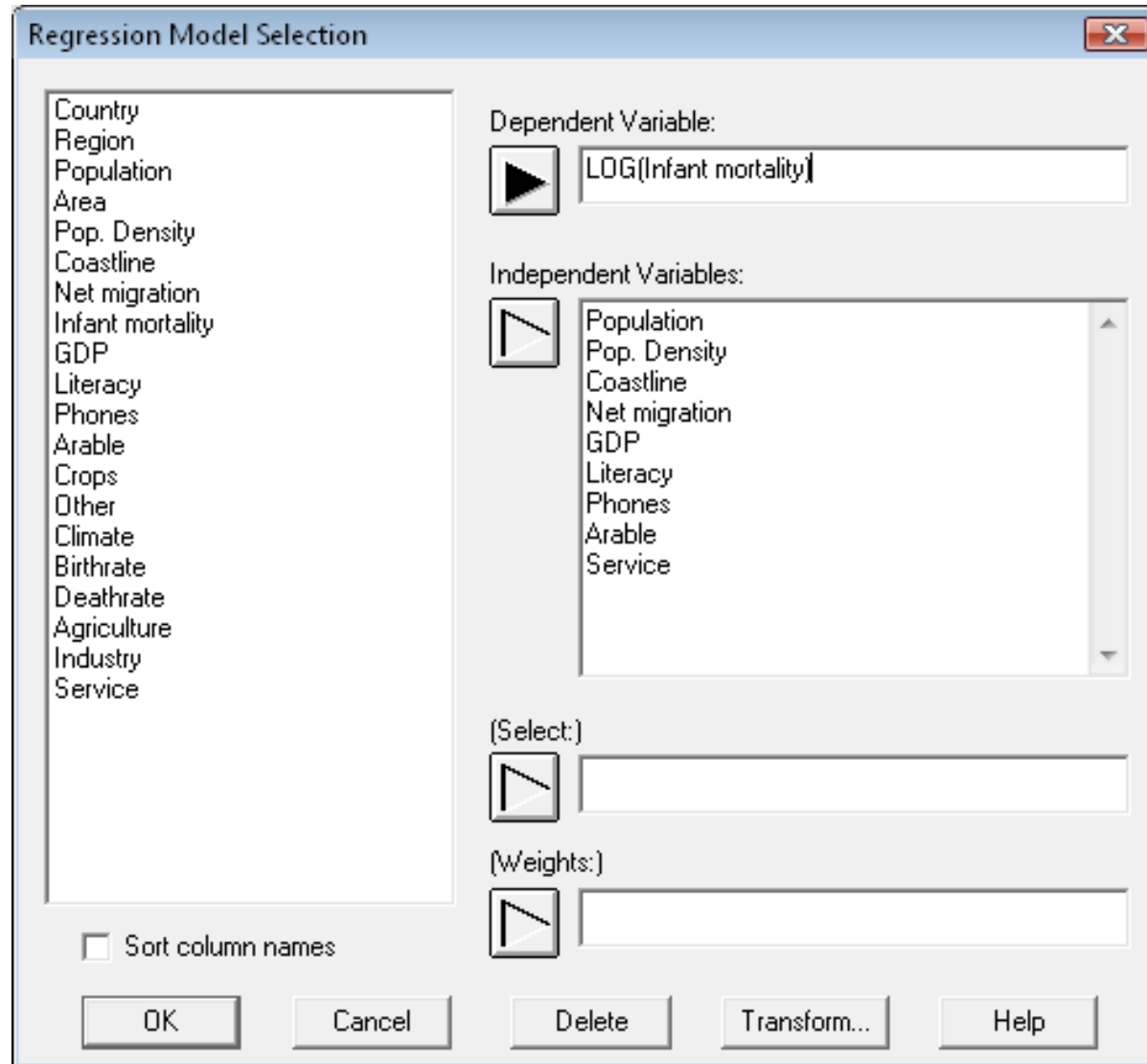
Selected Variables



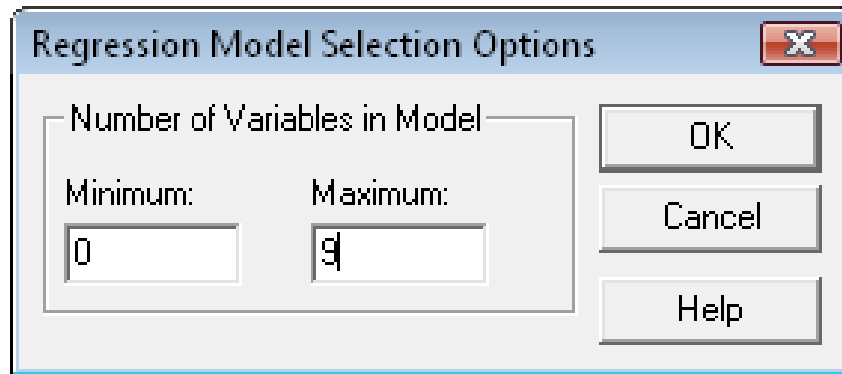
Residual Plot



All Possible Regressions



Analysis Options



A dialog box titled "Regression Model Selection Options" with a close button (X) in the top right corner. The dialog contains a section titled "Number of Variables in Model" with two input fields: "Minimum:" containing the value "0" and "Maximum:" containing the value "9". To the right of these fields are three buttons: "OK", "Cancel", and "Help".

Regression Model Selection Options

Number of Variables in Model

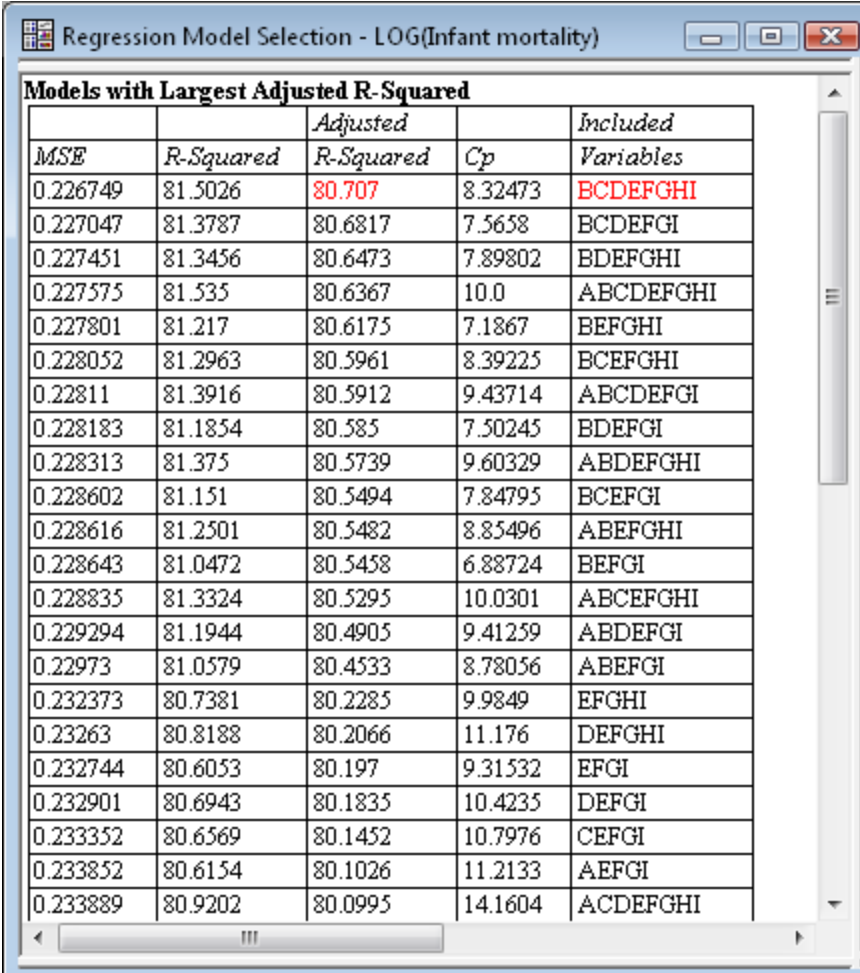
Minimum: 0 Maximum: 9

OK

Cancel

Help

Best Adjusted R-Squared Models



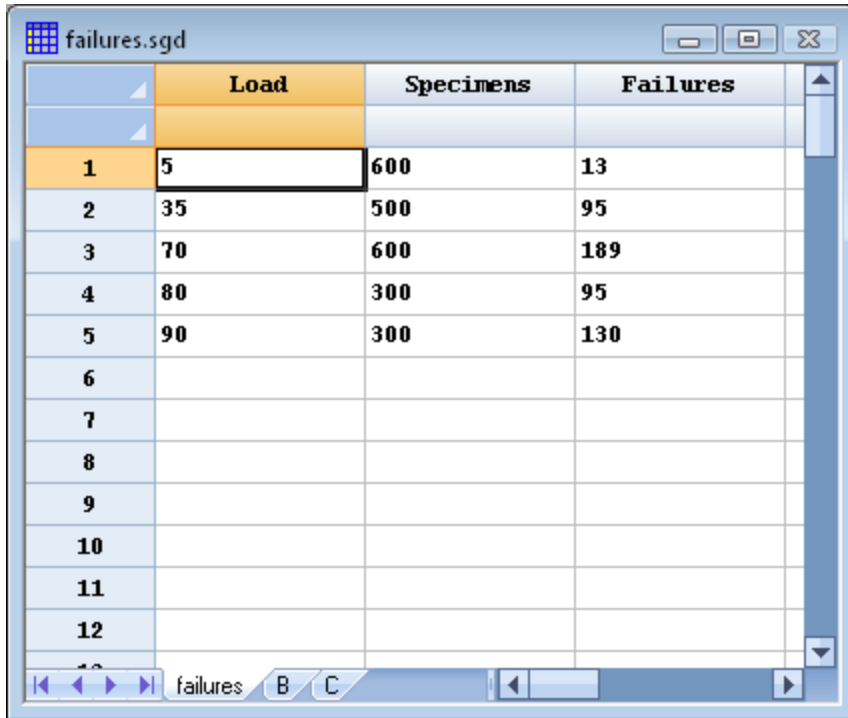
Regression Model Selection - LOG(Infant mortality)

Models with Largest Adjusted R-Squared

<i>MSE</i>	<i>R-Squared</i>	<i>Adjusted R-Squared</i>	<i>Cp</i>	<i>Included Variables</i>
0.226749	81.5026	80.707	8.32473	BCDEFGHI
0.227047	81.3787	80.6817	7.5658	BCDEFGI
0.227451	81.3456	80.6473	7.89802	BDEFGHI
0.227575	81.535	80.6367	10.0	ABCDEFGHGI
0.227801	81.217	80.6175	7.1867	BEFGHI
0.228052	81.2963	80.5961	8.39225	BCEFGHI
0.22811	81.3916	80.5912	9.43714	ABCDEFGFI
0.228183	81.1854	80.585	7.50245	BDEFGI
0.228313	81.375	80.5739	9.60329	ABDEFGHI
0.228602	81.151	80.5494	7.84795	BCEFGI
0.228616	81.2501	80.5482	8.85496	ABEFGHI
0.228643	81.0472	80.5458	6.88724	BEFGI
0.228835	81.3324	80.5295	10.0301	ABCEFGHI
0.229294	81.1944	80.4905	9.41259	ABDEFGI
0.22973	81.0579	80.4533	8.78056	ABEFGI
0.232373	80.7381	80.2285	9.9849	EFGHI
0.23263	80.8188	80.2066	11.176	DEFGHI
0.232744	80.6053	80.197	9.31532	EFGI
0.232901	80.6943	80.1835	10.4235	DEFGI
0.233352	80.6569	80.1452	10.7976	CEFGI
0.233852	80.6154	80.1026	11.2133	AEFGI
0.233889	80.9202	80.0995	14.1604	ACDEFGHI

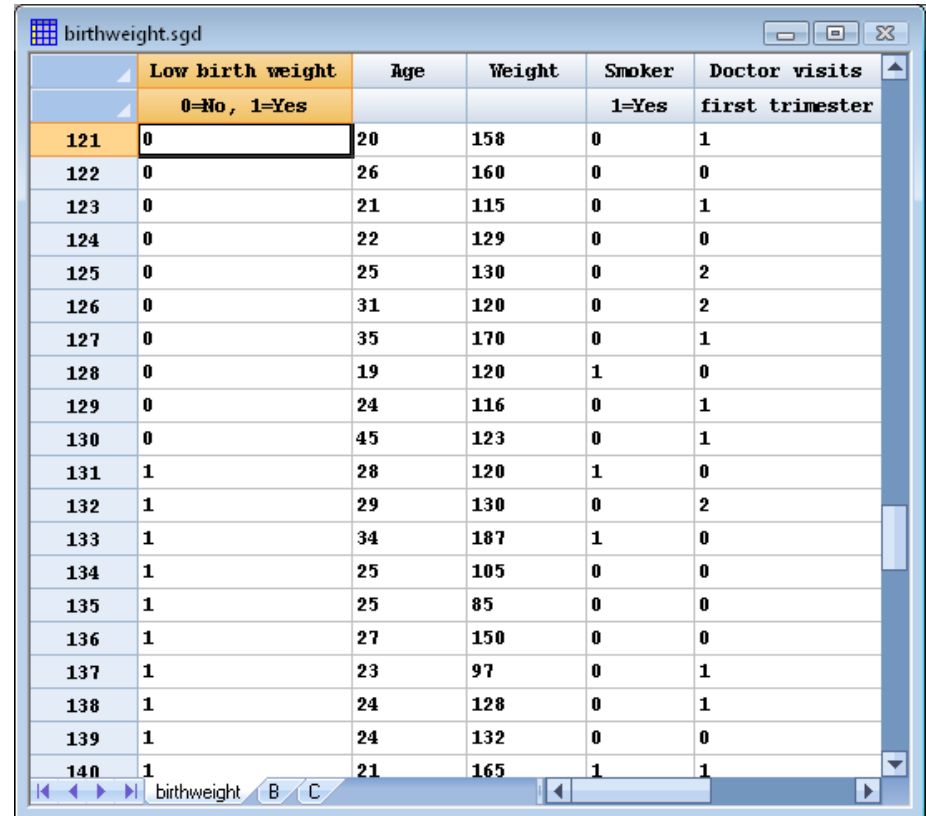
Example 6: Logistic Regression

Response variable may be in the form of proportions or binary (0/1).



failures.sgd

	Load	Specimens	Failures
1	5	600	13
2	35	500	95
3	70	600	189
4	80	300	95
5	90	300	130
6			
7			
8			
9			
10			
11			
12			



birthweight.sgd

	Low birth weight 0=No, 1=Yes	Age	Weight	Smoker 1=Yes	Doctor visits first trimester
121	0	20	158	0	1
122	0	26	160	0	0
123	0	21	115	0	1
124	0	22	129	0	0
125	0	25	130	0	2
126	0	31	120	0	2
127	0	35	170	0	1
128	0	19	120	1	0
129	0	24	116	0	1
130	0	45	123	0	1
131	1	28	120	1	0
132	1	29	130	0	2
133	1	34	187	1	0
134	1	25	105	0	0
135	1	25	85	0	0
136	1	27	150	0	0
137	1	23	97	0	1
138	1	24	128	0	1
139	1	24	132	0	0
140	1	21	165	1	1

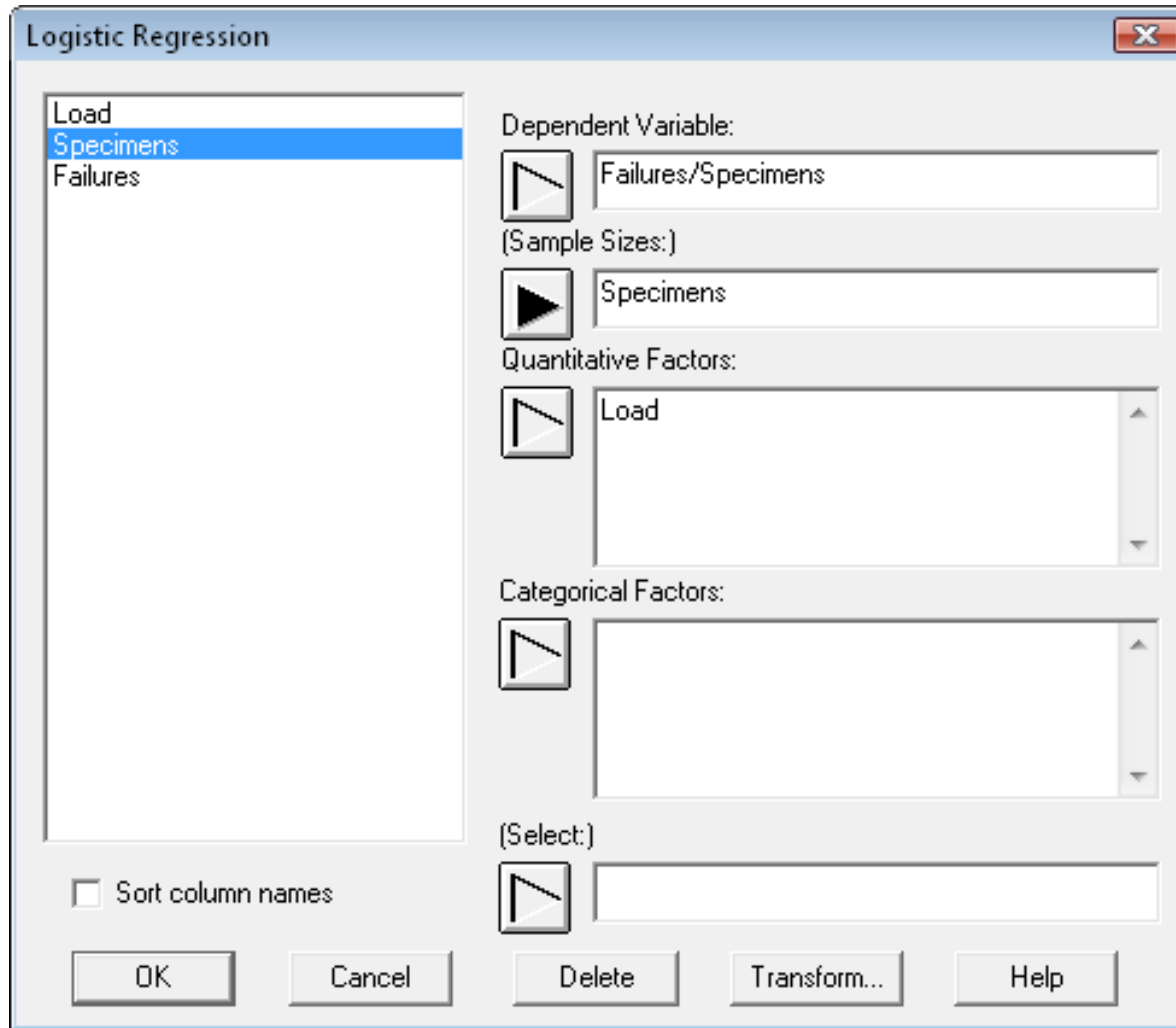
Logistic Model

Let $P(\text{Event})$ be the probability an event occurs at specified values of the independent variables X .

$$P(\text{Event}) = \frac{1}{1 + \exp[-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k)]} \quad (1)$$

$$\log\left(\frac{P(\text{Event})}{1 - P(\text{Event})}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k \quad (2)$$

Data Input - Proportions



Analysis Options

Logistic Regression Options ✕

Method

- Maximum Likelihood
- Weighted Least Squares

Smallest Proportion:
0.5 /n

Model

- First Order
- Second Order

Include Constant

Fit

- All Variables
- Forward Selection
- Backward Selection

P-to-Enter: 0.05 **P-to-Remove:** 0.05

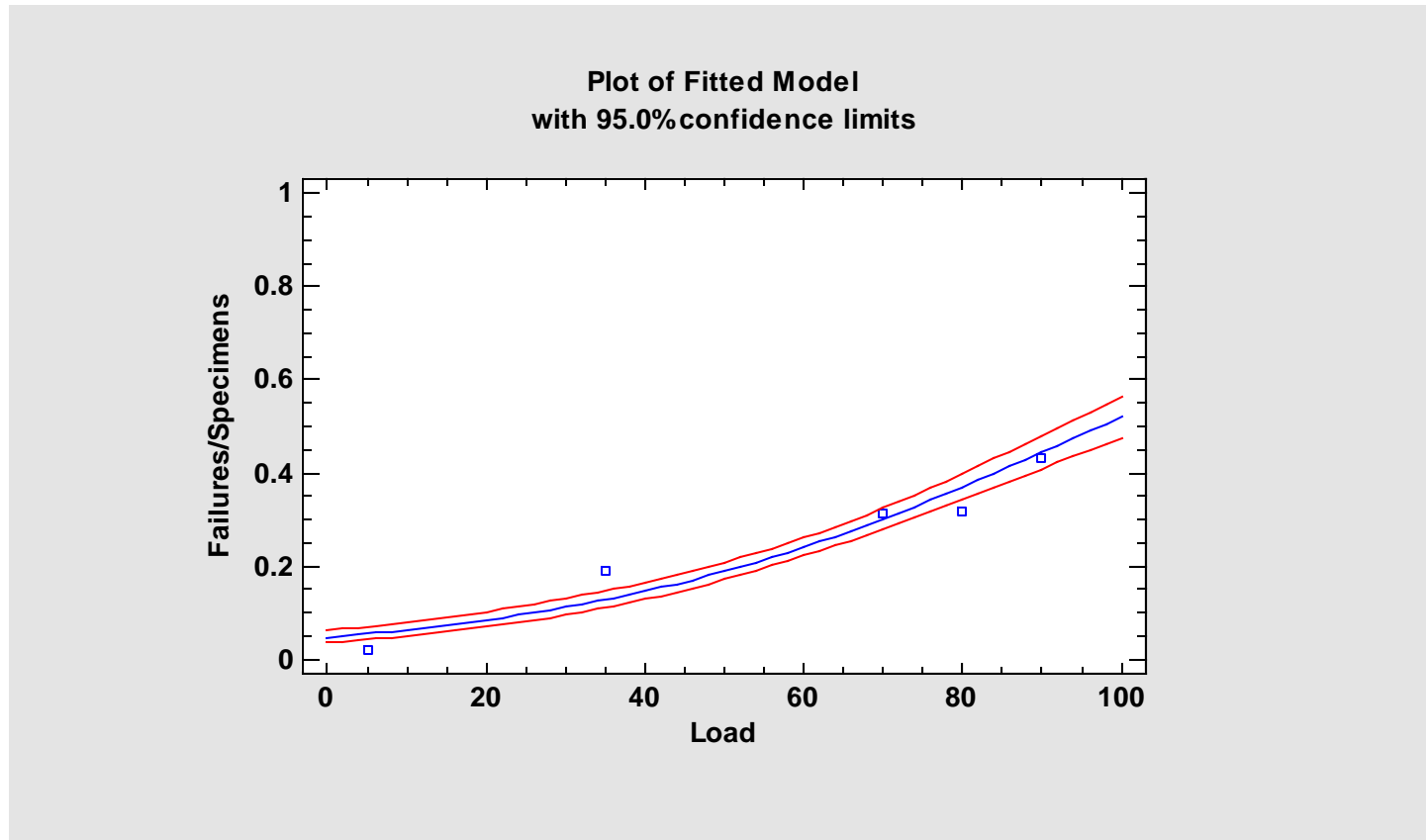
Max. Steps: 50

Display

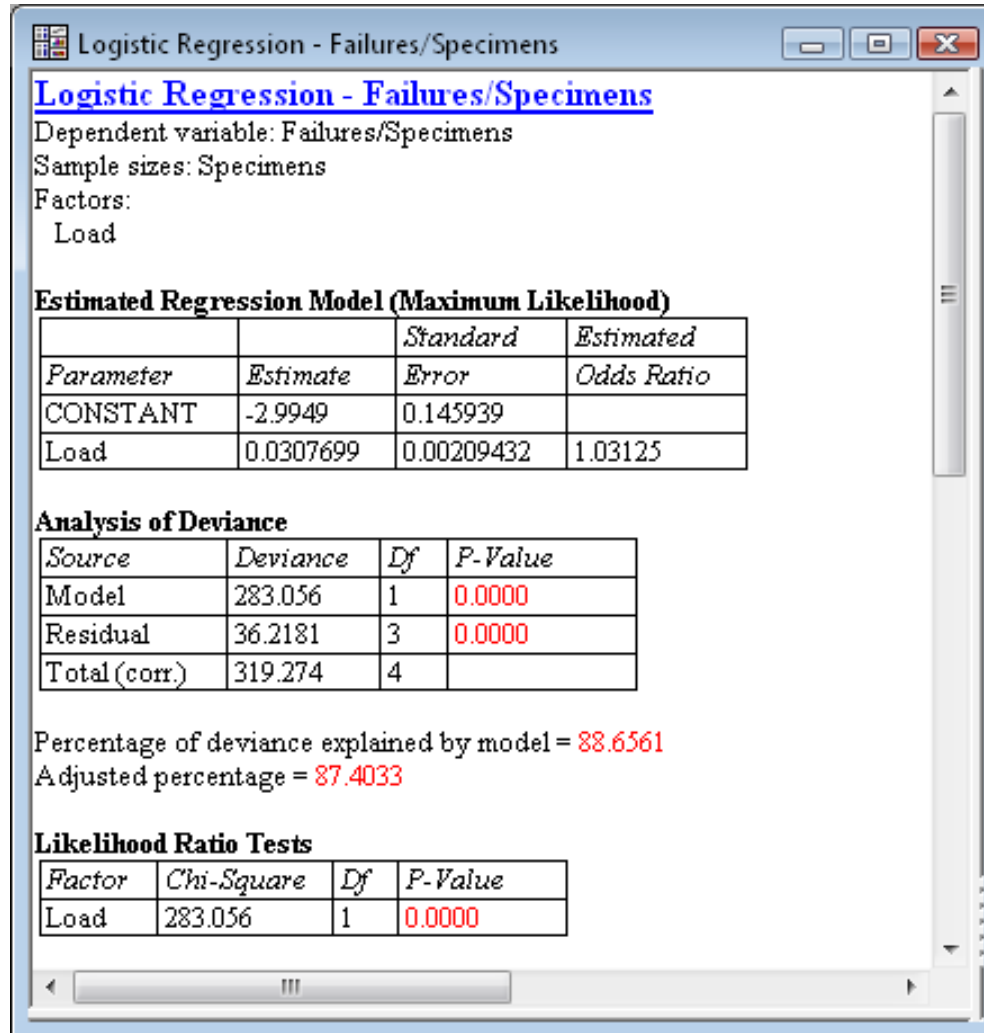
- Final Model Only
- All Steps

OK
Cancel
Exclude...
Help

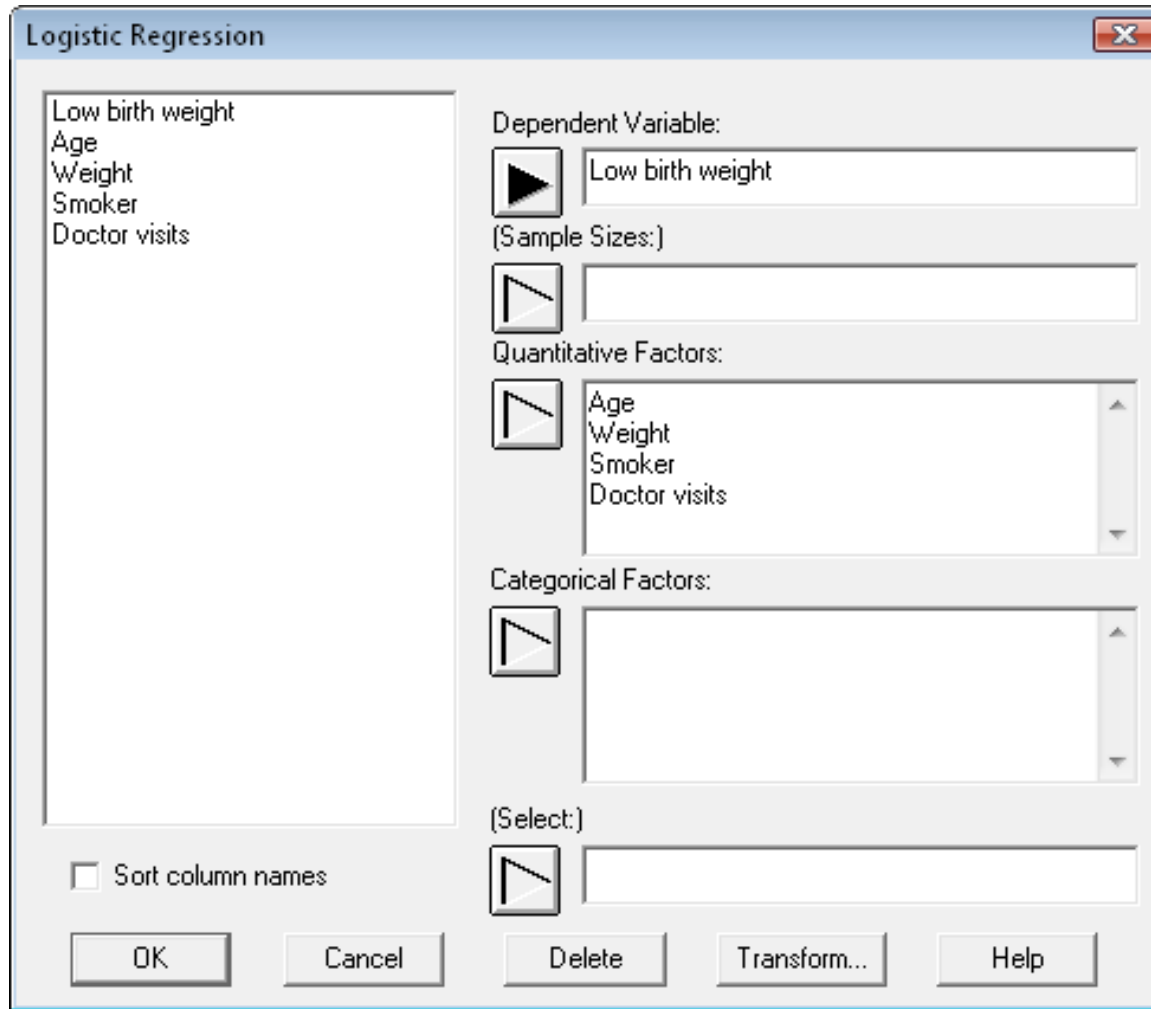
Plot of Fitted Model



Statistical Results



Data Input - Binary



Analysis Options

Logistic Regression Options ✕

Method

- Maximum Likelihood
- Weighted Least Squares

Smallest Proportion: /n

Model

- First Order
- Second Order

Include Constant

Fit

- All Variables
- Forward Selection
- Backward Selection

P-to-Enter: P-to-Remove:

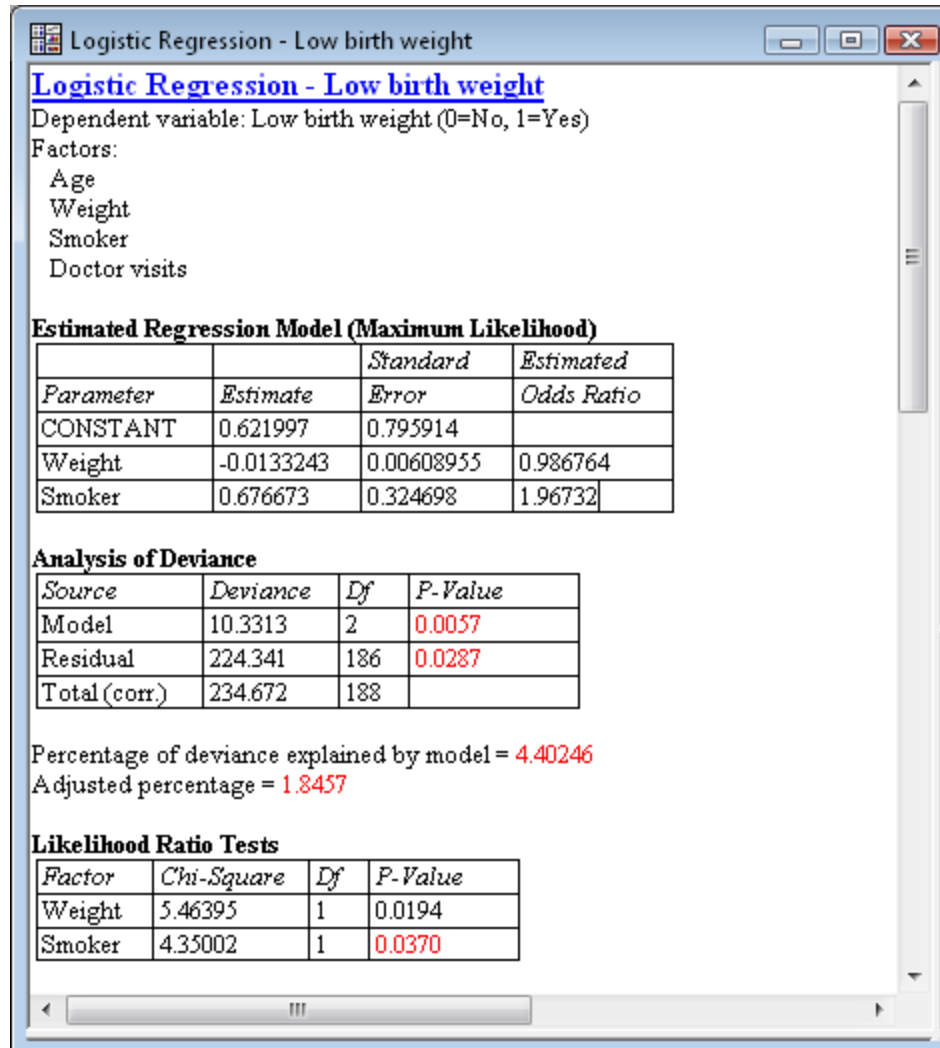
Max. Steps:

Display

- Final Model Only
- All Steps

OK
Cancel
Exclude...
Help

Analysis Summary



Example 7: Poisson Regression

Response variable is a count.

	Injuries per subregion	Thickness inner burden (feet)	Extraction percent of previous seam	Height lower seam (feet)	Years since mine opened
1	2	50	70	52	1
2	1	230	65	42	6
3	0	125	70	45	1
4	4	75	65	68	0.5
5	1	70	65	53	0.5
6	2	65	70	46	3
7	0	65	60	62	1
8	0	350	60	54	0.5
9	4	350	90	54	0.5
10	4	160	80	38	0
11	1	145	65	38	10
12	4	145	85	38	0
13	1	180	70	42	2
14	5	43	80	40	0
15	2	42	85	51	12
16	5	42	85	51	0
17	5	45	85	42	0
18	5	83	85	48	10

Poisson Model

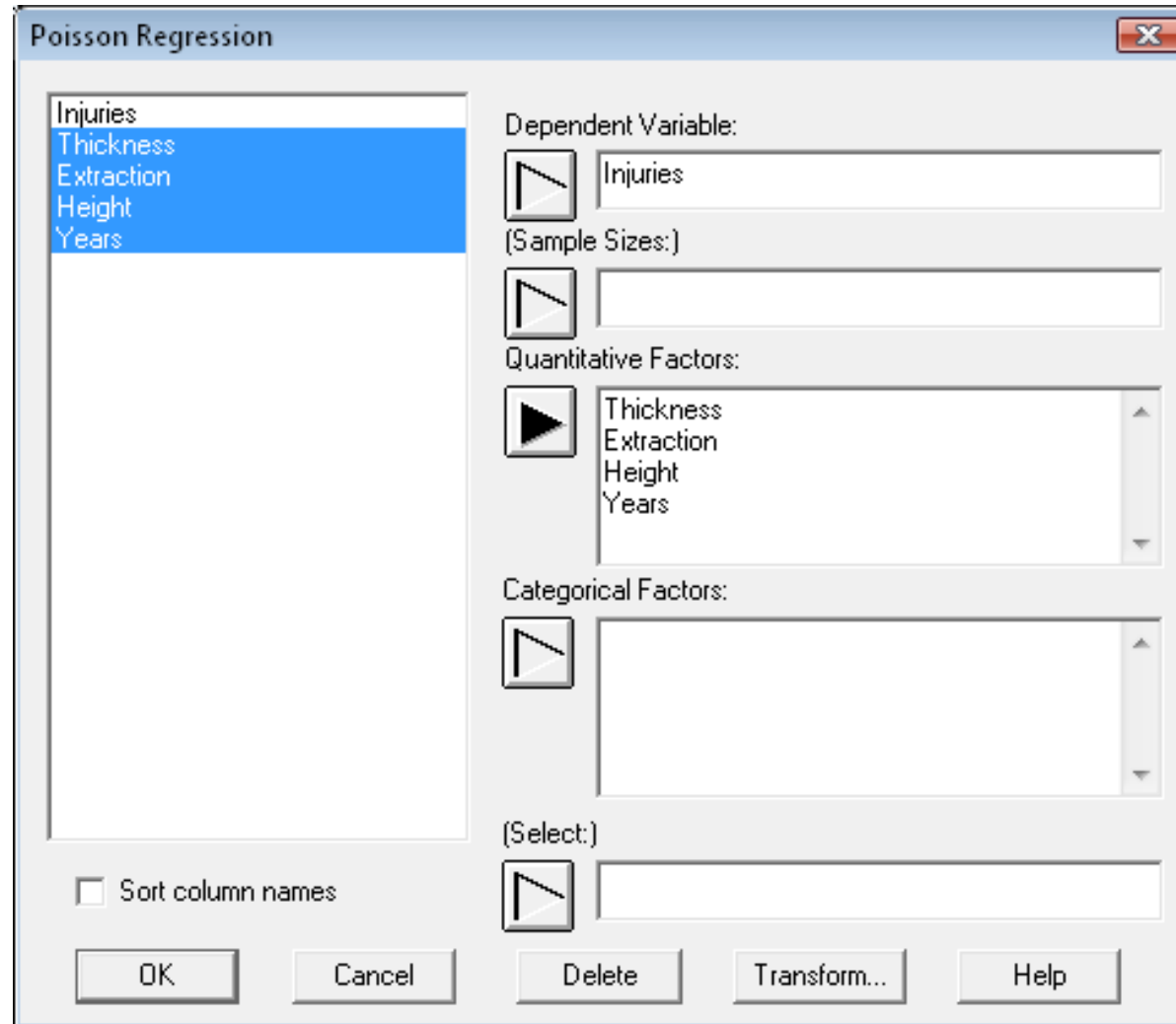
Values of the response variable are assumed to follow a Poisson distribution:

$$p(Y) = \frac{\lambda^Y e^{-\lambda}}{Y!}$$

The rate parameter λ is related to the predictor variables through a log-linear link function:

$$\log(\lambda) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k$$

Data Input



Analysis Options

Poisson Regression Options

Model

- First Order
- Second Order

Fit

- All Variables
- Forward Selection
- Backward Selection

Include Constant

P-to-Enter: P-to-Remove:

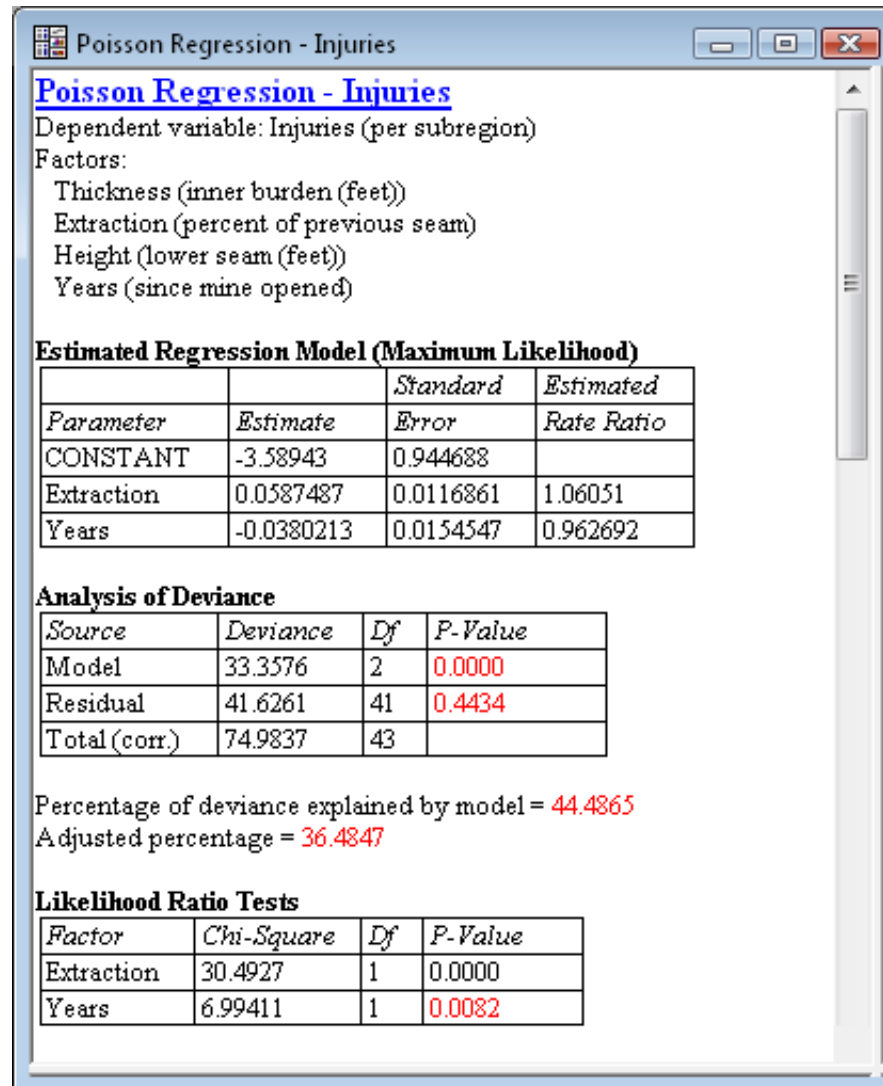
Max. Steps:

Display

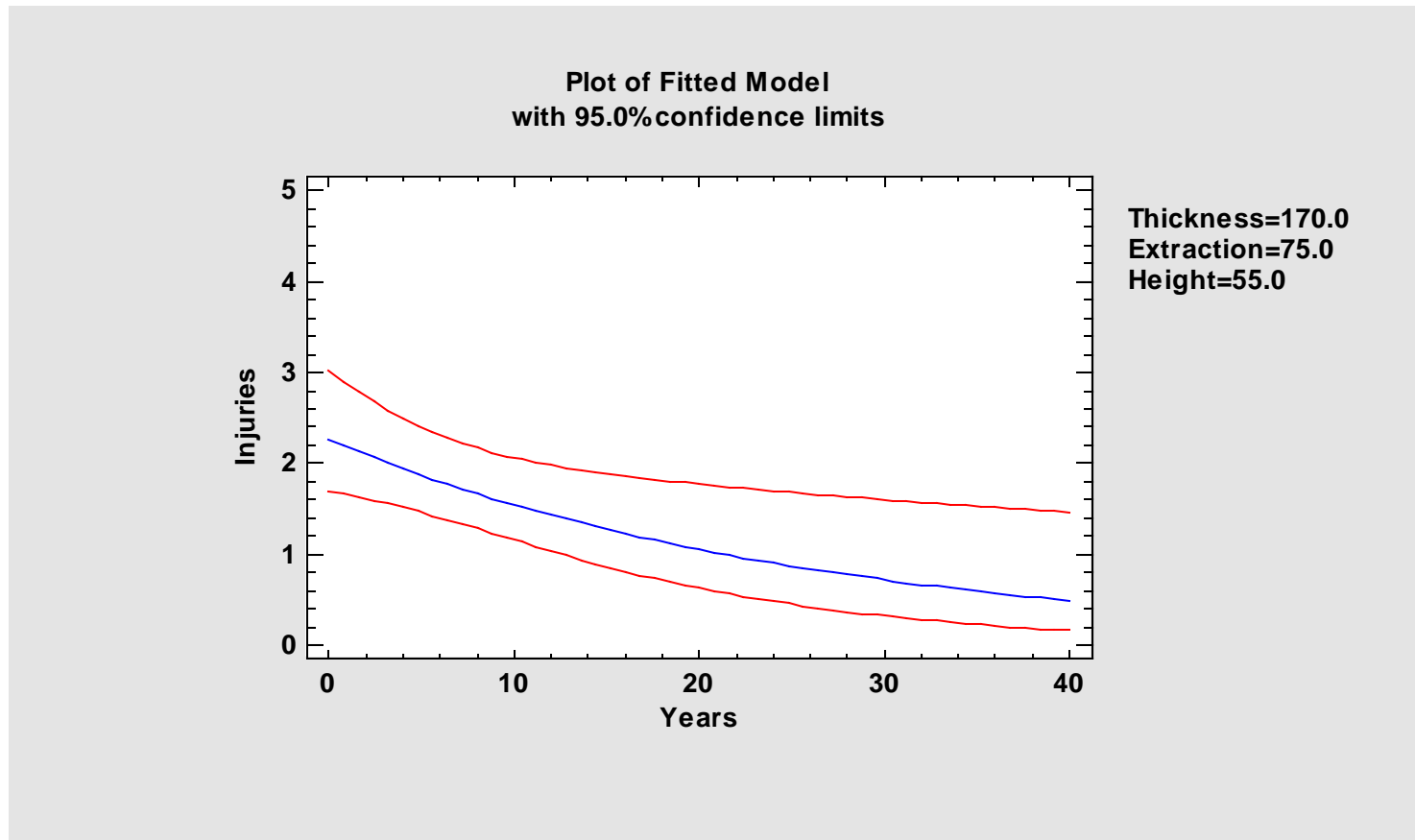
- Final Model Only
- All Steps

OK
Cancel
Exclude...
Help

Statistical Results



Plot of Fitted Model



References

- Applied Logistic Regression (second edition) – Hosmer and Lemeshow, Wiley, 2000.
- Applied Regression Analysis (third edition) – Draper and Smith, Wiley, 1998.
- Applied Linear Statistical Models (fifth edition) – Kutner et al., McGraw-Hill, 2004.
- Classical and Modern Regression with Applications (second edition) – Myers, Brookes-Cole, 1990.



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