

MULTIPLE LINEAR REGRESSION

EXAMPLE: BLOOD VISCOSITY AND PACKED CELL VOLUME

The following blood viscosity data studied earlier are a good example of where multiple regression could be used. Recall that the data blood viscosity in samples taken from 32 hospital patients. We wish to model viscosity (y) as a function three covariates

- Packed Cell Volume (PCV), x_1 .
- Plasma Fibrinogen, x_2 .
- Plasma Protein, x_3 .

Unit	Viscosity y	PCV x_1	Plasma Fib. x_2	Plasma Pro. x_3
1	3.71	40.00	344	6.27
2	3.78	40.00	330	4.86
3	3.85	42.50	280	5.09
4	3.88	42.00	418	6.79
5	3.98	45.00	774	6.40
6	4.03	42.00	388	5.48
7	4.05	42.50	336	6.27
8	4.14	47.00	431	6.89
9	4.14	46.75	276	5.18
10	4.20	48.00	422	5.73
11	4.20	46.00	280	5.89
12	4.27	47.00	460	6.58
13	4.27	43.25	412	5.67
14	4.37	45.00	320	6.23
15	4.41	50.00	502	4.99
16	4.64	45.00	550	6.37
17	4.68	51.25	414	6.40
18	4.73	50.25	304	6.00
19	4.87	49.00	472	5.94
20	4.94	50.00	728	5.16
21	4.95	50.00	716	6.29
22	4.96	49.00	400	5.96
23	5.02	50.50	576	5.90
24	5.02	51.25	354	5.81
25	5.12	49.50	392	5.49
26	5.15	56.00	352	5.41
27	5.17	50.00	572	6.24
28	5.18	47.00	634	6.50
29	5.38	53.25	458	6.60
30	5.77	57.00	1070	4.82
31	5.90	54.00	488	5.70
32	5.90	54.00	488	5.70

We consider four analyses:

Multiple regression : $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \epsilon$

Regression on x_1 : $y = \beta_0 + \beta_1 x_1 + \epsilon$

Regression on x_2 : $y = \beta_0 + \beta_2 x_2 + \epsilon$

Regression on x_3 : $y = \beta_0 + \beta_3 x_3 + \epsilon$

Multiple Regression

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.885 ^a	.784	.761	.30370

a. Predictors: (Constant), Plasma Protein (g/100ml), Plasma Fibrinogen (mg/100ml), Packed Cell Volume (%)

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.368	3	3.123	33.856	.000 ^a
	Residual	2.582	28	.092		
	Total	11.950	31			

a. Predictors: (Constant), Plasma Protein (g/100ml), Plasma Fibrinogen (mg/100ml), Packed Cell Volume (%)

b. Dependent Variable: Blood Viscosity (cP)

Multiple Regression: Parameter Estimates

Tests are of the hypotheses
 H_0 : beta equal to 0
 H_a : beta not equal to zero

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-1.378	.897		-1.537	.136	-3.215	.458
	Packed Cell Volume (%)	.117	.014	.839	8.584	.000	.089	.145
	Plasma Fibrinogen (mg/100ml)	.000	.000	.111	1.147	.261	.000	.001
	Plasma Protein (g/100ml)	.040	.097	.037	.412	.683	-.159	.239

a. Dependent Variable: Blood Viscosity (cP)

Only the packed cell volume coefficient is significantly different from zero ($p < 0.001$)

 The other covariates do not seem to be significantly different from zero.

Regression on Packed Cell Volume only

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.879 ^a	.772	.765	.30116

a. Predictors: (Constant), Packed Cell Volume (%)

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.230	1	9.230	101.764	.000 ^a
	Residual	2.721	30	.091		
	Total	11.950	31			

a. Predictors: (Constant), Packed Cell Volume (%)

b. Dependent Variable: Blood Viscosity (cP)

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-1.223	.584		-2.094	.045	-2.416	-.030
	Packed Cell Volume (%)	.122	.012	.879	10.088	.000	.098	.147

a. Dependent Variable: Blood Viscosity (cP)

PCV is a significant term in the model ($p < 0.001$)

Regression on Plasma Protein only

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.457 ^a	.209	.183	.56129

a. Predictors: (Constant), Plasma Fibrinogen (mg/100ml)

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.499	1	2.499	7.932	.009 ^a
	Residual	9.451	30	.315		
	Total	11.950	31			

a. Predictors: (Constant), Plasma Fibrinogen (mg/100ml)

b. Dependent Variable: Blood Viscosity (cP)

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	3.871	.292		13.236	.000	3.274	4.468
	Plasma Fibrinogen (mg/100ml)	.002	.001	.457	2.816	.009	.000	.003

a. Dependent Variable: Blood Viscosity (cP)

Plasfib is a significant term in the model (p = 0.009)

Regression on Plasma Fibrinogen only

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.101 ^a	.010	-.023	.62791

a. Predictors: (Constant), Plasma Protein (g/100ml)

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.122	1	.122	.310	.582 ^a
	Residual	11.828	30	.394		
	Total	11.950	31			

a. Predictors: (Constant), Plasma Protein (g/100ml)

b. Dependent Variable: Blood Viscosity (cP)

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	5.296	1.174		4.510	.000	2.898	7.694
	Plasma Protein (g/100ml)	-.110	.198	-.101	-.556	.582	-.515	.295

a. Dependent Variable: Blood Viscosity (cP)

Plaspro is not a significant term in the model (p = 0.582)

Blood Viscosity Data Set

The screenshot shows the SPSS Data Editor interface for a file named 'Viscosity.sav [DataSet2]'. The window title bar includes the SPSS logo and the file name. The menu bar contains 'File', 'Edit', 'View', 'Data', 'Transform', 'Analyze', 'Graphs', 'Utilities', 'Window', and 'Help'. Below the menu bar is a toolbar with various icons for file operations and analysis. The main area is a data grid with 32 rows and 26 columns. The columns are labeled: 'Patient', 'viscosity', 'pcv', 'plasfib', 'plaspro', and 20 columns labeled 'var'. The data is as follows:

Patient	viscosity	pcv	plasfib	plaspro	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var
1	1	3.71	40.00	344	6.27																				
2	2	3.78	40.00	330	4.86																				
3	3	3.85	42.50	280	5.09																				
4	4	3.88	42.00	418	6.79																				
5	5	3.98	45.00	774	6.40																				
6	6	4.03	42.00	388	5.48																				
7	7	4.05	42.50	336	6.27																				
8	8	4.14	47.00	431	6.89																				
9	9	4.14	46.75	276	5.18																				
10	10	4.20	48.00	422	5.73																				
11	11	4.20	46.00	280	5.89																				
12	12	4.27	47.00	460	6.58																				
13	13	4.27	43.25	412	5.67																				
14	14	4.37	45.00	320	6.23																				
15	15	4.41	50.00	502	4.99																				
16	16	4.64	45.00	550	6.37																				
17	17	4.68	51.25	414	6.40																				
18	18	4.73	50.25	304	6.00																				
19	19	4.87	49.00	472	5.94																				
20	20	4.94	50.00	728	5.16																				
21	21	4.95	50.00	716	6.29																				
22	22	4.96	49.00	400	5.96																				
23	23	5.02	50.50	576	5.90																				
24	24	5.02	51.25	354	5.81																				
25	25	5.12	49.50	392	5.49																				
26	26	5.15	56.00	352	5.41																				
27	27	5.17	50.00	572	6.24																				
28	28	5.18	47.00	634	6.50																				
29	29	5.38	53.25	458	6.60																				
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Use the *Analyze, Regression, Linear* pulldown selections

The screenshot shows the SPSS Data Editor window for a file named 'Viscosity.sav [DataSet2]'. The 'Analyze' menu is open, and the path 'Analyze > Regression > Linear...' is selected. The data grid shows two columns: 'Patient' and 'viscosity'. The 'Patient' column contains values from 1 to 32, and the 'viscosity' column contains values ranging from 3.71 to 5.90. The status bar at the bottom indicates 'Data View' and 'Variable View' tabs, and the SPSS Processor is ready.

Patient	viscosity
1	3.71
2	3.78
3	3.85
4	3.88
5	3.98
6	4.03
7	4.05
8	4.14
9	4.14
10	4.20
11	4.20
12	4.27
13	4.27
14	4.37
15	4.41
16	4.64
17	4.68
18	4.73
19	4.87
20	4.94
21	4.95
22	4.96
23	5.02
24	5.02
25	5.12
26	5.15
27	5.17
28	5.18
29	5.38
30	5.77
31	5.90
32	5.90

Select the Dependent variable (**viscosity**) and the three independent variables (**pcv**, **plasfib** and **plaspro**) ³

The screenshot displays the SPSS Data Editor interface with a 'Linear Regression' dialog box open. The dialog box is configured with the following settings:

- Dependent:** Blood Viscosity (cP) [v]
- Independent(s):** Packed Cell Volume (%), Plasma Fibrinogen (mg/100m), Plasma Protein (g/100m)
- Method:** Enter
- Selection Variable:** (empty)
- Case Labels:** (empty)
- WLS Weight:** (empty)

The background data table shows the following data points:

Patient	viscosity	pcv	plasfib	plaspro	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var
1	3.71	40.00	344	6.27																
2	3.78	40.00	330	4.86																
25	5.12	49.50	392	5.49																
26	5.15	56.00	352	5.41																
27	5.17	50.00	572	6.24																
28	5.18	47.00	634	6.50																
29	5.38	53.25	458	6.60																
30	5.77	57.00	1070	4.82																
31	5.90	54.00	488	5.70																
32	5.90	54.00	488	5.70																

Click the *Statistics* button: on the *Statistics* dialog, select *Estimates*, *Confidence Intervals* and *Model fit*. Click *Continue*.

The screenshot shows the SPSS Data Editor interface with a data grid. A 'Linear Regression' dialog box is open, and its 'Statistics' sub-dialog is also open. In the 'Statistics' sub-dialog, the following options are checked:

- Regression Coefficients
- Estimates
- Confidence intervals
- Model fit

The 'Residuals' section is currently unchecked. The 'WLS Weight' field is empty. The 'Statistics...' button is highlighted.

Patient	viscosity	pcv	plasfib	plaspro	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	
1	3.71	40.00	344	6.27																
2	3.78	40.00	330	4.86																
25	5.12	49.50	392	5.49																
26	5.15	56.00	352	5.41																
27	5.17	50.00	572	6.24																
28	5.18	47.00	634	6.50																
29	5.38	53.25	458	6.60																
30	5.77	57.00	1070	4.82																
31	5.90	54.00	488	5.70																
32	5.90	54.00	488	5.70																

Click the *Plots* button

The screenshot shows the SPSS Data Editor interface with a Linear Regression dialog box open. The 'Plots' sub-dialog is active, showing options for standardized residual plots. The 'Produce all partial plots' checkbox is checked. The background data grid shows the following data points:

Row	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
19	19	4.87	49.00	472	5.94	
20	20	4.94	50.00	728	5.16	
21	21	4.95	50.00	716	6.29	
22	22	4.96	49.00	400	5.96	
23	23	5.02	50.50	576	5.90	
24	24	5.02	51.25	354	5.81	
25	25	5.12	49.50	392	5.49	
26	26	5.15	56.00	352	5.41	
27	27	5.17	50.00	572	6.24	
28	28	5.18	47.00	634	6.50	
29	29	5.38	53.25	458	6.60	
30	30	5.77	57.00	1070	4.82	
31	31	5.90	54.00	488	5.70	
32	32	5.90	54.00	488	5.70	
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Select ***ZRESID** for the Y variable and ***ZPRED** for the X variable.

Then click *Next*.

The screenshot shows the SPSS Data Editor window with a data grid. A dialog box titled "Linear Regression: Plots" is open, showing the configuration for the regression analysis. The dependent variable is *ZRESID and the independent variable is *ZPRED. The "Standardized Residual Plots" section is checked, and the "Histogram" and "Normal probability plot" options are selected. The "WLS Weight" field is empty. The "Plots..." button is highlighted.

Case	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
	19	20	21	22	23	24	25	26	27	28	29	30	31	32																							
	4.87	4.94	4.95	4.96	5.02	5.02	5.12	5.15	5.17	5.18	5.38	5.77	5.90	5.90																							
	49.00	50.00	50.00	49.00	50.50	51.25	49.50	56.00	50.00	47.00	53.25	57.00	54.00	54.00																							
	472	728	716	400	576	354	392	352	572	634	458	1070	488	488																							
	5.94	5.16	6.29	5.96	5.90	5.81	5.49	5.41	6.24	6.50	6.60	4.82	5.70	5.70																							

Select ***ZRESID** for the Y variable and ***ZPRED** for the X variable.

Then click *Produce all partial Plots*. Then *Continue*.

The screenshot shows the SPSS Data Editor window with the 'Linear Regression: Plots' dialog box open. The dialog is titled 'Linear Regression: Plots' and is part of the 'Linear Regression' process. The 'DEPENDENT' variable is set to '*ZRESID' and the 'INDEPENDENT' variable is set to '*ZPRED'. The 'Standardized Residual Plots' section has the 'Produce all partial plots' checkbox checked. The 'WLS Weight' field is empty. The dialog has buttons for 'Previous', 'Next', 'Continue', 'Reset', 'Cancel', and 'Help'. The background shows a data grid with columns labeled 'var' and rows numbered 19 to 54.

Row	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var
19	19	4.87	49.00	472	5.94															
20	20	4.94	50.00	728	5.16															
21	21	4.95	50.00	716	6.29															
22	22	4.96	49.00	400	5.96															
23	23	5.02	50.50	576	5.90															
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Click the Save button, to compute and store the residuals etc.

The screenshot shows the SPSS Data Editor interface with a 'Linear Regression: Save' dialog box open. The dialog box has several sections for saving results:

- Predicted Values:** Unstandardized, Standardized, Adjusted, S.E. of mean predictions
- Distances:** Mahalanobis, Cook's, Leverage values
- Prediction Intervals:** Mean, Individual, Confidence Interval: 95%
- Coefficient statistics:** Create coefficient statistics
- Residuals:** Unstandardized, Standardized, Studentized, Deleted, Studentized deleted
- Influence Statistics:** DIBeta(s), Standardized DIBeta(s), DIFR, Standardized DIFR, Covariance ratio

At the bottom of the dialog, there are radio buttons for 'Create a new dataset' (selected) and 'Write a new data file'. The 'Create a new dataset' option has a 'Dataset name:' field.

The background shows a data table with the following data:

19					
20					
21					
22	22	4.96	49.00	400	5.96
23	23	5.02	50.50	576	5.90
24	24	5.02	51.25	354	5.81
25	25	5.12	49.50	392	5.49
26	26	5.15	56.00	352	5.41
27	27	5.17	50.00	572	6.24
28	28	5.18	47.00	634	6.50
29	29	5.38	53.25	458	6.60
30	30	5.77	57.00	1070	4.82
31	31	5.90	54.00	488	5.70
32	32	5.90	54.00	488	5.70
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Select the quantities to store as new variables in the data set.

Click *Continue*.

Viscosity.sav [DataSet2] - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window Help

Linear Regression

Linear Regression: Save

Predicted Values

- Unstandardized
- Standardized
- Adjusted
- S.E. of mean predictions

Distances

- Mahalanobis
- Cook's
- Leverage values

Prediction Intervals

- Mean
- Individual

Confidence Interval: %

Coefficient statistics

- Create coefficient statistics

Residuals

- Unstandardized
- Standardized
- Studentized
- Deleted
- Studentized deleted

Influence Statistics

- DIBeta(s)
- Standardized DIBeta(s)
- DIFR
- Standardized DIFR
- Covariance ratio

Buttons: Continue, Cancel, Help

Options: Create a new dataset (selected), Dataset name: ; Write a new data file, File...

19					
20					
21					
22	22	4.96	49.00	400	5.96
23	23	5.02	50.50	576	5.90
24	24	5.02	51.25	354	5.81
25	25	5.12	49.50	392	5.49
26	26	5.15	56.00	352	5.41
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32	32	5.90	54.00	488	5.70
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Data View Variable View

SPSS Processor is ready

Click OK and the output is generated.

The screenshot displays the SPSS Data Editor window with a dataset named 'Viscosity.sav'. The data table includes columns for Patient, viscosity, pcv, plasfib, plaspro, PRE_1, RES_1, ZRE_1, LMCI_1, UMCI_1, LIC1_1, and UICI_1. The 'Output9 - SPSS Viewer' window is open, showing the results of a regression analysis. The regression model includes variables: Plasma Protein (g/l 100ml), Plasma Fibrinogen (mg/100ml), and Packed Cell Volume (%). The model summary shows an R value of .885, an R Square of .784, an Adjusted R Square of .761, and a Std. Error of the Estimate of 30370. The ANOVA table is also partially visible.

Regression
 [DataSet2] C:\Work\Courses\204\SPSS\Viscosity.sav

Variables Entered/Removed^a

Model	Variables Entered	Variables Removed	Method
1	Plasma Protein (g/l 100ml), Plasma Fibrinogen (mg/100ml), Packed Cell Volume (%)		Enter

a. All requested variables entered.
 b. Dependent Variable: Blood Viscosity (cP)

Model Summary^a

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.885 ^a	.784	.761	30370

a. Predictors: (Constant), Plasma Protein (g/l100ml), Plasma Fibrinogen (mg/100ml), Packed Cell Volume (%)
 b. Dependent Variable: Blood Viscosity (cP)

ANOVA^a

Model	Sum of Squares	df	Mean Square	F	Sig.
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SPSS Processor is ready

New variables have been computed.

*Viscosity.sav [DataSet2] - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window Help

40 : plaspro

Patient	viscosity	pcv	plastib	plaspro	PRE_1	RES_1	ZRE_1	LMCI_1	UMCI_1	LICI_1	UICI_1	var	var	var	var	var	var	var	var	var		
1	1	3.71	40.00	344	6.27	3.68399	.02601	.08565	3.45258	3.91540	3.02025	4.34773										
2	2	3.78	40.00	330	4.86	3.62191	.15809	.52055	3.29311	3.95071	2.91827	4.32555										
3	3	3.85	42.50	280	5.09	3.90308	-.05308	-.17478	3.64141	4.16475	3.22819	4.57797										
4	4	3.88	42.00	418	6.79	3.96820	-.08820	-.29042	3.72518	4.21122	3.30032	4.63608										
5	5	3.98	45.00	774	6.40	4.44615	-.46615	-1.53491	4.14732	4.74498	3.75600	5.13630										
6	6	4.03	42.00	388	5.48	3.90369	.12631	.41590	3.68995	4.11743	3.24590	4.56148										
7	7	4.05	42.50	336	6.27	3.97283	.07717	.25409	3.78695	4.15872	3.32366	4.62211										
8	8	4.14	47.00	431	6.89	4.56154	-.42154	-1.38804	4.33621	4.78688	3.89990	5.22319										
9	9	4.14	46.75	276	5.18	4.40157	-.26157	-.86130	4.17972	4.62343	3.74110	5.05204										
10	10	4.20	48.00	422	5.73	4.62831	-.42831	-1.41031	4.50915	4.74747	3.99490	5.26171										
11	11	4.20	46.00	280	5.89	4.34399	-.14399	-.47413	4.17954	4.50844	3.70053	4.98745										
12	12	4.27	47.00	460	6.58	4.56079	-.29079	-.96750	4.38678	4.73480	3.91482	5.20676										
13	13	4.27	43.25	412	5.67	4.06698	.20302	.66851	3.89335	4.24060	3.42110	4.71285										
14	14	4.37	45.00	320	6.23	4.25686	.11314	.37255	4.09611	4.41761	3.61433	4.89939										
15	15	4.41	50.00	502	4.99	4.86448	-.45448	-1.49650	4.65413	5.07484	4.20779	5.52118										
16	16	4.64	45.00	550	6.37	4.35491	.28509	.93873	4.17363	4.53619	3.70694	5.00288										
17	17	4.68	51.25	414	6.40	5.03159	-.35159	-1.15771	4.83663	5.22655	4.37966	5.68352										
18	18	4.73	50.25	304	6.00	4.85454	-.12454	-.41008	4.66195	5.04713	4.20331	5.50577										
19	19	4.87	49.00	472	5.94	4.77364	.09636	.31730	4.65936	4.88791	4.14113	5.40614										
20	20	4.94	50.00	728	5.16	4.96213	-.02213	-.07287	4.71448	5.20978	4.29255	5.63171										
21	21	4.95	50.00	716	6.29	5.00255	-.05255	-.17303	4.78804	5.21706	4.34451	5.66059										
22	22	4.96	49.00	400	5.96	4.74550	.21450	.70631	4.61602	4.87497	4.11007	5.38092										
23	23	5.02	50.50	576	5.90	4.98907	.03093	.10184	4.85220	5.12594	4.35210	5.62605										
24	24	5.02	51.25	354	5.81	4.98385	.03615	.11902	4.80178	5.16593	4.33566	5.63205										
25	25	5.12	49.50	392	5.49	4.78188	.33812	1.11336	4.62664	4.93711	4.14070	5.42305										
26	26	5.15	56.00	352	5.41	5.52195	-.37195	-1.22473	5.22653	5.61736	4.83327	6.21062										
27	27	5.17	50.00	572	6.24	4.94267	.22733	.74856	4.79012	5.09521	4.30214	5.58319										
28	28	5.18	47.00	634	6.50	4.62753	.55247	1.81916	4.42040	4.83465	3.97186	5.28320										
29	29	5.38	53.25	458	6.60	5.29093	.08907	.29328	5.04425	5.53762	4.62171	5.96015										
30	30	5.77	57.00	1070	4.82	5.90375	-.13375	-.44040	5.45045	6.35704	5.13402	6.67347										
31	31	5.90	54.00	488	5.70	5.35457	.54543	1.79595	5.15881	5.55034	4.70240	6.00675										
32	32	5.90	54.00	488	5.70	5.35457	.54543	1.79595	5.15881	5.55034	4.70240	6.00675										
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Data View Variable View

SPSS Processor is ready

Full information on the new variables is available.

*Viscosity.sav [DataSet2] - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window Help

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
1	Patient	Numeric	4	0	Patient ID	None	None	8	Right	Nominal
2	viscosity	Numeric	10	2	Blood Viscosity (cP)	None	None	10	Right	Scale
3	pcv	Numeric	10	2	Packed Cell Volume (%)	None	None	8	Right	Scale
4	plasfib	Numeric	10	0	Plasma Fibrinogen (mg/100ml)	None	None	11	Right	Scale
5	plaspro	Numeric	10	2	Plasma Protein (g/100ml)	None	None	8	Right	Scale
6	PRE_1	Numeric	11	5	Unstandardized Predicted Value	None	None	13	Right	Scale
7	RES_1	Numeric	11	5	Unstandardized Residual	None	None	13	Right	Scale
8	ZRE_1	Numeric	11	5	Standardized Residual	None	None	13	Right	Scale
9	LMCI_1	Numeric	11	5	95% L CI for viscosity mean	None	None	13	Right	Scale
10	UMCI_1	Numeric	11	5	95% U CI for viscosity mean	None	None	13	Right	Scale
11	LICI_1	Numeric	11	5	95% L CI for viscosity individual	None	None	13	Right	Scale
12	UICI_1	Numeric	11	5	95% U CI for viscosity individual	None	None	13	Right	Scale
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Data View Variable View

SPSS Processor is ready

Results: Model Summary

R squared and Adjusted R squared are quite high, so the fit is moderately good.

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.885 ^a	.784	.761	.30370

- a. Predictors: (Constant), Plasma Protein (g/100ml), Plasma Fibrinogen (mg/100ml), Packed Cell Volume (%)
- b. Dependent Variable: Blood Viscosity (cP)

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.368	3	3.123	33.856	.000 ^a
	Residual	2.582	28	.092		
	Total	11.950	31			

- a. Predictors: (Constant), Plasma Protein (g/100ml), Plasma Fibrinogen (mg/100ml), Packed Cell Volume (%)
- b. Dependent Variable: Blood Viscosity (cP)

The ANOVA for the multiple regression has a highly significant F value, with a p-value < 0.001. Here

$H_0 : E[Y] = \text{beta}.0$

$H_1 : E[Y] = \text{beta}.0 + \text{beta}.1 x_1 + \text{beta}.2 x_2 + \text{beta}.3 x_3$

This result implies that the multiple regression (H_a) fits significantly better than the model with no dependence on any of the predictors (H_0).

Results: Parameter Estimates

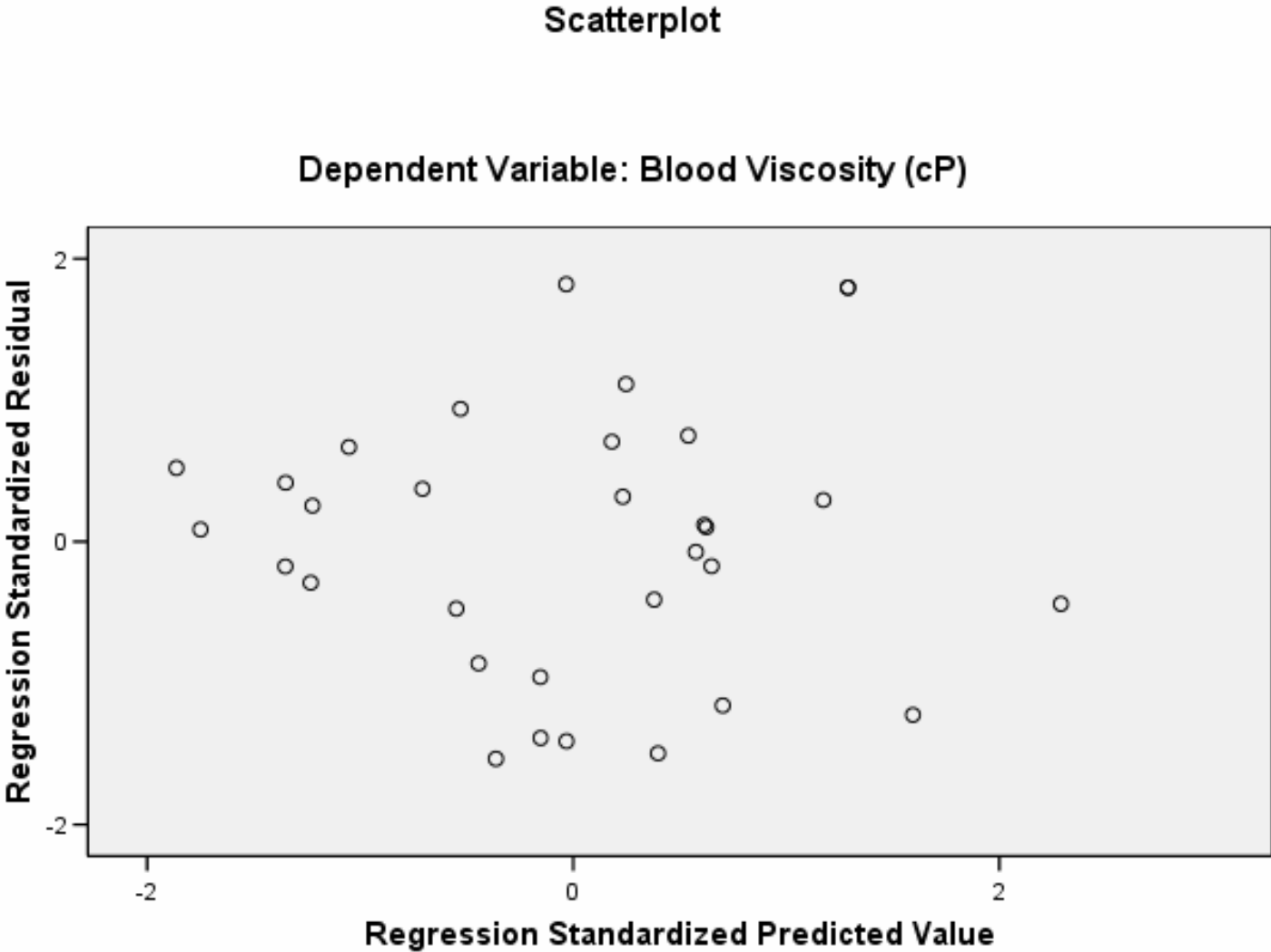
Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-1.378	.897		-1.537	.136	-3.215	.458
	Packed Cell Volume (%)	.117	.014	.839	8.584	.000	.089	.145
	Plasma Fibrinogen (mg/100ml)	.000	.000	.111	1.147	.261	.000	.001
	Plasma Protein (g/100ml)	.040	.097	.037	.412	.683	-.159	.239

a. Dependent Variable: Blood Viscosity (cP)

The coefficient and standard error for Plasma Fibrinogen are not exactly zero, but are zero to three decimal places.

Only the Packed Cell Volume coefficient is significantly different from zero ($p < 0.001$). The intercept (Constant), Plasma Fibrinogen, and Plasma Protein coefficients are not significantly different from zero ($p=0.136, 0.261, 0.683$ respectively)



Obtaining: Plots of Residuals vs Covariates

The screenshot shows the SPSS Data Editor interface for a file named 'ViscosityAnalyzed.sav [DataSet2]'. The main window displays a data grid with the following columns: Patient, viscosity, pcv, PRE_1, RES_1, ZRE_1, LMCI_1, UMCI_1, LIC1_1, UICI_1, and a series of 'var' columns. The 'Patient' column ranges from 1 to 32. The 'viscosity' column ranges from 3.71 to 5.90. The 'pcv' column ranges from 40.00 to 54.00. The residuals and variance columns contain numerical values for each patient. A 'Chart Builder' dialog box is open, showing the 'Interactive' tab with a list of chart types including Bar, Line, Area, Pie, High-Low, Pareto, Control, Boxplot, Error Bar, Population Pyramid, Scatter/Dot, Histogram, P-P, Q-Q, Sequence, ROC Curve, and Time Series. The 'Scatter/Dot...' option is currently selected.

Patient	viscosity	pcv	PRE_1	RES_1	ZRE_1	LMCI_1	UMCI_1	LIC1_1	UICI_1	var	var	var	var	var	var	var	var	var
1	3.71	40.00	3.68399	.02601	.08565	3.45258	3.91540	3.02025	4.34773									
2	3.78	40.00	3.62191	.15809	.52055	3.29311	3.95071	2.91827	4.32555									
3	3.85	42.50	3.90308	-.05308	-.17478	3.64141	4.16475	3.22819	4.57797									
4	3.88	42.00	3.96820	-.08820	-.29042	3.72518	4.21122	3.30032	4.63608									
5	3.98	45.00	4.44615	-.46615	-1.53491	4.14732	4.74498	3.75600	5.13630									
6	4.03	42.00	3.90369	.12631	.41590	3.68995	4.11743	3.24590	4.56148									
7	4.05	42.50	3.97283	.07717	.25409	3.78695	4.15872	3.32366	4.62211									
8	4.14	47.00	4.56154	-.42154	-1.38804	4.33621	4.78688	3.89990	5.22319									
9	4.14	46.75	4.40157	-.26157	-.86130	4.17972	4.62343	3.74110	5.05204									
10	4.20	48.00	4.62831	-.42831	-1.41031	4.50915	4.74747	3.99490	5.26171									
11	4.20	46.00	4.34399	-.14399	-.47413	4.17954	4.50844	3.70053	4.98745									
12	4.27	47.00	4.56079	-.29079	-.95750	4.38678	4.73480	3.91482	5.20676									
13	4.27	43.25	4.06698	.20302	.66851	3.89335	4.24060	3.42110	4.71285									
14	4.37	45.00	4.25686	.11314	.37255	4.09611	4.41761	3.61433	4.89939									
15	4.41	50.00	4.86448	-.45448	-1.49650	4.65413	5.07484	4.20779	5.52118									
16	4.64	45.00	4.35491	.28509	.93873	4.17363	4.53619	3.70694	5.00288									
17	4.68	51.25	5.03159	-.35159	-1.15771	4.83663	5.22655	4.37966	5.68352									
18	4.73	50.25	4.85454	-.12454	-.41008	4.66195	5.04713	4.20331	5.50577									
19	4.87	49.00	4.77364	.09636	.31730	4.65936	4.88791	4.14113	5.40614									
20	4.94	50.00	4.96213	-.02213	-.07287	4.71448	5.20978	4.29255	5.63171									
21	4.95	50.00	5.00255	-.05255	-.17303	4.78804	5.21706	4.34451	5.66059									
22	4.96	49.00	4.74550	.21450	.70631	4.61602	4.87497	4.11007	5.38092									
23	5.02	50.50	4.98907	.03093	.10184	4.85220	5.12594	4.35210	5.62605									
24	5.02	51.25	4.98385	.03615	.11902	4.80178	5.16593	4.33566	5.63205									
25	5.12	49.50	4.78188	.33812	1.11336	4.62664	4.93711	4.14070	5.42305									
26	5.15	56.00	5.52195	-.37195	-1.22473	5.22653	5.61736	4.83327	6.21062									
27	5.17	50.00	4.94267	.22733	.74856	4.79012	5.09521	4.30214	5.58319									
28	5.18	47.00	4.62753	.55247	1.81916	4.42040	4.83465	3.97186	5.28320									
29	5.38	53.25	5.29093	.08907	.29328	5.04425	5.53762	4.62171	5.96015									
30	5.77	57.00	5.90375	-.13375	-.44040	5.45045	6.35704	5.13402	6.67347									
31	5.90	54.00	5.35457	.54543	1.79595	5.15881	5.55034	4.70240	6.00675									
32	5.90	54.00	5.35457	.54543	1.79595	5.15881	5.55034	4.70240	6.00675									

Use the *Matrix Scatter* option, and click *Define*

ViscosityAnalyzed.sav [DataSet2] - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window Help

3:

	Patient	viscosity	pcv	plastib	plaspro	PRE_1	RES_1	ZRE_1	LMCI_1	UMCI_1	LICI_1	UICI_1	var	var	var	var	var	var	var	var		
1	1	3.71	40.00	344	6.27	3.68399	.02601	.08565	3.45258	3.91540	3.02025	4.34773										
2	2	3.78	40.00	330	4.86	3.62191	.15809	.52055	3.29311	3.95071	2.91827	4.32555										
3	3	3.85	42.50	280	5.09	3.90308	-.05308	-.17478	3.64141	4.16475	3.22819	4.57797										
4	4	3.88	42.00	418	6.79	3.96820	-.08820	-.29042	3.72518	4.21122	3.30032	4.63608										
5	5	3.98	45.00	774	6.40	4.44615	-.46615	-1.53491	4.14732	4.74498	3.75600	5.13630										
6	6	4.03	42.00	388	5.48	3.90369	.12631	.41590	3.68895	4.11743	3.24590	4.56148										
7	7	4.05	42.50	336	6.27	3.97283	.07717	.25409	3.78695	4.15872	3.32356	4.62211										
8	8	4.14	47.00	431	6.89	4.56154	-.42154	-1.38804	4.33621	4.78688	3.89990	5.22319										
9	9	4.14	46.75	276	5.18	4.40157	-.26157	-.86130	4.17972	4.62343	3.74110	5.06204										
10	10	4.20	48.00	422	5.73	4.62831	-.42831	-1.41031	4.50915	4.74747	3.99490	5.26171										
11	11	4.20	46.00	280	5.89	4.34399	-.14399	-.47413	4.17954	4.50844	3.70053	4.98745										
12	12	4.27	47.00	460	6.58	4.56079	-.29079	-.95750	4.38678	4.73480	3.91482	5.20676										
13	13	4.27	43.25	412	5.67	4.06698	.20302	.68851	3.89335	4.24060	3.42110	4.71285										
14	14	4.37	45.00	320	6.23	4.25686	.11314	.37255	4.09611	4.41761	3.61433	4.89939										
15	15	4.41	50.00	502	4.99	4.86448	-.45448	-1.49650	4.65413	5.07484	4.20779	5.52118										
16	16	4.64	45.00	550	6.37	4.35491	.28509	.93873	4.17363	4.53619	3.70694	5.00288										
17	17	4.68	51.25	414	6.40	5.03159	-.35159	-1.15771	4.83663	5.22655	4.37966	5.68352										
18	18	4.73	50.25	304	6.00	4.85454	-.12454	-.41008	4.66195	5.04713	4.20331	5.50577										
19	19	4.87	49.00	472	5.94	4.77364	.09636	.31730	4.65936	4.88791	4.14113	5.40614										
20	20	4.94	50.00	728	5.16	4.96213	-.02213	-.07287	4.71448	5.20978	4.29255	5.63171										
21	21	4.95	50.00	716	6.29	5.00255	-.05255	-.17303	4.78804	5.21706	4.34451	5.66059										
22	22	4.96	49.00	400	5.96	4.74550	.21450	.52188	4.52188	4.81488	3.51488	5.38092										
23	23	5.02	50.50	576	5.90	4.98907	.03093	.03093	4.98907	5.03093	3.53093	5.62605										
24	24	5.02	51.25	354	5.81	4.98385	.03615	.03615	4.98385	5.03615	3.53615	5.63205										
25	25	5.12	49.50	392	5.49	4.78188	.33812	.33812	4.78188	4.83812	3.53812	5.42305										
26	26	5.15	56.00	352	5.41	5.52195	-.37195	-.37195	5.52195	5.57195	3.57195	6.21062										
27	27	5.17	50.00	572	6.24	4.94267	.22733	.22733	4.94267	5.02733	3.52733	5.58319										
28	28	5.18	47.00	634	6.50	4.62753	.55247	.55247	4.62753	4.75247	3.55247	5.28320										
29	29	5.38	53.25	458	6.60	5.29093	.08907	.08907	5.29093	5.38907	3.58907	5.96015										
30	30	5.77	57.00	1070	4.82	5.90375	-.13375	-.13375	5.90375	6.03750	3.53750	6.67347										
31	31	5.90	54.00	488	5.70	5.35457	.54543	.54543	5.35457	5.55034	3.55034	6.00675										
32	32	5.90	54.00	488	5.70	5.35457	.54543	.54543	5.35457	5.55034	3.55034	6.00675										
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Scatter/Dot

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Overlay Scatter 3-D Scatter

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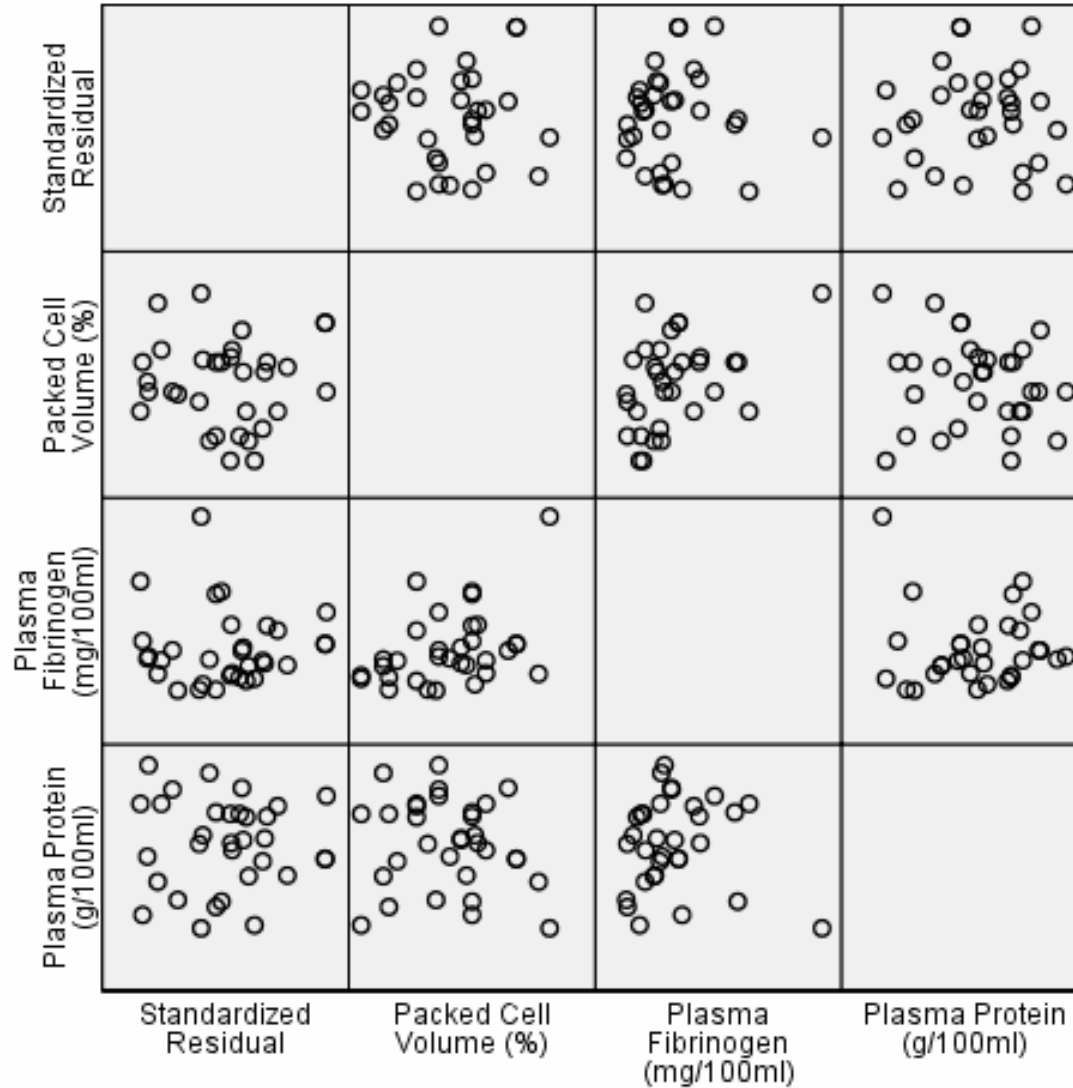
Data View Variable View / SPSS Processor is ready

Select the standardized residuals, and the three covariates for the *Matrix Variables*. Click *OK*.

The screenshot shows the SPSS Data Editor window with a dataset named 'ViscosityAnalyzed.sav [DataSet2]'. The data table contains 32 rows of patient data with columns for Patient ID, viscosity, pcv, plasfib, plaspro, and standardized residuals (PRE_1, RES_1, ZRE_1), along with three covariates (LMCI_1, UMCI_1, LIC1_1) and their standardized residuals (UICI_1). A 'Scatterplot Matrix' dialog box is open, showing the selection of 'Standardized Resi', 'Packed Cell Volun', 'Plasma Fibrinogen', and 'Plasma Protein (g)' as matrix variables. The dialog also includes options for 'Set Markers by', 'Label Cases by', 'Panel by', and 'Template'.

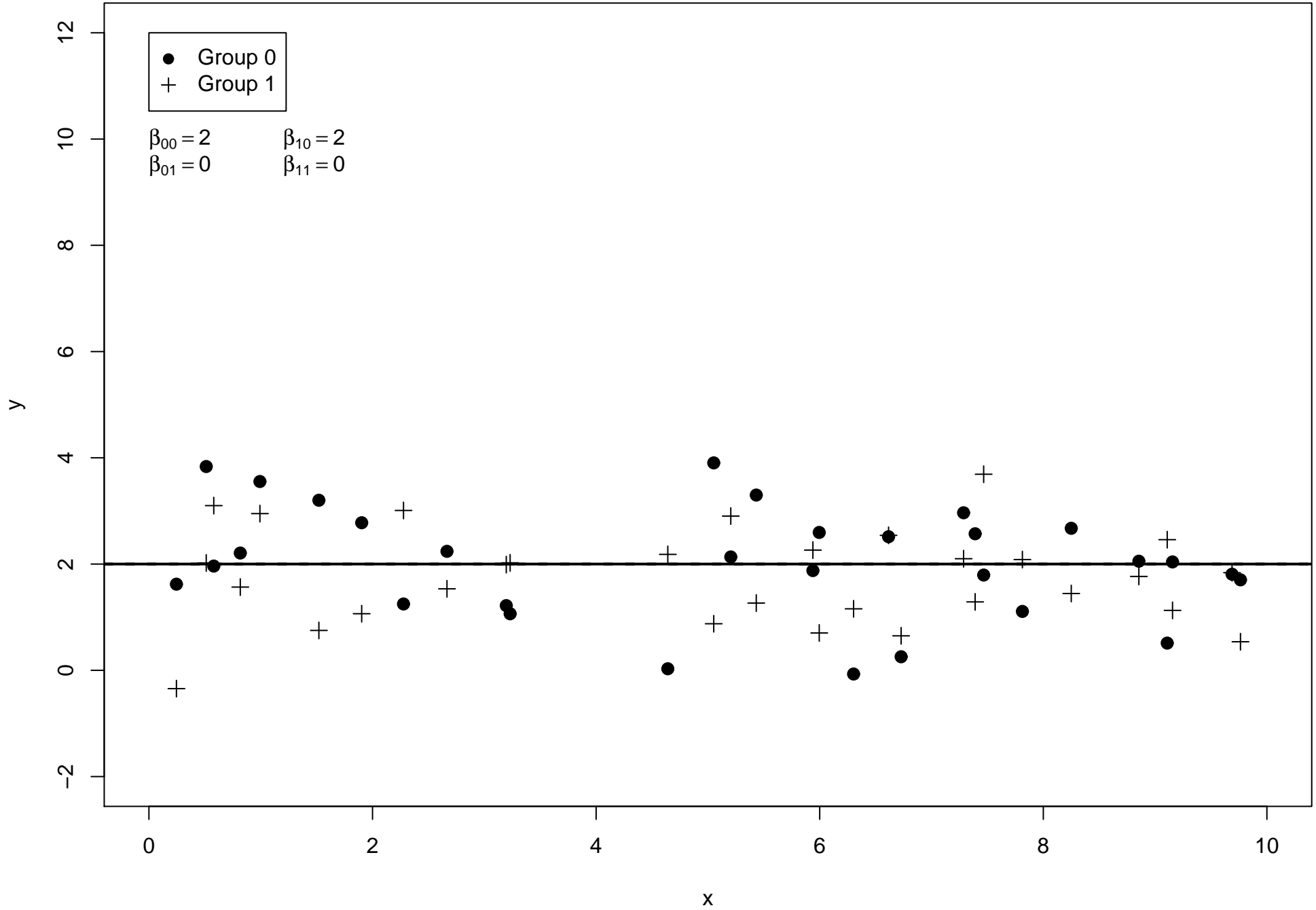
Patient	viscosity	pcv	plasfib	plaspro	PRE_1	RES_1	ZRE_1	LMCI_1	UMCI_1	LIC1_1	UICI_1	var	var	var	var	var	var	var	var
1	3.71	40.00	344	6.27	3.68399	.02601	.08565	3.45258	3.91540	3.02025	4.34773								
2	3.78	40.00	330	4.86	3.62191	.16809	.52055	3.29311	3.95071	2.91827	4.32555								
3	3.85	42.50	280	5.09	3.90308	-.05308	-.17478	3.64141	4.16475	3.22819	4.57797								
4	3.88	42.00	418	6.79	3.96820	-.08820	-.29042	3.72518	4.21122	3.30032	4.63608								
5	3.98	45.00	774	6.40	4.44615	-.46615	-1.53491	4.14732	4.74498	3.75600	5.13630								
6	4.03	42.00	388	5.48	3.90369	.12631	.41590	3.68895	4.11743	3.24590	4.56148								
7	4.05	42.50	336	6.27	3.97283	.07717	.25409	3.78695	4.15872	3.32366	4.62211								
8	4.14	47.00	431	6.89	4.56154	-.42154	-1.38804	4.33621	4.78688	3.89990	5.22319								
9	4.14	46.75	276	5.18	4.40157	-.26157	-.86130	4.17972	4.62343	3.74110	5.06204								
10	4.20	48.00	422	5.73	4.62831	-.42831	-1.41031	4.50915	4.74747	3.99490	5.26171								
11	4.20	46.00	280	5.89	4.34399	-.14399	-.47413	4.17954	4.50844	3.70053	4.98745								
12	4.27	47.00	460	6.58	4.56079	-.29079	-.07559	4.05559	4.53499	3.64499	5.20676								
13	4.27	43.25	412	5.67	4.06898	.20302	-.07559	4.05559	4.53499	3.64499	4.71285								
14	4.37	45.00	320	6.23	4.25686	.11314	-.07559	4.05559	4.53499	3.64499	4.89939								
15	4.41	50.00	502	4.99	4.86448	-.45448	-.07559	4.05559	4.53499	3.64499	5.52118								
16	4.64	45.00	550	6.37	4.35491	.28509	-.07559	4.05559	4.53499	3.64499	5.00288								
17	4.68	51.25	414	6.40	5.03159	-.35159	-.07559	4.05559	4.53499	3.64499	5.68352								
18	4.73	50.25	304	6.00	4.85454	-.12454	-.07559	4.05559	4.53499	3.64499	5.50577								
19	4.87	49.00	472	5.94	4.77364	.09636	-.07559	4.05559	4.53499	3.64499	5.40614								
20	4.94	50.00	728	5.16	4.96213	-.02213	-.07559	4.05559	4.53499	3.64499	5.63171								
21	4.95	50.00	716	6.29	5.00255	-.05255	-.07559	4.05559	4.53499	3.64499	5.66059								
22	4.96	49.00	400	5.96	4.74550	.21450	-.07559	4.05559	4.53499	3.64499	5.38092								
23	5.02	50.50	576	5.90	4.98907	.03093	-.07559	4.05559	4.53499	3.64499	5.62605								
24	5.02	51.25	354	5.81	4.98385	.03615	-.07559	4.05559	4.53499	3.64499	5.63205								
25	5.12	49.50	392	5.49	4.78188	.33812	-.07559	4.05559	4.53499	3.64499	5.42305								
26	5.15	56.00	352	5.41	5.52195	-.37195	-.07559	4.05559	4.53499	3.64499	6.21062								
27	5.17	50.00	572	6.24	4.94267	.22733	-.07559	4.05559	4.53499	3.64499	5.58319								
28	5.18	47.00	634	6.50	4.62753	.55247	-.07559	4.05559	4.53499	3.64499	5.28320								
29	5.38	53.25	458	6.60	5.29093	.08907	-.07559	4.05559	4.53499	3.64499	5.96015								
30	5.77	57.00	1070	4.82	5.90375	-.13375	-.07559	4.05559	4.53499	3.64499	6.67347								
31	5.90	54.00	488	5.70	5.35457	.54543	-.07559	4.05559	4.53499	3.64499	6.00675								
32	5.90	54.00	488	5.70	5.35457	.54543	-.07559	4.05559	4.53499	3.64499	6.00675								

Results: Scatterplot Matrix

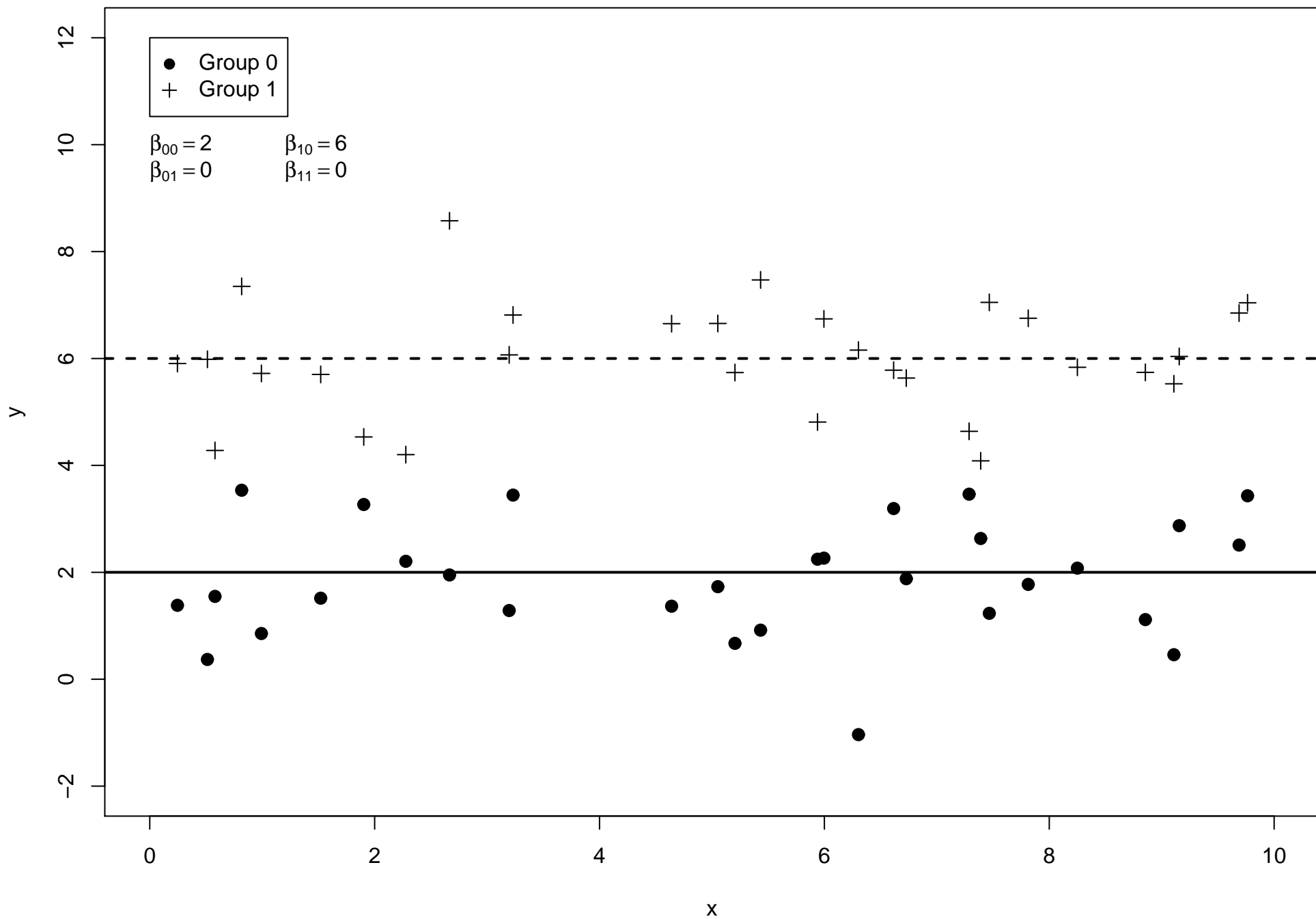


No real pattern in the plot of standardized residuals against the three predictors.

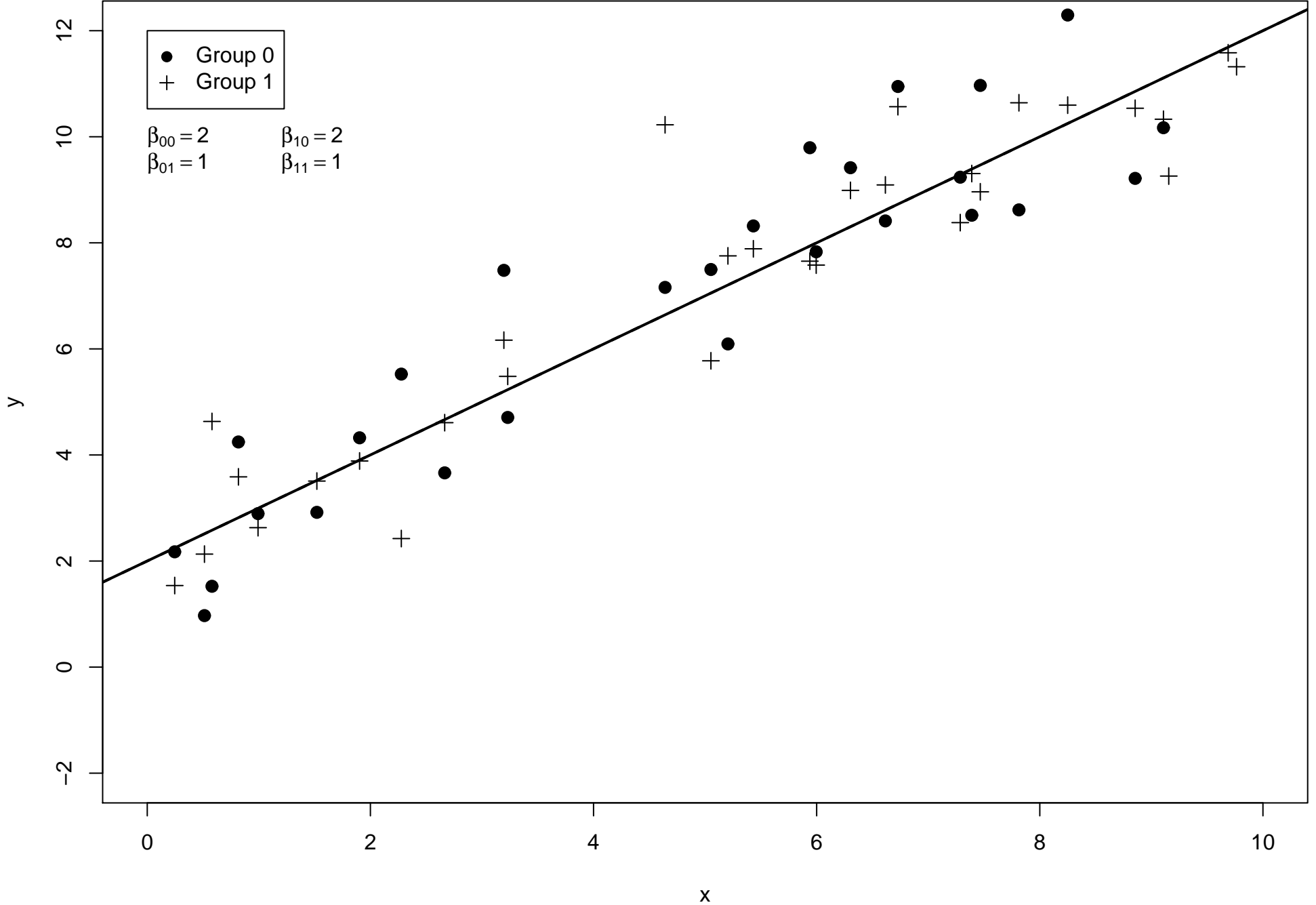
Null Model



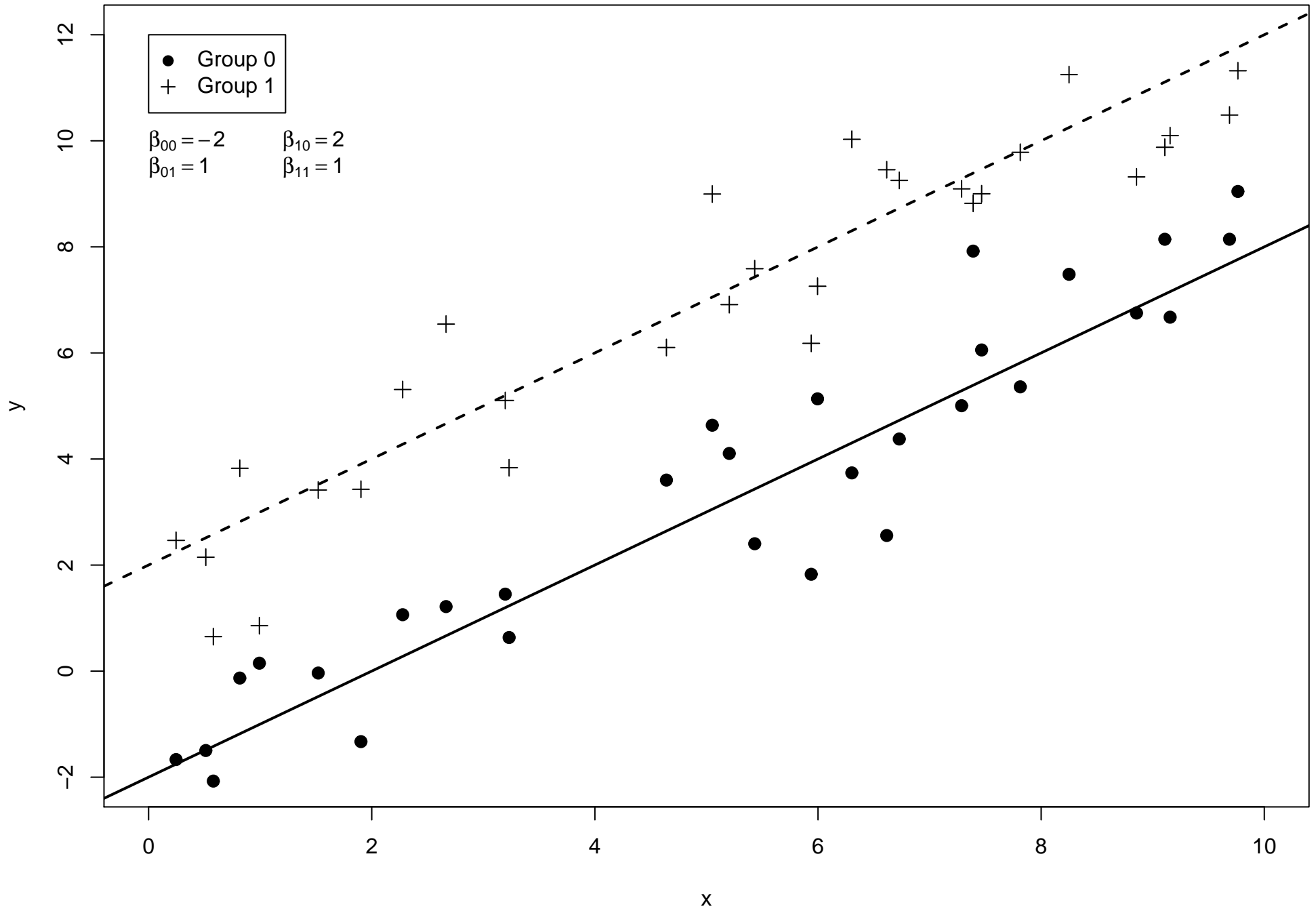
Main Effect Model: Significant Factor Effect (different intercept in both groups, slope=0)



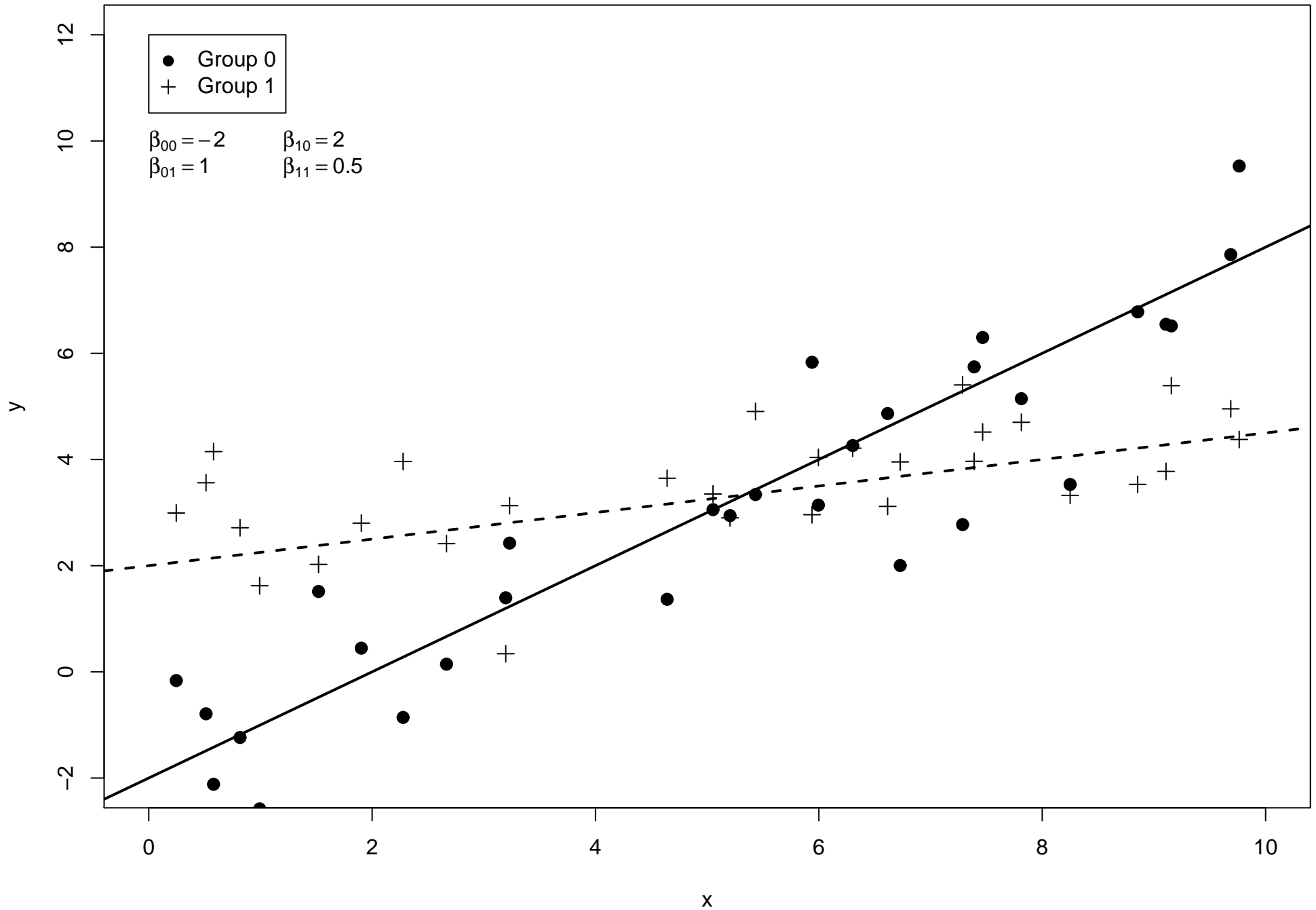
Main Effect Model: Significant Covariate Effect (intercept, slope same in both groups)



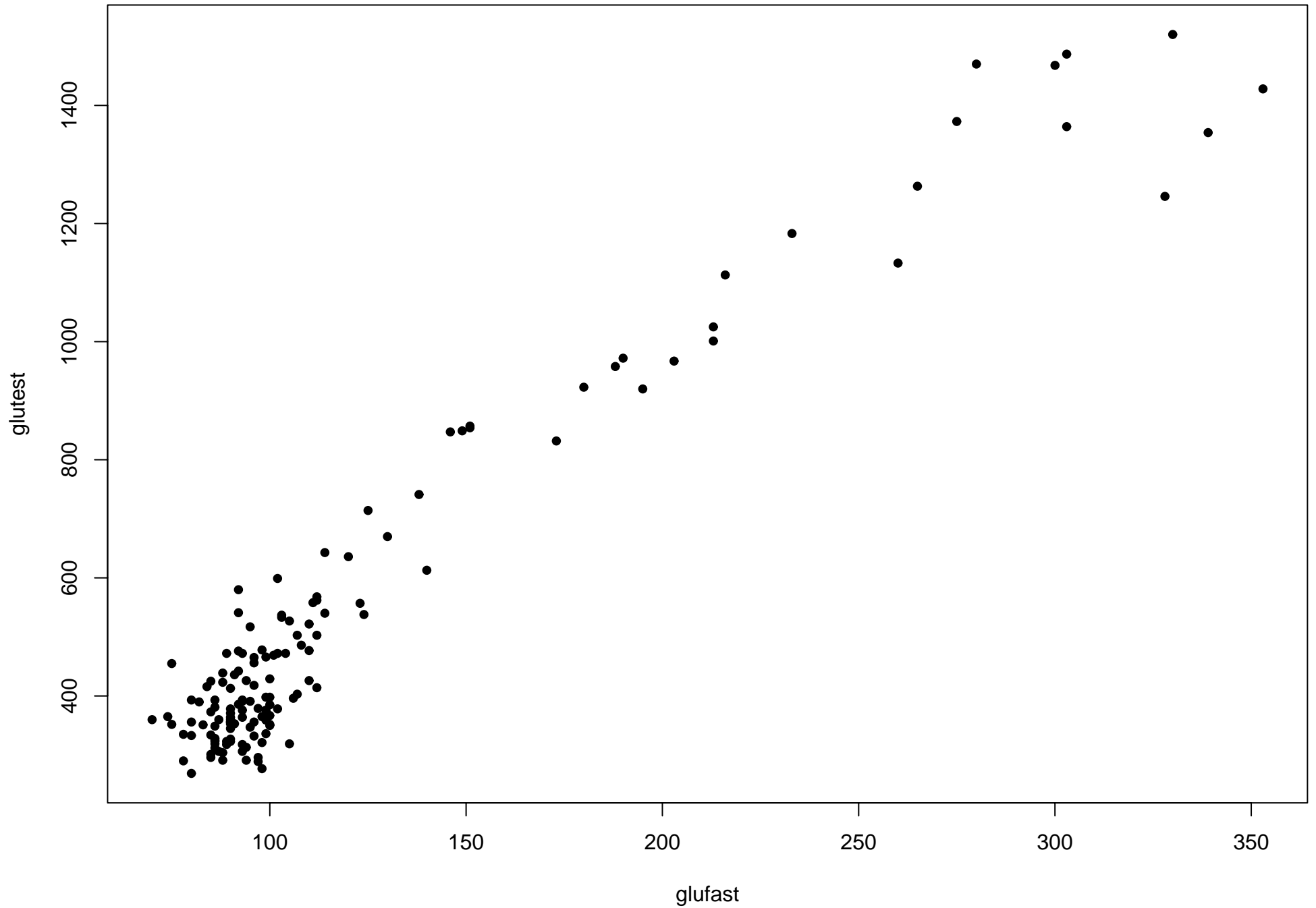
Main Effect Model: Significant Covariate and Factor Effect (intercept different, slope same in the two groups)



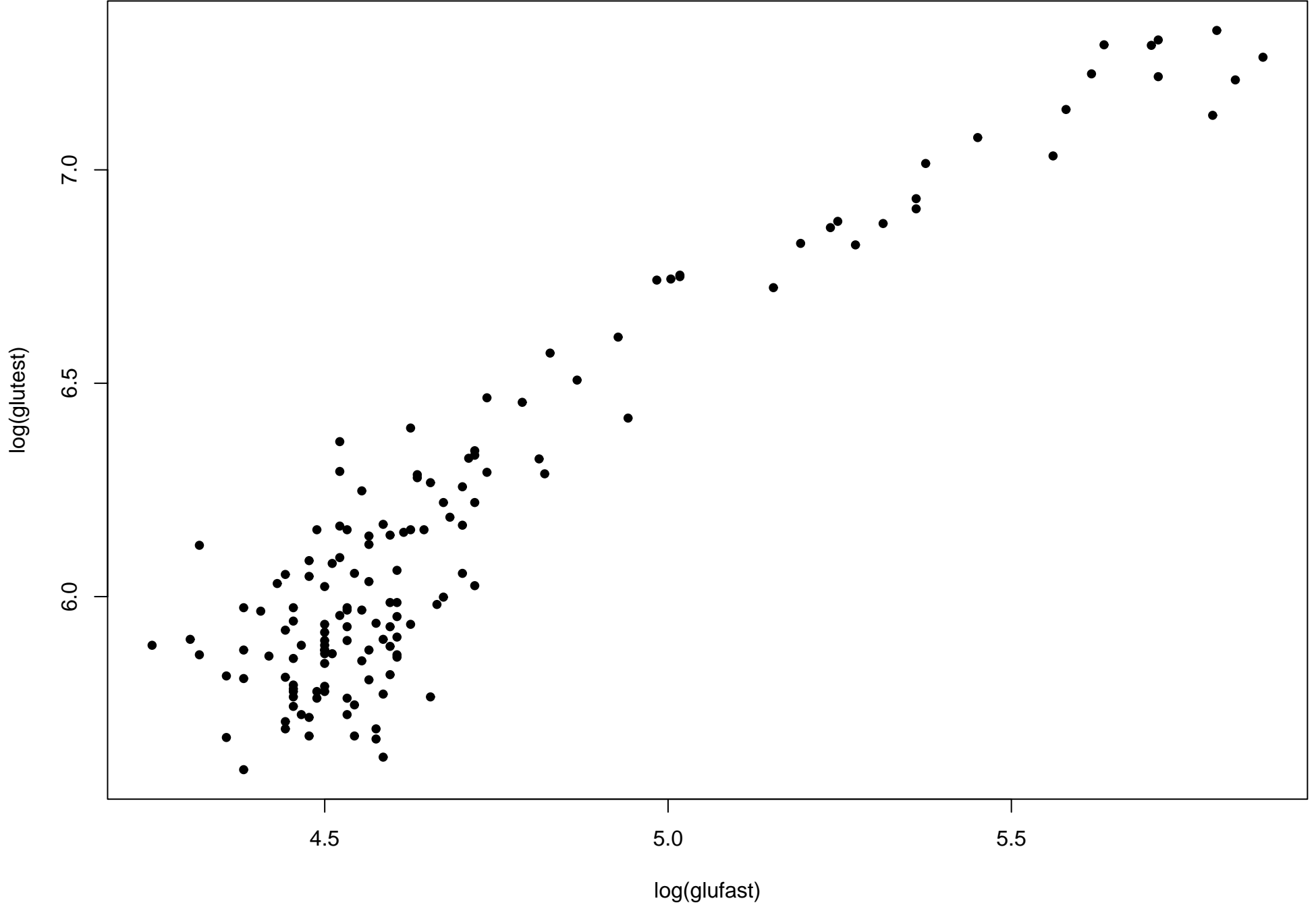
Interaction Model: Covariate, Factor and Interaction Effect (different intercept and slope in the two groups)



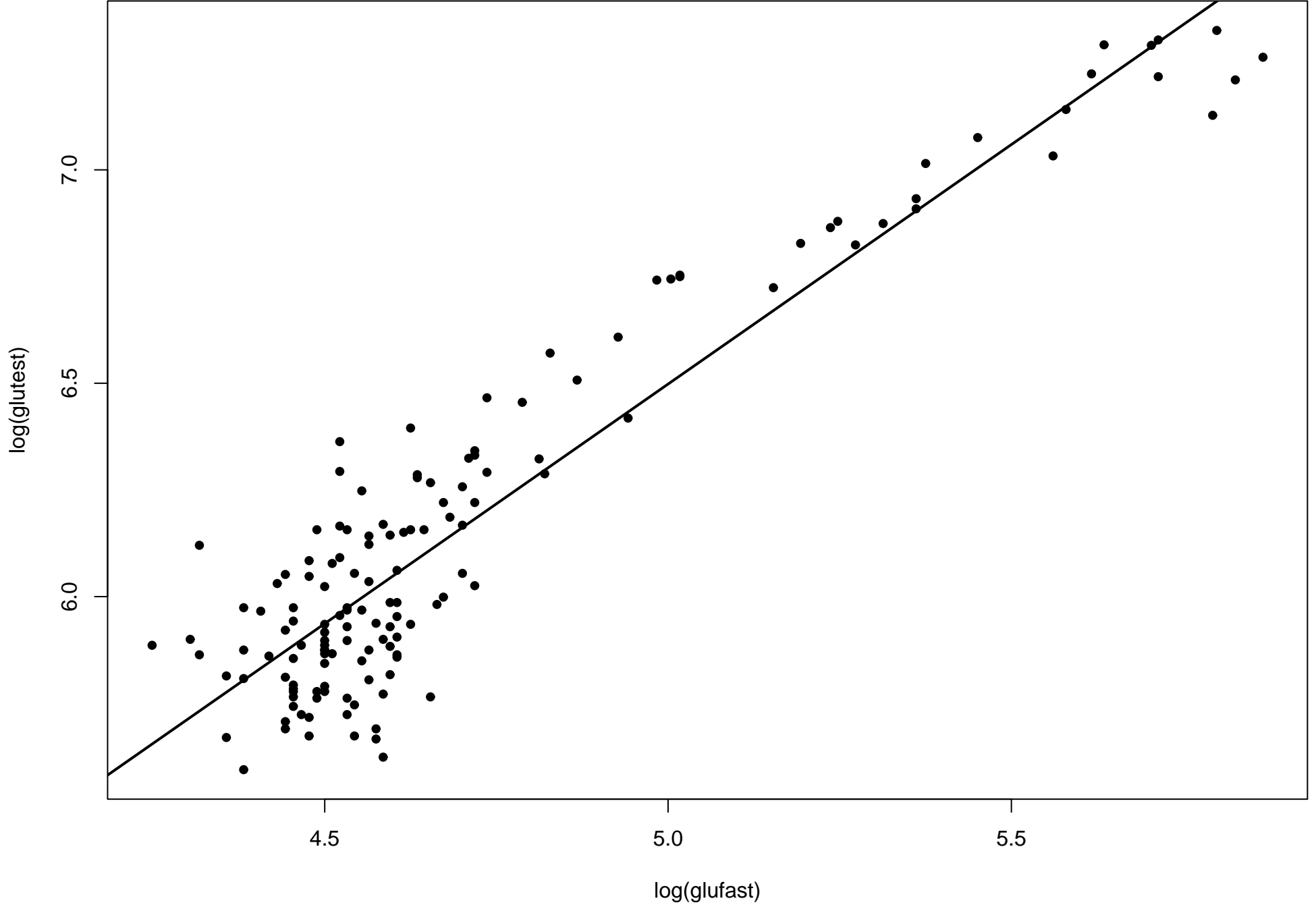
Original Data



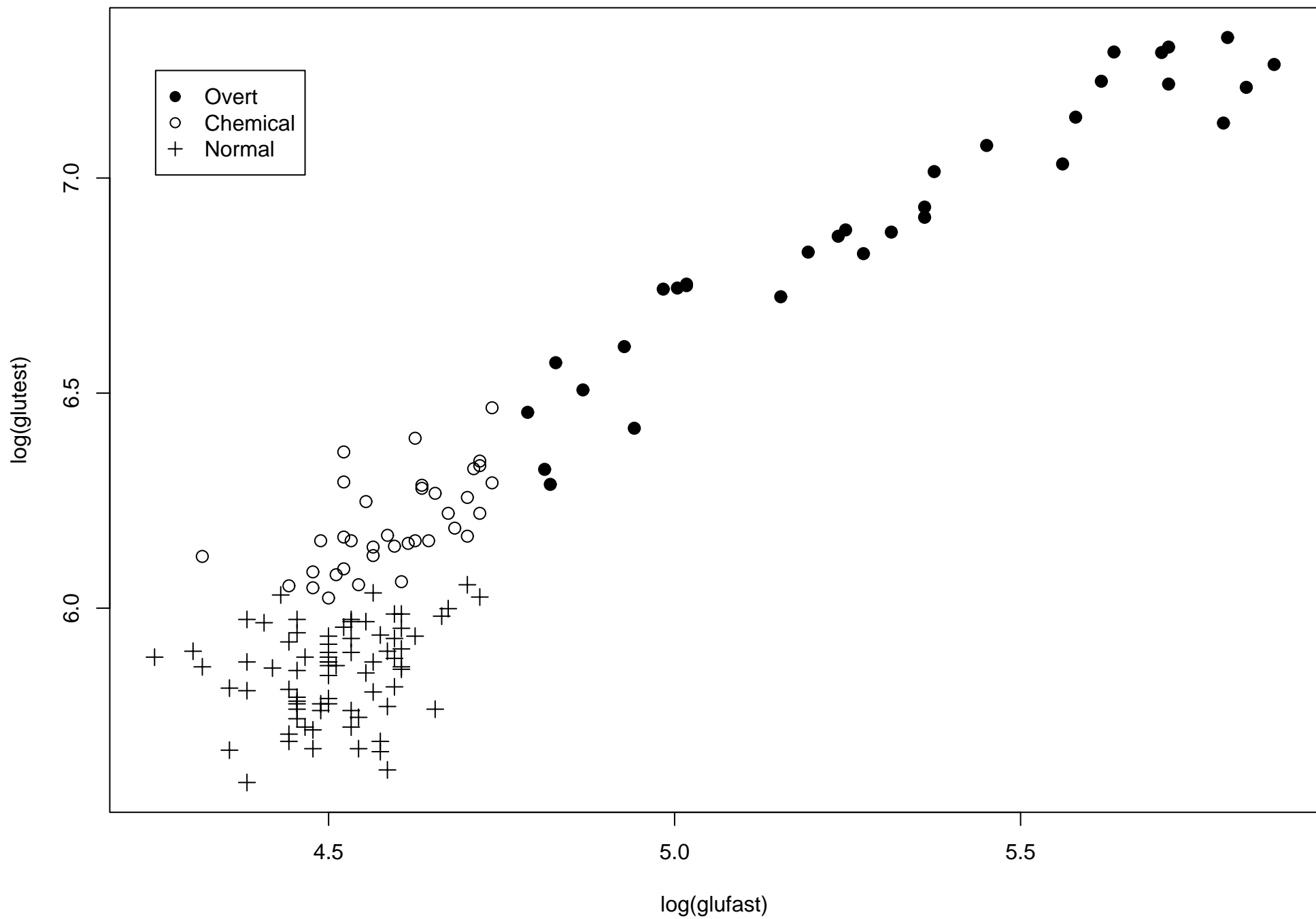
Log-scale Data



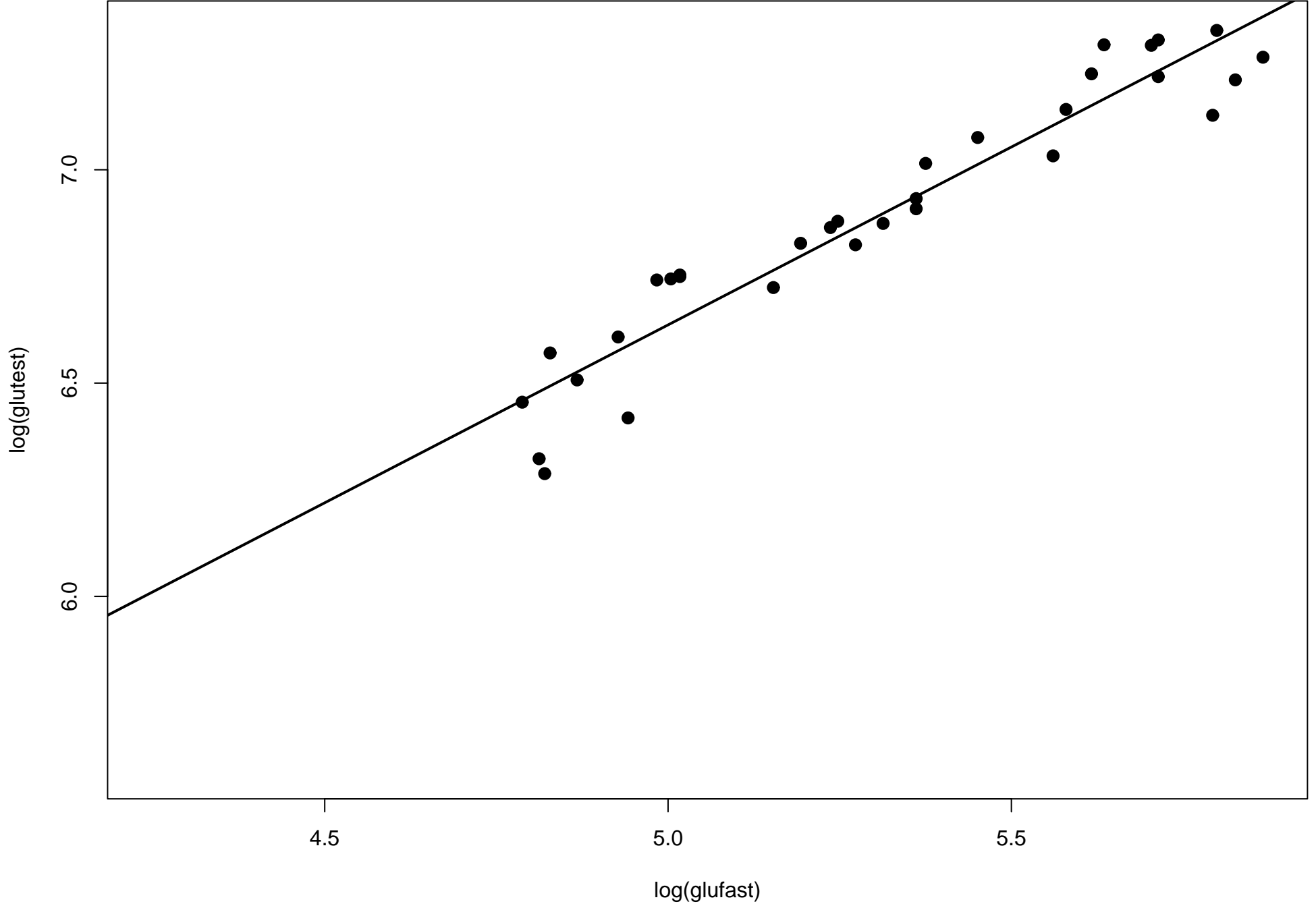
Log-scale Data



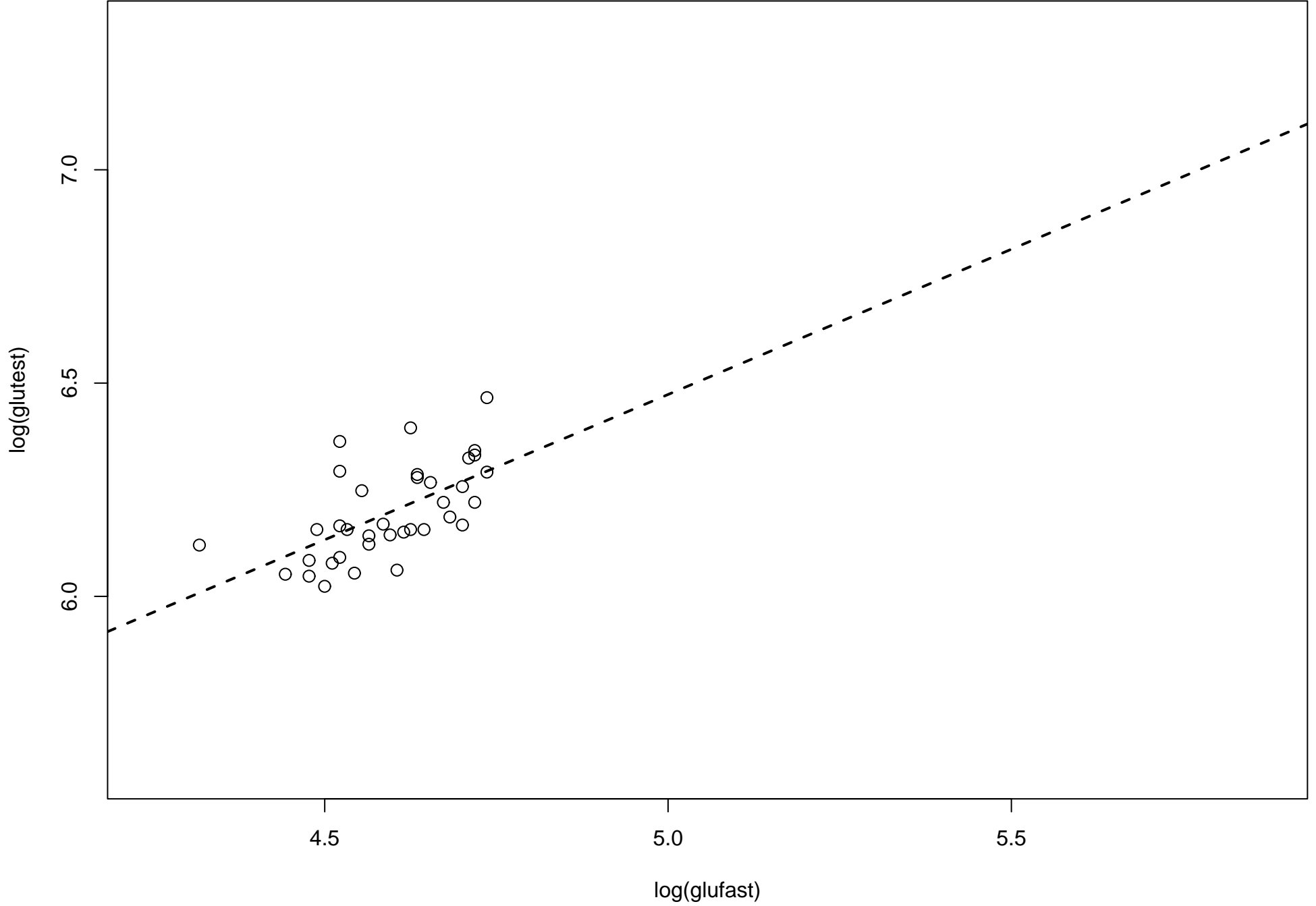
Subgroups



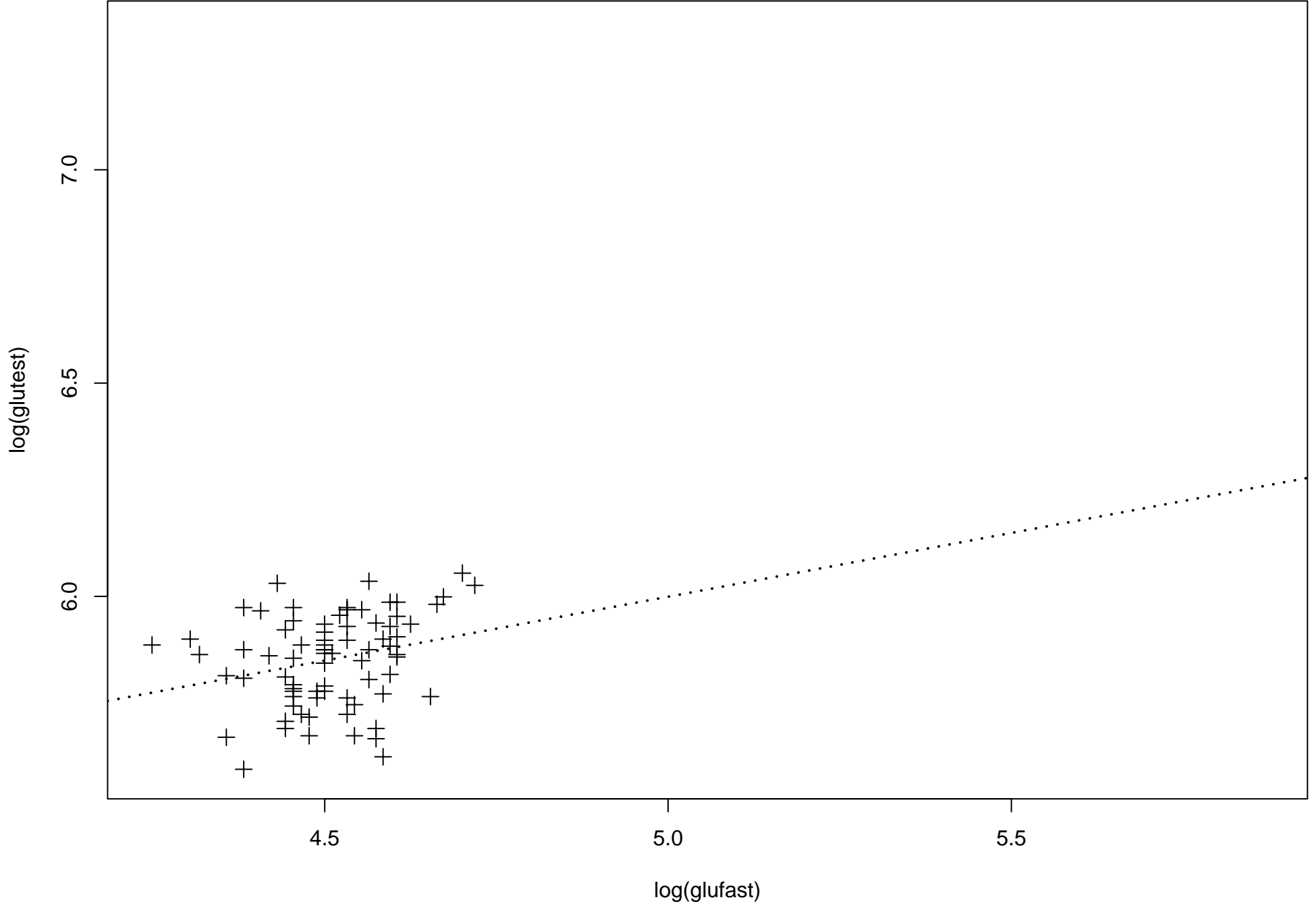
Group 1



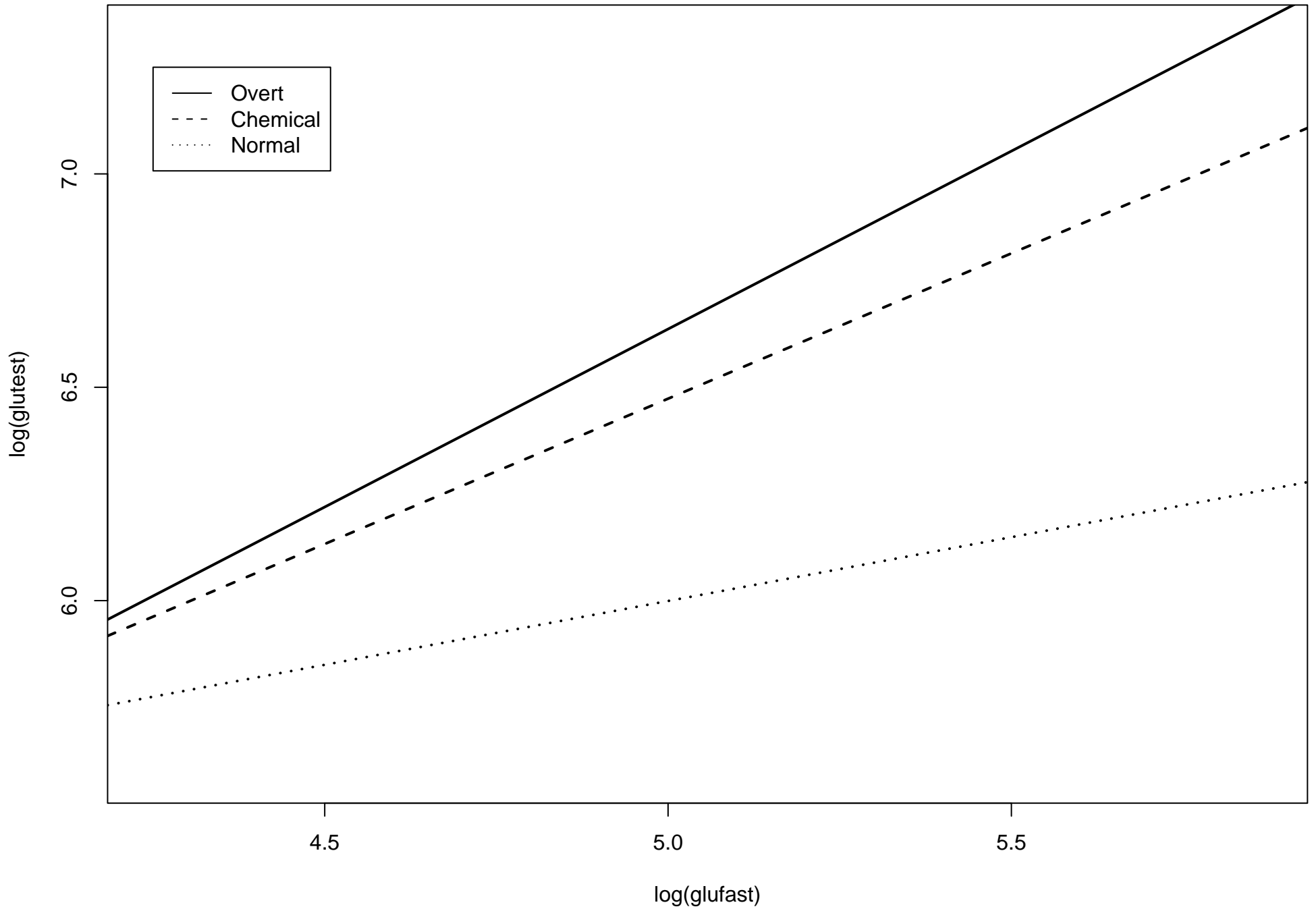
Group 2



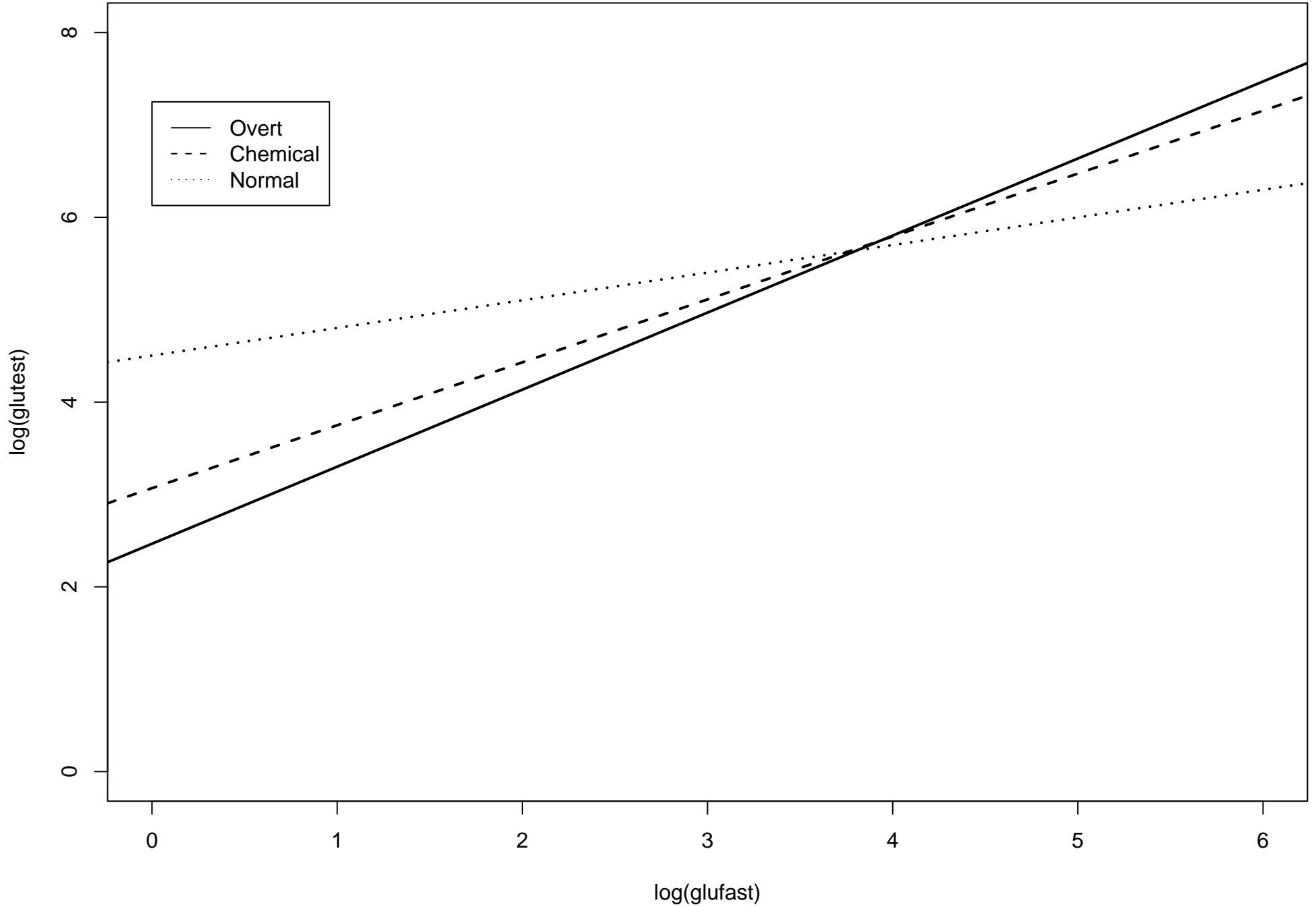
Group 3



Fits to the three subgroups



Projection back to the axis



FACTOR PREDICTOR REGRESSION

We need to take some care when combining factor predictors and covariates in the regression model. Suppose that we have only two predictors

- A **covariate**, x_1
- A **factor predictor**, x_2 , now taking L levels, with the levels being indexed by $l = 1, 2, \dots, L$.

We want to build a model that takes into account both x_1 and x_2 .

Example : Binary Factor $L = 2$

Suppose that factor predictor x_2 takes two levels, labelled 0 and 1, that identify two data subgroups. Five models can be considered, that correspond to different straight-line models

- **MODEL 0** : Same intercept, slope zero, in the two subgroups
- **MODEL 1** : Different intercept, slope zero, in the two subgroups
- **MODEL 2** : Same intercept, same non-zero slope, in the two subgroups
- **MODEL 3** : Different intercept, same non-zero slope, in the two subgroups
- **MODEL 4** : Different intercept, different non-zero slopes, in the two subgroups

We can write out the models in terms of the usual slope and intercept parameters. The general model can be written

$$y = \begin{cases} \beta_{00} + \beta_{01}x_1 + \epsilon & \text{GROUP 0} \quad (l = 0) \\ \beta_{10} + \beta_{11}x_1 + \epsilon & \text{GROUP 1} \quad (l = 1) \end{cases}$$

- **MODEL 0 :** $\beta_{00} = \beta_{10} = \beta_0, \beta_{01} = \beta_{11} = 0$
- **MODEL 1 :** $\beta_{00} \neq \beta_{10}, \beta_{01} = \beta_{11} = 0$
- **MODEL 2 :** $\beta_{00} = \beta_{10} = \beta_0, \beta_{01} = \beta_{11} = \beta_1 \neq 0$
- **MODEL 3 :** $\beta_{00} \neq \beta_{10}, \beta_{01} = \beta_{11} = \beta_1 \neq 0$
- **MODEL 4 :** $\beta_{00} \neq \beta_{10}, \beta_{01} \neq \beta_{11}$

The numbers of parameters, p , in each model are as follows:

MODEL 0	:	$p = 1$	β_0
MODEL 1	:	$p = 2$	β_{00}, β_{10}
MODEL 2	:	$p = 2$	β_0, β_1
MODEL 3	:	$p = 3$	$\beta_{00}, \beta_{10}, \beta_1$
MODEL 4	:	$p = 4$	$\beta_{00}, \beta_{10}, \beta_{10}, \beta_{11}$

SPSS Parameterization: The default parameterization used by SPSS is different from the one described above. SPSS takes a baseline group, and looks for **differences** in the parameters compared to the baseline group. The baseline group is taken to be the last listed subgroup for the factor predictor; in the binary example above, the baseline group would be Group 1.

The interaction model is therefore written

$$y = [\beta_0 + (1 - x_2)\delta_{00}] + [(\beta_1 + (1 - x_2)\delta_{01})x_1] + \epsilon$$

- δ_{00} is the **change in intercept** from Group 1 to Group 0
- δ_{01} is the **change in slope** from Group 1 to Group 0

Example: Diabetes Data Set

The data in the data set **DIABETES.SAV** contain information on 68 diabetes patients falling into two clinically different categories (overt and chemical diabetics) and 76 normal controls. Measurements of plasma glucose in blood samples when fasting and in a dietary test are recorded.

The objective is to predict the the test glucose levels from the fasting glucose levels in the three subgroups, and to find out if there is any significant difference between the subgroups.

In this analysis, there is a single response variable, one covariate and one factor predictor:

- y : **glutest**, the test glucose level
- x_1 : covariate **glufast**, the fasting glucose level
- x_2 : factor predictor **group**, the diabetes group
 - GROUP 1: Overt Diabetic
 - GROUP 2: Chemical Diabetic
 - GROUP 3: Normal Patients

Tests of Between-Subjects Effects

Dependent Variable: Log(GluTest)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	27.187^a	5	5.437	569.463	.000
Intercept	.973	1	.973	101.906	.000
group	.104	2	.052	5.447	.005
loggluf	.675	1	.675	70.702	.000
group * loggluf	.155	2	.077	8.099	.000
Error	1.318	138	.010		
Total	5509.040	144			
Corrected Total	28.504	143			

a. R Squared = .954 (Adjusted R Squared = .952)

Parameter Estimates

Dependent Variable: Log(GluTest)

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	4.504	.559	8.060	.000	3.399	5.608
[group=1]	-2.037	.619	-3.289	.001	-3.262	-.813
[group=2]	-1.436	.958	-1.499	.136	-3.330	.458
[group=3]	0 ^a	.	.	.	.	.
loggluf	.299	.124	2.414	.017	.054	.544
[group=1] * loggluf	.535	.134	4.001	.000	.270	.799
[group=2] * loggluf	.382	.210	1.820	.071	-.033	.797
[group=3] * loggluf	0 ^a	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

The first ANOVA table demonstrates that there **is** a significant interaction between the covariate and the factor predictor ($F = 8.099$, $p\text{-value} < 0.001$). This means that there is a **significantly different slope in at least two of the three** subgroups.

The second table gives the slope and intercept parameters in the three groups. The SPSS parameterization is not directly in terms of the slopes and intercepts, but looks at **differences** from baseline subgroup, Group 3. For example, the Group 1 intercept and slope are, respectively,

$$\text{INTERCEPT} : 4.504 + (-2.037) = 2.467 \quad \text{SLOPE} : 0.299 + 0.535 = 0.834.$$

Diabetes Data Set

Diabetes.sav [DataSet1] - SPSS Data Editor																											
File Edit View Data Transform Analyze Graphs Utilities Window Help																											
33 :																											
	id	relwt	glufast	glutest	instest	sspg	group	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var
1	1	.81	80	356	124	55	Normal																				
2	2	.95	97	289	117	76	Normal																				
3	3	.94	105	319	143	105	Normal																				
4	4	1.04	90	356	199	108	Normal																				
5	5	1.00	90	323	240	143	Normal																				
6	6	.76	86	381	157	165	Normal																				
7	7	.91	100	350	221	119	Normal																				
8	8	1.10	85	301	186	105	Normal																				
9	9	.99	97	379	142	98	Normal																				
10	10	.78	97	296	131	94	Normal																				
11	11	.90	91	353	221	53	Normal																				
12	12	.73	87	306	178	66	Normal																				
13	13	.96	78	290	136	142	Normal																				
14	14	.84	90	371	200	93	Normal																				
15	15	.74	86	312	208	68	Normal																				
16	16	.98	80	393	202	102	Normal																				
17	17	1.10	90	364	152	76	Normal																				
18	18	.85	99	359	185	37	Normal																				
19	19	.83	85	296	116	60	Normal																				
20	20	.93	90	345	123	50	Normal																				
21	21	.95	90	378	136	47	Normal																				
22	22	.74	88	304	134	50	Normal																				
23	23	.95	95	347	184	91	Normal																				
24	24	.97	90	327	192	124	Normal																				
25	25	.72	92	386	279	74	Normal																				
26	26	1.11	74	365	228	235	Normal																				
27	27	1.20	98	365	145	158	Normal																				
28	28	1.13	100	352	172	140	Normal																				
29	29	1.00	86	325	179	145	Normal																				
30	30	.78	98	321	222	99	Normal																				
31	31	1.00	70	360	134	90	Normal																				
32	32	1.00	99	336	143	105	Normal																				
33	33	.71	75	352	169	32	Normal																				
34	34	.76	90	353	263	165	Normal																				
35	35	.89	85	373	174	78	Normal																				
36	36	.88	99	376	134	80	Normal																				
37	37	1.17	100	367	182	54	Normal																				
38	38	.85	78	335	241	175	Normal																				
39	39	.97	106	396	128	80	Normal																				
40	40	1.00	98	277	222	186	Normal																				
41	41	1.00	102	378	165	117	Normal																				
42	42	.89	90	360	282	160	Normal																				
43	43	.98	94	291	94	71	Normal																				
44	44	.78	80	269	121	29	Normal																				
45	45	.74	93	318	73	42	Normal																				
46	46	.91	86	328	106	56	Normal																				
47	47	.95	85	334	118	122	Normal																				
48	48	.95	96	356	112	73	Normal																				
49	49	1.03	88	291	157	122	Normal																				
50	50	.87	87	360	292	128	Normal																				
51	51	.87	94	313	200	233	Normal																				
52	52	1.17	93	306	220	132	Normal																				
53	53	.83	86	319	144	138	Normal																				
54	54	.82	86	349	109	83	Normal																				
55	55	.86	96	332	151	109	Normal																				

Create two new variables **loggulf** and **logglt** for the logged variables

***Diabetes.sav [DataSet1] - SPSS Data Editor**

File Edit View Data Transform Analyze Graphs Utilities Window Help

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
1	id	Numeric	11	0	Patient ID	None	None	8	Right	Scale
2	relwt	Numeric	11	2	Relative Weight	None	None	8	Right	Scale
3	glufast	Numeric	11	0	Fasting Plasma Glucose	None	None	8	Right	Scale
4	glutest	Numeric	11	0	Test Plasma Glucose	None	None	8	Right	Scale
5	instest	Numeric	11	0	Plasma Insulin during Test	None	None	8	Right	Scale
6	sspg	Numeric	11	0	Steady State Plasma Glucose	None	None	8	Right	Scale
7	group	Numeric	11	0	Clinical Group	(1, Overt Diabe	None	14	Right	Ordinal
8	loggulf	Numeric	8	2	Log(GluFast)	None	None	8	Right	Scale
9	logglt	Numeric	8	2	Log(GluTest)	None	None	8	Right	Scale
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
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Data View Variable View

SPSS Processor is ready

Use the *Compute* pulldown menu to compute the log transform

The screenshot shows the SPSS Data Editor window for a file named "Diabetes.sav". The "Compute..." menu is open, showing options like Recode, Count, Rank Cases, Date/Time, etc. The data table below has the following columns: test, sspg, group, loggluf, logglut, and 18 columns labeled "var".

test	sspg	group	loggluf	logglut	var	var	var	var	var	var	var	var	var	var	var	var	var	var
10	10																	
11	11																	
12	12																	
13	13																	
14	14																	
15	15																	
16	16																	
17	17																	
18	18																	
19	19	.83	85	296	116	60	Normal	.	.									
20	20	.93	90	345	123	50	Normal	.	.									
21	21	.95	90	378	136	47	Normal	.	.									
22	22	.74	88	304	134	50	Normal	.	.									
23	23	.95	95	347	184	91	Normal	.	.									
24	24	.97	90	327	192	124	Normal	.	.									
25	25	.72	92	386	279	74	Normal	.	.									
26	26	1.11	74	365	228	235	Normal	.	.									
27	27	1.20	98	365	145	158	Normal	.	.									
28	28	1.13	100	352	172	140	Normal	.	.									
29	29	1.00	86	325	179	145	Normal	.	.									
30	30	.78	98	321	222	99	Normal	.	.									
31	31	1.00	70	360	134	90	Normal	.	.									
32	32	1.00	99	336	143	105	Normal	.	.									
33	33	.71	75	352	169	32	Normal	.	.									
34	34	.76	90	353	263	165	Normal	.	.									
35	35	.88	85	373	174	78	Normal	.	.									
36	36	.88	99	376	134	80	Normal	.	.									
37	37	1.17	100	367	182	54	Normal	.	.									
38	38	.85	78	335	241	175	Normal	.	.									
39	39	.97	106	396	128	80	Normal	.	.									
40	40	1.00	98	277	222	186	Normal	.	.									
41	41	1.00	102	378	165	117	Normal	.	.									
42	42	.89	90	360	282	160	Normal	.	.									
43	43	.98	94	291	94	71	Normal	.	.									
44	44	.78	80	269	121	29	Normal	.	.									
45	45	.74	93	318	73	42	Normal	.	.									
46	46	.91	86	328	106	56	Normal	.	.									
47	47	.95	85	334	118	122	Normal	.	.									
48	48	.95	96	356	112	73	Normal	.	.									
49	49	1.03	88	291	157	122	Normal	.	.									
50	50	.87	87	360	292	128	Normal	.	.									
51	51	.87	94	313	200	233	Normal	.	.									
52	52	1.17	93	306	220	132	Normal	.	.									
53	53	.83	86	319	144	138	Normal	.	.									
54	54	.82	86	349	109	83	Normal	.	.									
55	55	.86	96	332	151	109	Normal	.	.									
56	56	1.01	86	323	158	96	Normal	.	.									
57	57	.88	89	323	73	52	Normal	.	.									
58	58	.75	83	351	81	42	Normal	.	.									
59	59	.99	98	478	151	122	Chemically Diabetic	.	.									
60	60	1.12	100	398	122	176	Normal	.	.									
61	61	1.09	110	426	117	118	Normal	.	.									
62	62	1.02	88	439	208	244	Chemically Diabetic	.	.									
63	63	1.19	100	429	201	194	Chemically Diabetic	.	.									
64	64	1.06	80	333	131	136	Normal	.	.									

In *Target Variable* insert **loggluf**, and in *Numeric Expression* type **Ln(glufast)**, and click OK

The screenshot shows the SPSS Data Editor interface with the 'Compute Variable' dialog box open. The dialog box is titled 'Compute Variable' and has a close button (X) in the top right corner. The 'Target Variable' field contains 'loggluf'. The 'Numeric Expression' field contains 'Ln(glufast)'. The 'Function group' is set to 'All'. The 'Functions and Special Variables' list is open, showing 'Ln' selected. The 'If...' field is empty. The dialog box has 'OK', 'Reset', 'Cancel', and 'Help' buttons at the bottom.

The background shows a data grid with the following columns: Patient ID [id], Relative Weight [relwt], Fasting Plasma Glucose [fgluc], Test Plasma Glucose [tpluc], Plasma Insulin during [pidur], Steady State Plasma [sspl], Clinical Group [group], Log(GluFast) [loggluf], and Log(GluEst) [logglut]. The data grid shows rows of data for Patient IDs 24 through 55.

Click OK when the confirmation screen appears

The screenshot shows the SPSS Data Editor interface with the 'Compute Variable' dialog box open. The 'Target Variable' is 'loggluf' and the 'Numeric Expression' is 'Ln(glufast)'. A smaller dialog box titled 'SPSS 14.0 for Windows Student Version' is overlaid on top, asking 'Change existing variable?' with 'OK' and 'Cancel' buttons. The background shows a data grid with columns labeled 'loggluf', 'logglut', and several 'var' columns. The status bar at the bottom indicates 'SPSS Processor is ready'.

The log transformed variable **logg1uf** is computed.

***Diabetes.sav [DataSet1] - SPSS Data Editor**

File Edit View Data Transform Analyze Graphs Utilities Window Help

7:

	id	rehwt	glufast	glutest	instest	sspg	group	logg1uf	logg1ut	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var
1	1	.81	80	356	124	55	Normal	4.38																		
2	2	.95	97	289	117	76	Normal	4.57																		
3	3	.94	105	319	143	105	Normal	4.65																		
4	4	1.04	90	356	199	108	Normal	4.50																		
5	5	1.00	90	323	240	143	Normal	4.50																		
6	6	.76	86	381	157	165	Normal	4.45																		
7	7	.91	100	350	221	119	Normal	4.61																		
8	8	1.10	85	301	186	105	Normal	4.44																		
9	9	.99	97	379	142	98	Normal	4.57																		
10	10	.78	97	296	131	94	Normal	4.57																		
11	11	.90	91	353	221	53	Normal	4.51																		
12	12	.73	87	306	178	66	Normal	4.47																		
13	13	.96	78	290	136	142	Normal	4.36																		
14	14	.84	90	371	200	93	Normal	4.50																		
15	15	.74	86	312	208	68	Normal	4.45																		
16	16	.98	80	393	202	102	Normal	4.38																		
17	17	1.10	90	364	152	76	Normal	4.50																		
18	18	.85	99	359	185	37	Normal	4.60																		
19	19	.83	85	296	116	60	Normal	4.44																		
20	20	.93	90	345	123	50	Normal	4.50																		
21	21	.95	90	378	136	47	Normal	4.50																		
22	22	.74	88	304	134	50	Normal	4.48																		
23	23	.95	95	347	184	91	Normal	4.55																		
24	24	.97	90	327	192	124	Normal	4.50																		
25	25	.72	92	386	279	74	Normal	4.52																		
26	26	1.11	74	365	228	235	Normal	4.30																		
27	27	1.20	98	365	145	158	Normal	4.58																		
28	28	1.13	100	352	172	140	Normal	4.61																		
29	29	1.00	86	325	179	145	Normal	4.45																		
30	30	.78	98	321	222	99	Normal	4.58																		
31	31	1.00	70	360	134	90	Normal	4.25																		
32	32	1.00	99	336	143	105	Normal	4.60																		
33	33	.71	75	352	169	32	Normal	4.32																		
34	34	.76	90	353	263	165	Normal	4.50																		
35	35	.89	85	373	174	78	Normal	4.44																		
36	36	.88	99	376	134	80	Normal	4.60																		
37	37	1.17	100	367	182	54	Normal	4.61																		
38	38	.85	78	335	241	175	Normal	4.36																		
39	39	.97	106	396	128	80	Normal	4.66																		
40	40	1.00	98	277	222	186	Normal	4.58																		
41	41	1.00	102	378	165	117	Normal	4.62																		
42	42	.89	90	360	282	160	Normal	4.50																		
43	43	.98	94	291	94	71	Normal	4.54																		
44	44	.78	80	269	121	29	Normal	4.38																		
45	45	.74	93	318	73	42	Normal	4.53																		
46	46	.91	86	328	106	56	Normal	4.45																		
47	47	.95	85	334	118	122	Normal	4.44																		
48	48	.95	96	356	112	73	Normal	4.56																		
49	49	1.03	88	291	157	122	Normal	4.48																		
50	50	.87	87	360	292	128	Normal	4.47																		
51	51	.87	94	313	200	233	Normal	4.54																		
52	52	1.17	93	306	220	132	Normal	4.53																		
53	53	.83	86	319	144	138	Normal	4.45																		
54	54	.82	86	349	109	83	Normal	4.45																		
55	55	.86	96	332	151	109	Normal	4.56																		

Data View Variable View

SPSS Processor is ready

The same procedure computes the log transformed variable **loggltut**; we log transform the glutest variable using the *Compute* pulldown

*Diabetes.sav [DataSet1] - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window Help

7:

	id	relwt	glufast	glutest	instest	sspg	group	loggltut	loggltut	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	
1	1	.81	80	356	124	55	Normal	4.38	5.87																	
2	2	.95	97	289	117	76	Normal	4.57	5.67																	
3	3	.94	105	319	143	105	Normal	4.65	5.77																	
4	4	1.04	90	356	199	108	Normal	4.50	5.87																	
5	5	1.00	90	323	240	143	Normal	4.50	5.78																	
6	6	.76	86	381	157	165	Normal	4.45	5.94																	
7	7	.91	100	350	221	119	Normal	4.61	5.86																	
8	8	1.10	85	301	186	105	Normal	4.44	5.71																	
9	9	.99	97	379	142	98	Normal	4.57	5.94																	
10	10	.78	97	296	131	94	Normal	4.57	5.69																	
11	11	.90	91	353	221	53	Normal	4.51	5.87																	
12	12	.73	87	306	178	66	Normal	4.47	5.72																	
13	13	.96	78	290	136	142	Normal	4.36	5.67																	
14	14	.84	90	371	200	93	Normal	4.50	5.92																	
15	15	.74	86	312	208	68	Normal	4.45	5.74																	
16	16	.98	80	393	202	102	Normal	4.38	5.97																	
17	17	1.10	90	364	152	76	Normal	4.50	5.90																	
18	18	.85	99	359	185	37	Normal	4.60	5.88																	
19	19	.83	85	296	116	60	Normal	4.44	5.69																	
20	20	.93	90	345	123	50	Normal	4.50	5.84																	
21	21	.95	90	378	136	47	Normal	4.50	5.93																	
22	22	.74	88	304	134	50	Normal	4.48	5.72																	
23	23	.95	95	347	184	91	Normal	4.55	5.85																	
24	24	.97	90	327	192	124	Normal	4.50	5.79																	
25	25	.72	92	386	279	74	Normal	4.52	5.96																	
26	26	1.11	74	365	228	235	Normal	4.30	5.90																	
27	27	1.20	98	365	145	158	Normal	4.58	5.90																	
28	28	1.13	100	352	172	140	Normal	4.61	5.86																	
29	29	1.00	86	325	179	145	Normal	4.45	5.78																	
30	30	.78	98	321	222	99	Normal	4.58	5.77																	
31	31	1.00	70	360	134	90	Normal	4.25	5.89																	
32	32	1.00	99	336	143	105	Normal	4.60	5.82																	
33	33	.71	75	352	169	32	Normal	4.32	5.86																	
34	34	.76	90	353	263	165	Normal	4.50	5.87																	
35	35	.89	85	373	174	78	Normal	4.44	5.92																	
36	36	.88	99	376	134	80	Normal	4.60	5.93																	
37	37	1.17	100	367	182	54	Normal	4.61	5.91																	
38	38	.85	78	335	241	175	Normal	4.36	5.81																	
39	39	.97	106	396	128	80	Normal	4.66	5.98																	
40	40	1.00	98	277	222	186	Normal	4.58	5.62																	
41	41	1.00	102	378	165	117	Normal	4.62	5.93																	
42	42	.89	90	360	282	160	Normal	4.50	5.89																	
43	43	.98	94	291	94	71	Normal	4.54	5.67																	
44	44	.78	80	269	121	29	Normal	4.38	5.59																	
45	45	.74	93	318	73	42	Normal	4.53	5.76																	
46	46	.91	86	328	106	56	Normal	4.45	5.79																	
47	47	.95	85	334	118	122	Normal	4.44	5.81																	
48	48	.95	96	356	112	73	Normal	4.56	5.87																	
49	49	1.03	88	291	157	122	Normal	4.48	5.67																	
50	50	.87	87	360	292	128	Normal	4.47	5.89																	
51	51	.87	94	313	200	233	Normal	4.54	5.75																	
52	52	1.17	93	306	220	132	Normal	4.53	5.72																	
53	53	.83	86	319	144	138	Normal	4.45	5.77																	
54	54	.82	86	349	109	83	Normal	4.45	5.86																	
55	55	.86	96	332	151	109	Normal	4.56	5.81																	

57

SPSS Processor is ready

We now perform the linear regression using the *General Linear Model* pulldown. ⁸

The screenshot shows the SPSS Data Editor interface for a file named 'Diabetes.sav'. The 'Analyze' menu is open, and the path 'General Linear Model > Univariate...' is highlighted. The data table below shows the following columns: 'id', 'relwt', 'gl', 'group', 'loggluf', and 'logglut'. The 'group' column contains the value 'Normal' for all rows. The 'loggluf' and 'logglut' columns contain numerical values ranging from approximately 4.25 to 5.88.

	id	relwt	gl	group	loggluf	logglut			
1	1	.81		Normal	4.38	5.87			
2	2	.95		Normal	4.57	5.67			
3	3	.94		Normal	4.65	5.77			
4	4	1.04		Normal	4.50	5.87			
5	5	1.00		Normal	4.50	5.78			
6	6	.76		Normal	4.45	5.94			
7	7	.91		Normal	4.61	5.86			
8	8	1.10		Normal	4.44	5.71			
9	9	.99	97	379	142	98	Normal	4.57	5.94
10	10	.78	97	296	131	94	Normal	4.57	5.69
11	11	.90	91	353	221	53	Normal	4.51	5.87
12	12	.73	87	306	178	66	Normal	4.47	5.72
13	13	.96	78	290	136	142	Normal	4.36	5.67
14	14	.84	90	371	200	93	Normal	4.50	5.92
15	15	.74	86	312	208	68	Normal	4.45	5.74
16	16	.98	80	393	202	102	Normal	4.38	5.97
17	17	1.10	90	364	152	76	Normal	4.50	5.90
18	18	.85	99	359	185	37	Normal	4.60	5.88
19	19	.83	85	296	116	60	Normal	4.44	5.69
20	20	.93	90	345	123	50	Normal	4.50	5.84
21	21	.95	90	378	136	47	Normal	4.50	5.93
22	22	.74	88	304	134	50	Normal	4.48	5.72
23	23	.95	95	347	184	91	Normal	4.55	5.85
24	24	.97	90	327	192	124	Normal	4.50	5.79
25	25	.72	92	386	279	74	Normal	4.52	5.96
26	26	1.11	74	365	228	235	Normal	4.30	5.90
27	27	1.20	98	365	145	158	Normal	4.58	5.90
28	28	1.13	100	352	172	140	Normal	4.61	5.86
29	29	1.00	86	325	179	145	Normal	4.45	5.78
30	30	.78	98	321	222	99	Normal	4.58	5.77
31	31	1.00	70	360	134	90	Normal	4.25	5.89
32	32	1.00	99	336	143	105	Normal	4.60	5.82
33	33	.71	75	352	169	32	Normal	4.32	5.86
34	34	.76	90	353	263	165	Normal	4.50	5.87
35	35	.89	85	373	174	78	Normal	4.44	5.92
36	36	.88	99	376	134	80	Normal	4.60	5.93
37	37	1.17	100	367	182	54	Normal	4.61	5.91
38	38	.85	78	335	241	175	Normal	4.36	5.81
39	39	.97	106	396	128	80	Normal	4.66	5.98
40	40	1.00	98	277	222	186	Normal	4.58	5.62
41	41	1.00	102	378	165	117	Normal	4.62	5.93
42	42	.89	90	360	282	160	Normal	4.50	5.89
43	43	.98	94	291	94	71	Normal	4.54	5.67
44	44	.78	80	269	121	29	Normal	4.38	5.59
45	45	.74	93	318	73	42	Normal	4.53	5.76
46	46	.91	86	328	106	56	Normal	4.45	5.79
47	47	.95	85	334	118	122	Normal	4.44	5.81
48	48	.95	96	356	112	73	Normal	4.56	5.87
49	49	1.03	88	291	157	122	Normal	4.48	5.67
50	50	.87	87	360	292	128	Normal	4.47	5.89
51	51	.87	94	313	200	233	Normal	4.54	5.75
52	52	1.17	93	306	220	132	Normal	4.53	5.72
53	53	.83	86	319	144	138	Normal	4.45	5.77
54	54	.82	86	349	109	83	Normal	4.45	5.86
55	55	.86	96	332	151	109	Normal	4.56	5.81

Select the *Dependent Variable (logglut)*, the *Fixed Factor (group)* and the *Covariate (loggluf)*.

The screenshot shows the SPSS Data Editor window with a data table and an open Univariate dialog box. The data table has columns for patient ID, various glucose and insulin measurements, a clinical group, and two log-transformed variables. The Univariate dialog box is configured as follows:

- Dependent Variable:** Log(GluTest) [logglut]
- Fixed Factor(s):** Clinical Group [group]
- Covariate(s):** Log(GluFast) [loggluf]

id	relwt	glufast	glutest	instest	sspg	group	loggluf	logglut
1	.81	80	356	124	55	Normal	4.38	5.87
2	.95	97	289	117	76	Normal	4.57	5.67
3	.94	105	319	143	105	Normal	4.65	5.77
4	1.04	90	265	100	108	Normal	4.50	5.87
5	1.04	90	265	100	108	Normal	4.50	5.78
6	1.04	90	265	100	108	Normal	4.45	5.94
7	1.04	90	265	100	108	Normal	4.61	5.86
8	1.04	90	265	100	108	Normal	4.44	5.71
9	1.04	90	265	100	108	Normal	4.57	5.94
10	1.04	90	265	100	108	Normal	4.57	5.69
11	1.04	90	265	100	108	Normal	4.51	5.87
12	1.04	90	265	100	108	Normal	4.47	5.72
13	1.04	90	265	100	108	Normal	4.36	5.67
14	1.04	90	265	100	108	Normal	4.50	5.92
15	1.04	90	265	100	108	Normal	4.45	5.74
16	1.04	90	265	100	108	Normal	4.38	5.97
17	1.04	90	265	100	108	Normal	4.50	5.90
18	1.04	90	265	100	108	Normal	4.60	5.88
19	1.04	90	265	100	108	Normal	4.44	5.69
20	1.04	90	265	100	108	Normal	4.50	5.84
21	1.04	90	265	100	108	Normal	4.50	5.93
22	1.04	90	265	100	108	Normal	4.48	5.72
23	1.04	90	265	100	108	Normal	4.55	5.85
24	.97	90	327	192	124	Normal	4.50	5.79
25	.72	92	386	279	74	Normal	4.52	5.96
26	1.11	74	365	228	235	Normal	4.30	5.90
27	1.20	98	365	145	158	Normal	4.58	5.90
28	1.13	100	352	172	140	Normal	4.61	5.86
29	1.00	86	325	179	145	Normal	4.45	5.78
30	.78	98	321	222	99	Normal	4.58	5.77
31	1.00	70	360	134	90	Normal	4.25	5.89
32	1.00	99	336	143	105	Normal	4.60	5.82
33	.71	75	352	169	32	Normal	4.32	5.86
34	.76	90	353	263	165	Normal	4.50	5.87
35	.89	85	373	174	78	Normal	4.44	5.92
36	.88	99	376	134	80	Normal	4.60	5.93
37	1.17	100	367	182	54	Normal	4.61	5.91
38	.85	78	335	241	175	Normal	4.36	5.81
39	.97	106	396	128	80	Normal	4.66	5.98
40	1.00	98	277	222	186	Normal	4.58	5.62
41	1.00	102	378	165	117	Normal	4.62	5.93
42	.89	90	360	282	160	Normal	4.50	5.89
43	.98	94	291	94	71	Normal	4.54	5.67
44	.78	80	269	121	29	Normal	4.38	5.59
45	.74	93	318	73	42	Normal	4.53	5.76
46	.91	86	328	106	56	Normal	4.45	5.79
47	.95	85	334	118	122	Normal	4.44	5.81
48	.95	96	356	112	73	Normal	4.56	5.87
49	1.03	88	291	157	122	Normal	4.48	5.67
50	.87	87	360	292	128	Normal	4.47	5.89
51	.87	94	313	200	233	Normal	4.54	5.75
52	1.17	93	306	220	132	Normal	4.53	5.72
53	.83	86	319	144	138	Normal	4.45	5.77
54	.82	86	349	109	83	Normal	4.45	5.86
55	.86	96	332	151	109	Normal	4.56	5.81

To specify the model, click the *Model* button to get the *Model Dialog*.

We wish to specify a *Custom* main effects plus interaction model.

The image shows the SPSS Data Editor window with a data set named 'Diabetes.sav'. The 'Univariate' dialog box is open, and the 'Univariate: Model' sub-dialog is also open. In the 'Univariate: Model' dialog, the 'Specify Model' section has 'Custom' selected. The 'Factors & Covariates' list contains 'group(F)' and 'loggluf(C)'. The 'Build Term(s)' section has a dropdown menu set to 'Main effects', and the 'Model' list is empty. The 'Sum of squares' dropdown is set to 'Type III', and the 'Include intercept in model' checkbox is checked. The background data editor shows a grid of data with columns for 'group', 'loggluf', 'logglut', and several 'var' columns. The status bar at the bottom indicates 'SPSS Processor is ready'.

We select the factor and covariate as main effects.

The image shows the SPSS Data Editor interface with a Univariate dialog box open. The dialog box is titled "Univariate: Model" and is set to "Custom". Under "Factors & Covariates", "group(F)" and "loggluf(C)" are listed. The "Model" list contains "group" and "loggluf". The "Sum of squares" is set to "Type III" and "Include intercept in model" is checked. The background shows a data grid with columns for "group", "loggluf", "logglut", and several "var" columns. The status bar at the bottom indicates "SPSS Processor is ready".

Select *Interaction* from the *Build Terms* pulldown.

Diabetes.sav [DataSet1] - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window Help

7: group loggluf logglut var var var var var var var var var var var var var var var var var var var

1 Normal 4.38 5.87
 2 4.57 5.67
 3 4.65 5.77
 4 4.50 5.87
 5 4.50 5.78
 6 4.45 5.94
 7 4.61 5.86
 8 4.44 5.71
 9 4.57 5.94
 10 4.57 5.69
 11 4.51 5.87
 12 4.47 5.72
 13 4.36 5.67
 14 4.50 5.92
 15 4.45 5.74
 16 4.38 5.97
 17 4.50 5.90
 18 4.60 5.88
 19 4.44 5.69
 20 20 .93 90 345 123 50 Normal 4.50 5.84
 21 21 .95 90 378 136 47 Normal 4.50 5.93
 22 22 .74 88 304 134 50 Normal 4.48 5.72
 23 23 .95 95 347 184 91 Normal 4.55 5.85
 24 24 .97 90 327 192 124 Normal 4.50 5.79
 25 25 .72 92 386 279 74 Normal 4.52 5.96
 26 26 1.11 74 365 228 235 Normal 4.30 5.90
 27 27 1.20 98 365 145 158 Normal 4.58 5.90
 28 28 1.13 100 352 172 140 Normal 4.61 5.86
 29 29 1.00 86 325 179 145 Normal 4.45 5.78
 30 30 .78 98 321 222 99 Normal 4.58 5.77
 31 31 1.00 70 360 134 90 Normal 4.25 5.89
 32 32 1.00 99 336 143 105 Normal 4.60 5.82
 33 33 .71 75 352 169 32 Normal 4.32 5.86
 34 34 .76 90 353 263 165 Normal 4.50 5.87
 35 35 .89 85 373 174 78 Normal 4.44 5.92
 36 36 .88 99 376 134 80 Normal 4.60 5.93
 37 37 1.17 100 367 182 54 Normal 4.61 5.91
 38 38 .85 78 335 241 175 Normal 4.36 5.81
 39 39 .97 106 396 128 80 Normal 4.66 5.98
 40 40 1.00 98 277 222 186 Normal 4.58 5.62
 41 41 1.00 102 378 165 117 Normal 4.62 5.93
 42 42 .89 90 360 282 160 Normal 4.50 5.89
 43 43 .98 94 291 94 71 Normal 4.54 5.67
 44 44 .78 80 269 121 29 Normal 4.38 5.59
 45 45 .74 93 318 73 42 Normal 4.53 5.76
 46 46 .91 86 328 106 56 Normal 4.45 5.79
 47 47 .95 85 334 118 122 Normal 4.44 5.81
 48 48 .95 96 356 112 73 Normal 4.56 5.87
 49 49 1.03 88 291 157 122 Normal 4.48 5.67
 50 50 .87 87 360 292 128 Normal 4.47 5.89
 51 51 .87 94 313 200 233 Normal 4.54 5.75
 52 52 1.17 93 306 220 132 Normal 4.53 5.72
 53 53 .83 86 319 144 138 Normal 4.45 5.77
 54 54 .82 86 349 109 83 Normal 4.45 5.86
 55 55 .86 96 332 151 109 Normal 4.56 5.81

Univariate: Model

Specify Model
 Full factorial
 Custom

Factors & Covariates:
 group(F)
 loggluf(C)

Model
 group
 loggluf

Build Term(s)

Main effects
 Interaction
 Main effects
 All 2-way
 All 3-way
 All 4-way
 All 5-way

Sum of squares: Type III Include intercept in model

Data View Variable View

SPSS Processor is ready

Highlight the two variables, and click the *Build Terms* arrow.

Diabetes.sav [DataSet1] - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utilities Window Help

7:

	group	loggluf	logglut	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var
1	Normal	4.38	5.87																	
2		4.57	5.67																	
3		4.65	5.77																	
4		4.50	5.87																	
5		4.50	5.78																	
6		4.45	5.94																	
7		4.61	5.86																	
8		4.44	5.71																	
9		4.57	5.94																	
10		4.57	5.69																	
11		4.51	5.87																	
12		4.47	5.72																	
13		4.36	5.67																	
14		4.50	5.92																	
15		4.45	5.74																	
16		4.38	5.97																	
17		4.50	5.90																	
18		4.60	5.88																	
19		4.44	5.69																	
20	20	.93	90	345	123	50	Normal	4.50	5.84											
21	21	.95	90	378	136	47	Normal	4.50	5.93											
22	22	.74	88	304	134	50	Normal	4.48	5.72											
23	23	.95	95	347	184	91	Normal	4.55	5.85											
24	24	.97	90	327	192	124	Normal	4.50	5.79											
25	25	.72	92	386	279	74	Normal	4.52	5.96											
26	26	1.11	74	365	228	235	Normal	4.30	5.90											
27	27	1.20	98	365	145	158	Normal	4.58	5.90											
28	28	1.13	100	352	172	140	Normal	4.61	5.86											
29	29	1.00	86	325	179	145	Normal	4.45	5.78											
30	30	.78	98	321	222	99	Normal	4.58	5.77											
31	31	1.00	70	360	134	90	Normal	4.25	5.89											
32	32	1.00	99	336	143	105	Normal	4.60	5.82											
33	33	.71	75	352	169	32	Normal	4.32	5.86											
34	34	.76	90	353	263	165	Normal	4.50	5.87											
35	35	.89	85	373	174	78	Normal	4.44	5.92											
36	36	.88	99	376	134	80	Normal	4.60	5.93											
37	37	1.17	100	367	182	54	Normal	4.61	5.91											
38	38	.85	78	335	241	175	Normal	4.36	5.81											
39	39	.97	106	396	128	80	Normal	4.66	5.98											
40	40	1.00	98	277	222	186	Normal	4.58	5.62											
41	41	1.00	102	378	165	117	Normal	4.62	5.93											
42	42	.89	90	360	282	160	Normal	4.50	5.89											
43	43	.98	94	291	94	71	Normal	4.54	5.67											
44	44	.78	80	269	121	29	Normal	4.38	5.59											
45	45	.74	93	318	73	42	Normal	4.53	5.76											
46	46	.91	86	328	106	56	Normal	4.45	5.79											
47	47	.95	85	334	118	122	Normal	4.44	5.81											
48	48	.95	96	356	112	73	Normal	4.56	5.87											
49	49	1.03	88	291	157	122	Normal	4.48	5.67											
50	50	.87	87	360	292	128	Normal	4.47	5.89											
51	51	.87	94	313	200	233	Normal	4.54	5.75											
52	52	1.17	93	306	220	132	Normal	4.53	5.72											
53	53	.83	86	319	144	138	Normal	4.45	5.77											
54	54	.82	86	349	109	83	Normal	4.45	5.86											
55	55	.86	96	332	151	109	Normal	4.56	5.81											

Univariate: Model

Specify Model

Full factorial Custom

Factors & Covariables:

group(F)
loggluf(C)

Model

group
loggluf

Build Term(s)

Interaction

Sum of squares: Type III Include intercept in model

Continue Cancel Help

Data View Variable View

SPSS Processor is ready

The *Custom* model has been built. Click *Continue*.

The screenshot shows the SPSS Data Editor interface with a Univariate dialog box open. The dialog box is titled "Univariate: Model" and has the "Custom" radio button selected under "Specify Model". In the "Factors & Covariates:" list, "group(F)" and "loggluf(C)" are listed. In the "Model:" list, "group" and "loggluf" are selected. The "Sum of squares:" dropdown is set to "Type III", and the "Include intercept in model" checkbox is checked. The "Continue" button is highlighted. The background data grid shows a table with columns: group, loggluf, logglut, and 18 columns labeled "var". The data rows are numbered 1 through 55.

Row	group	loggluf	logglut	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	var	
1	Normal	4.38	5.87																	
2	Normal	4.57	5.67																	
3	Normal	4.65	5.77																	
4	Normal	4.50	5.87																	
5	Normal	4.50	5.78																	
6	Normal	4.45	5.94																	
7	Normal	4.61	5.86																	
8	Normal	4.44	5.71																	
9	Normal	4.57	5.94																	
10	Normal	4.57	5.69																	
11	Normal	4.51	5.87																	
12	Normal	4.47	5.72																	
13	Normal	4.36	5.67																	
14	Normal	4.50	5.92																	
15	Normal	4.45	5.74																	
16	Normal	4.38	5.97																	
17	Normal	4.50	5.90																	
18	Normal	4.60	5.88																	
19	Normal	4.44	5.69																	
20	Normal	4.50	5.84																	
21	Normal	4.50	5.93																	
22	Normal	4.48	5.72																	
23	Normal	4.55	5.85																	
24	Normal	4.50	5.79																	
25	Normal	4.52	5.96																	
26	Normal	4.30	5.90																	
27	Normal	4.58	5.90																	
28	Normal	4.61	5.86																	
29	Normal	4.45	5.78																	
30	Normal	4.58	5.77																	
31	Normal	4.25	5.89																	
32	Normal	4.60	5.82																	
33	Normal	4.32	5.86																	
34	Normal	4.50	5.87																	
35	Normal	4.44	5.92																	
36	Normal	4.60	5.93																	
37	Normal	4.61	5.91																	
38	Normal	4.36	5.81																	
39	Normal	4.66	5.98																	
40	Normal	4.58	5.62																	
41	Normal	4.62	5.93																	
42	Normal	4.50	5.89																	
43	Normal	4.54	5.67																	
44	Normal	4.38	5.59																	
45	Normal	4.53	5.76																	
46	Normal	4.45	5.79																	
47	Normal	4.44	5.81																	
48	Normal	4.56	5.87																	
49	Normal	4.48	5.67																	
50	Normal	4.47	5.89																	
51	Normal	4.54	5.75																	
52	Normal	4.53	5.72																	
53	Normal	4.45	5.77																	
54	Normal	4.45	5.86																	
55	Normal	4.56	5.81																	

The model is now built. On the *General Linear Model* dialog, click *Options*.

Select *Parameter Estimates* and *Residual plot*

The screenshot shows the SPSS Data Editor interface with the 'Univariate' dialog box open. The 'Options' sub-dialog is also open, showing the following settings:

- Estimated Marginal Means: Factor(s) and Factor Interactions: (OVERALL) group
- Display Means for: (empty)
- Compare main effects:
- Confidence interval adjustment: LSD (none)
- Display:
 - Descriptive statistics:
 - Estimates of effect size:
 - Observed power:
 - Parameter estimates:
 - Contrast coefficient matrix:
 - Homogeneity tests:
 - Spread vs. level plot:
 - Residual plot:
 - Lack of fit:
 - General estimable function:
- Significance level: .05
- Confidence intervals are 95%

The background data table has the following columns: group, logg1uf, logg1ut, and 18 'var' columns. The data rows show values for these variables across 55 cases.

The output is generated.

The screenshot displays the SPSS Data Editor window with a dataset named 'Diabetes.sav'. The data includes variables such as 'id', 'relwt', 'glufast', 'glutest', 'instest', 'sspg', 'group', 'loggluf', and 'logglut'. An 'Output3 - SPSS Viewer' window is open, showing the results of a Univariate Analysis of Variance. The dependent variable is 'Log(GluTest)'. The analysis includes a table for 'Between-Subjects Factors' and a table for 'Tests of Between-Subjects Effects'. The R Squared value is .954 (Adjusted R Squared = .952).

Univariate Analysis of Variance
 [DataSet1] C:\Work\Courses\204\SPSS\Diabetes.sav

Between-Subjects Factors

	Value Label	N
Clinical Group	1 Overt Diabetic	32
	2 Chemically Diabetic	36
	3 Normal	76

Tests of Between-Subjects Effects
 Dependent Variable: Log(GluTest)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	27.187 ^a	5	5.437	569.463	.000
Intercept	.973	1	.973	101.906	.000
group	.104	2	.052	5.447	.005
loggluf	.675	1	.675	70.702	.000
group * loggluf	.155	2	.077	8.099	.000
Error	1.318	138	.010		
Total	5509.040	144			
Corrected Total	28.504	143			

^a. R Squared = .954 (Adjusted R Squared = .952)

Parameter Estimates
 Dependent Variable: Log(GluTest)

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	4.504	.550	8.020	.000	3.299	5.690

SPSS Processor is ready

The ANOVA table describes the results. It can be read in the same way as an ordinary ANOVA table. We note significant main effects and interaction.

Tests of Between-Subjects Effects

Dependent Variable: Log(GluTest)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	27.187^a	5	5.437	569.463	.000
Intercept	.973	1	.973	101.906	.000
group	.104	2	.052	5.447	.005
loggluf	.675	1	.675	70.702	.000
group * loggluf	.155	2	.077	8.099	.000
Error	1.318	138	.010		
Total	5509.040	144			
Corrected Total	28.504	143			

a. R Squared = .954 (Adjusted R Squared = .952)

The high R squared value means that the model fit is quite good overall.

The parameter estimates/standard errors are also computed.

The SPSS parameterization of the model is used.

Parameter Estimates

Dependent Variable: Log(GluTest)

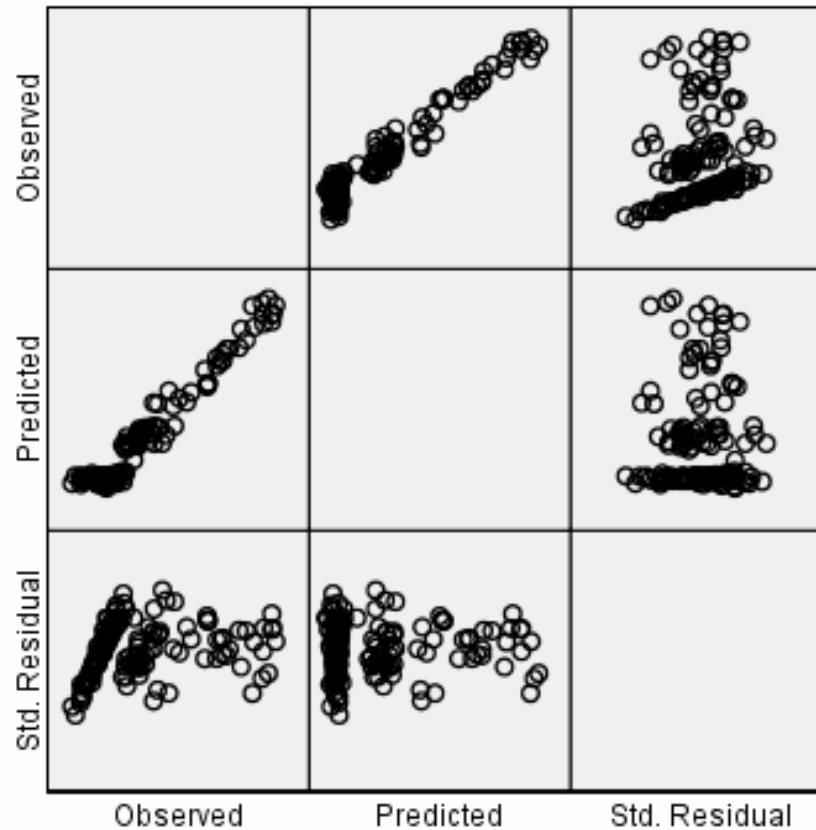
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	4.504	.559	8.060	.000	3.399	5.608
[group=1]	-2.037	.619	-3.289	.001	-3.262	-.813
[group=2]	-1.436	.958	-1.499	.136	-3.330	.458
[group=3]	0 ^a	.	.	.	.	.
loggluf	.299	.124	2.414	.017	.054	.544
[group=1] * loggluf	.535	.134	4.001	.000	.270	.799
[group=2] * loggluf	.382	.210	1.820	.071	-.033	.797
[group=3] * loggluf	0 ^a	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

In the main effects plus interaction model, there are six parameters; we are fitting three separate straight lines to the three subgroups, and there are two parameters in each straight line.

The residual plots demonstrate no significant pattern.

Dependent Variable: Log(GluTest)



No real pattern in the residuals indicates a reasonable fit.

However, there is mild evidence that the residual variance is not constant.

Model: Intercept + group + loggluf + loggluf