Chapter 10 – Inferential Tools for Multiple Regression

Case 10.1.1. Galileo's Data on the Motion of Falling Bodies – A Controlled Experiment. *R&S p.272-273*.

Step 1: Copy the data into a Minitab Worksheet: use these steps:

File \rightarrow Open Worksheet \rightarrow Browse your local directory and upload the csv file Case1001.csv. The data will appear as columns in Minitab with titles DISTANCE and HEIGHT. See *R&S Display 10.1* and the data display below:

Data Display

Row	DISTANCE	HEIGHT
1	253	100
2	337	200
3	395	300
4	451	450
5	495	600
6	534	800
7	573	1000

Step 2: Scatterplot of DISTANCE versus HEIGHT is shown below. The scatterplot shows a quadratic relationship between DISTANCE and HEIGHT. This suggests that DISTANCE may be related to both HEIGHT and HEIGHT squared, or HEIGHT².



Step 3: Create a new variable HEIGHTSQ. Go to Calc and save into column C3 the variable $C2^{**2}$. Both HEIGHT and HEIGHT² would be used as predictor variables in a Multiple Regression Model. This is in general called Polynomial Regression, and in this case we may call it a Quadratic Regression Model. As discussed in R&S p. 279, we may use a reference level of zero for height, in which case we use the predictor variables HEIGHT and HEIGHT². You may instead choose a reference height of 250 and use the predictor variables HEIGHT – 250 and (HEIGHT-250)². Using Calc, we compute these new variables and save them in columns C4-C5. The data is displayed below:

Row	DISTANCE	HEIGHT	HEIGHTSQ	HT-250	HT-250SQ
1	253	100	10000	-150	22500
2	337	200	40000	-50	2500
3	395	300	90000	50	2500
4	451	450	202500	200	40000
5	495	600	360000	350	122500
6	534	800	640000	550	302500
7	573	1000	1000000	750	562500

Step 4: Fit a Multiple Linear Regression of DISTANCE on two predictor variables, HEIGHT and HEIGHT². To do this, Go to Stat \rightarrow Regression; select DISTANCE into Response Variable and select HEIGHT and HEIGHT² into Predictors.

F	Regres	sion		x
	C1 C2 C3 C4 C5	Distance Height HeightSQ HT-250 HT-250SQ	R <u>e</u> sponses: Distance	 ▼
			<u>C</u> ontinuous predictors: Height HeightSQ	A
			C <u>a</u> tegorical predictors:	v
			Model Optio <u>n</u> s Co <u>d</u> ing	<u>S</u> tepwise
r		Select	<u>G</u> raphs <u>R</u> esults	S <u>t</u> orage
	ł	Help	<u>K</u>	Cancel

Regression Analysis: Distance versus Height, HeightSQ

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	76277.9	38139.0	205.03	0.000
Height	1	16670.7	16670.7	89.62	0.001
HeightSQ	1	4927.1	4927.1	26.49	0.007
Error	4	744.1	186.0		
Total	6	77022.0			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
13.6389	99.03%	98.55%	92.90%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	199.9	16.8	11.93	0.000	
Height	0.7083	0.0748	9.47	0.001	19.33
HeightSQ	-0.000344	0.000067	-5.15	0.007	19.33

Regression Equation

Distance = 199.9 + 0.7083 Height - 0.000344 HeightSQ



Fitted line plot



Step 5: Fit a Multiple Linear Regression of DISTANCE on two predictor variables, HT-250 and HT-250SQ. To do this, Go to Stat \rightarrow Regression; select DISTANCE into Response Variable and select HT-250 and HT-250SQ into Predictors.

Regression	×
C1 Distance C2 Height C3 HeightSQ C4 HT-250 C5 HT-250SQ	Responses:
	<u>C</u> ontinuous predictors: 'HT-250' 'HT-250SQ'
	Categorical predictors:
	Model Optio <u>n</u> s Co <u>d</u> ing <u>S</u> tepwise
Select	<u>G</u> raphs <u>R</u> esults S <u>t</u> orage
Help	<u>Q</u> K Cancel

Regression Analysis: Distance versus HT-250, HT-250SQ

Analysis of	Variance	2			
Source Regression HT-250 HT-250SQ Error Total	DF Adj 2 7627 1 2897 1 492 4 74 6 7702	SS Adj 7.9 38139 6.5 28976 7.1 4927 44.1 186 22.0	MS F-Val .0 205. .5 155. .1 26. .0	ue P-Val 03 0.0 77 0.0 49 0.0	ue 00 00 07
Model Summa	ry				
s 13.6389 99	R-sq R-s .03%	sq(adj) R- 98.55%	sq(pred) 92.90%		
Coefficient	S				
Term Constant HT-250 HT-250SQ -	Coef 355.51 0.5365 0.000344	SE Coef 6.62 0.0430 0.000067	T-Value 53.66 12.48 -5.15	P-Value 0.000 0.000 0.007	VIF 6.38 6.38

Regression Equation



Is there a reason to include a cubic term in Height? Investigate using an Extra-SS-F-test and change in R² statistic:

 μ {DISTANCE | HEIGHT, HEIGHT², HEIGHT³} = $\beta_0 + \beta_1$ HEIGHT+ β_2 HEIGHT² + β_3 HEIGHT³

Step 6: Create a new variable HEIGHT3. Go to Calc and save into column C10 the variable $C2^{**3}$. The three variables HEIGHT, HEIGHT² and HEIGHT³ are included as predictors in the multiple regression model.

Regre	ession		×
C1 C2 C3 C4	Distance Height HeightSQ HT-250	R <u>e</u> sponses: Distance	A ¥
C6	Height3	<u>C</u> ontinuous predictors: Height HeightSQ Height3	<u>_</u>
			~
		C <u>a</u> tegorical predictors:	*
		Model Optio <u>n</u> s Co <u>d</u> ing	Stepwise
	Select	<u>G</u> raphs <u>R</u> esults	S <u>t</u> orage
	Help	<u>O</u> K	Cancel

Regression Analysis: Distance versus Height, HeightSQ, Height3

Analysis of Variance							
Source Regression Height HeightSQ Height3 Error Total	DF Ad 3 769 1 46 1 13 1 6 3 6 770	j SS A 73.7 25 39.1 4 01.0 1 95.8 48.3 22.0	dj MS 657.9 639.1 301.0 695.8 16.1	F-Value 1595.19 288.42 80.89 43.26	P-Valu 0.00 0.00 0.00 0.00	1e 00 00 03 07	
Model Summary S R-sq R-sq(adj) R-sq(pred) 4.01056 99.94% 99.87% 98.58%							
Coefficients	Coefficients						
Term Constant Height HeightSQ -(Height3 (Coef 155.78 1.1153 0.001245 0.000001	SE Co 8. 0.06 0.0001 0.0000	ef T-V 33 1 57 1 38 - 00	alue P- 8.71 6.98 8.99 6.58	-Value 0.000 0.000 0.003 0.007	VIF 172.18 960.31 356.22	

Regression Equation





Case 10.1.2. The Energy Costs of Echolocation by Bats – An Observational Study. *R&S p.273-275*.

Step 1: Copy the data into a Minitab Worksheet: use these steps: File \rightarrow Open Worksheet \rightarrow Browse your local directory and upload the csv file Case1002.csv. To display the data in Minitab, go to Data \rightarrow Display Data, and copy the columns C1-C5 in the window on the right. The data will appear as columns in Minitab. *See R&S Display 10.3* for data display on 20 different species. Do a scatterplot of ENERGY versus MASS by TYPE.

Data Display

Row	MASS	TYPE		ENERGY
1	779.000	non-echolocating	bats	43.7000
2	628.000	non-echolocating	bats	34.8000
3	258.000	non-echolocating	bats	23.3000
4	315.000	non-echolocating	bats	22.4000
5	24.300	non-echolocating	birds	2.4600
6	35.000	non-echolocating	birds	3.9300

7	72.800	non-echolocating birds	9.1500	
8	120.000	non-echolocating birds	13.8000	
9	213.000	non-echolocating birds	14.6000	
10	275.000	non-echolocating birds	22.8000	
11	370.000	non-echolocating birds	26.2000	
12	384.000	non-echolocating birds	25.9000	
13	442.000	non-echolocating birds	29.5000	
14	412.000	non-echolocating birds	43.7000	
15	330.000	non-echolocating birds	34.0000	
16	480.000	non-echolocating birds	27.8000	
17	93.000	echolocating bats	8.8300	
18	8.000	echolocating bats	1.3500	
19	6.700	echolocating bats	1.1200	
20	7.700	echolocating bats	1.0200	







Data Display

Row	MASS	TYPE		ENERGY	LMASS	LENERGY
1	779.000	non-echolocating	bats	43.7000	6.65801	3.77735
2	628.000	non-echolocating	bats	34.8000	6.44254	3.54962

3	258.000	non-echolocating bats	23.3000	5.55296	3.14845	
4	315.000	non-echolocating bats	22.4000	5.75257	3.10906	
5	24.300	non-echolocating birds	2.4600	3.19048	0.90016	
6	35.000	non-echolocating birds	3.9300	3.55535	1.36864	
7	72.800	non-echolocating birds	9.1500	4.28772	2.21375	
8	120.000	non-echolocating birds	13.8000	4.78749	2.62467	
9	213.000	non-echolocating birds	14.6000	5.36129	2.68102	
10	275.000	non-echolocating birds	22.8000	5.61677	3.12676	
11	370.000	non-echolocating birds	26.2000	5.91350	3.26576	
12	384.000	non-echolocating birds	25.9000	5.95064	3.25424	
13	442.000	non-echolocating birds	29.5000	6.09131	3.38439	
14	412.000	non-echolocating birds	43.7000	6.02102	3.77735	
15	330.000	non-echolocating birds	34.0000	5.79909	3.52636	
16	480.000	non-echolocating birds	27.8000	6.17379	3.32504	
17	93.000	echolocating bats	8.8300	4.53260	2.17816	
18	8.000	echolocating bats	1.3500	2.07944	0.30010	
19	6.700	echolocating bats	1.1200	1.90211	0.11333	
20	7.700	echolocating bats	1.0200	2.04122	0.01980	

Step 3: Scatterplot of LENERGY versus LMASS by TYPE. Go to Graph \rightarrow Scatterplots \rightarrow with groups. Also see *R&S Display 10.4*.



Step 4: Create Indicator Variables. Create Indicator variables corresponding to the categorical variable TYPE. Go to Calc \rightarrow Make Indicator Variables, and select TYPE. This creates three new columns C6-C8, which we name ebat, nebat, and bird. Note that only two of the three indicator variables can be used as predictors.

vlake	e Indicator Variabl	es				_		×
C1 C2	Mass Type	<u>I</u> ndicator varia	ables for:	Тур	e			
C3	Energy	Store indicato	r variables	; in colun	nns:			
		Distin	ct Value			Column		
		echolog	ating ba	ts	'Type_echolo	cating bats'		
L		non-echo	locating	bats	'Type_non-e	cholocating bats'		
		non-echol	ocating t	birds	'Type_non-e	cholocating birds'		
	Select							
	Help					<u>0</u> K	Cancel	
	Help					<u>O</u> K	Cancel	
)ata	Help A Display		ebat	nebat	bird	<u>O</u> K	Cancel	
ata	Help A Display TYPE non-echoloca	ting bats	ebat 0	nebat 1	bird 0	<u>O</u> K	Cancel	
ata	Help A Display TYPE non-echoloca non-echoloca	ting bats ting bats	ebat 0 0	nebat 1 1	bird 0 0	<u>O</u> K	Cancel	
ata 1 2 3	Help A Display TYPE non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats	ebat 0 0 0	nebat 1 1 1	bird 0 0 0	<u>O</u> K	Cancel	
ata 2 3 4	Help TYPE non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting bats	ebat 0 0 0 0	nebat 1 1 1 1	bird 0 0 0 0	<u>0</u> K	Cancel	
Dw 1 2 3 4 5	Hep Display TYPE non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting bats ting birds	ebat 0 0 0 0 0	nebat 1 1 1 1 0	bird 0 0 0 0 1	<u>Q</u> K	Cancel	
2 3 4 5 6	Help TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting birds ting birds	ebat 0 0 0 0 0 0 0 0	nebat 1 1 1 1 0 0	bird 0 0 0 1 1	<u>Q</u> K	Cancel	
ow 1 2 3 4 5 6 7	Help TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting birds ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 0 0 0 0	bird 0 0 0 1 1 1 1	<u>Q</u> K	Cancel	
DW 1 2 3 4 5 6 7 8	Help TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting birds ting birds ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 0 0 0 0 0 0 0	bird 0 0 0 1 1 1 1	<u>Q</u> K	Cancel	
Dow 1 2 3 4 5 6 7 8 9	Help TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting birds ting birds ting birds ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 0 0 0 0 0 0 0 0 0 0	bird 0 0 0 1 1 1 1 1	<u>Q</u> K	Cancel	
Pata 2 3 4 5 6 7 8 9	Help TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting birds ting birds ting birds ting birds ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 0 0 0 0 0 0 0 0 0	bird 0 0 0 1 1 1 1 1 1	<u>Q</u> K	Cancel	
ow 1 2 3 4 5 6 7 8 9 10	Help TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting birds ting birds ting birds ting birds ting birds ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	bird 0 0 0 1 1 1 1 1 1 1 1	<u>Q</u> K	Cancel	
Ow 1 2 3 4 5 6 7 8 9 10 11 12	Help TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting birds ting birds ting birds ting birds ting birds ting birds ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	bird 0 0 0 1 1 1 1 1 1 1 1 1 1 1	<u>Q</u> K	Cancel	
Ow 1 2 3 4 5 6 7 8 9 10 11 12 13	Help TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting birds ting birds ting birds ting birds ting birds ting birds ting birds ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	bird 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1	<u>Q</u> K	Cancel	
Ow 1 2 3 4 5 6 7 8 9 10 11 12 13 14	Help TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting birds ting birds ting birds ting birds ting birds ting birds ting birds ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	bird 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1	<u>Q</u> K	Cancel	
Ow 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 14	Help TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting birds ting birds ting birds ting birds ting birds ting birds ting birds ting birds ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	bird 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	<u>O</u> K	Cancel	
Ow 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	Hep A Display TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	bird 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	<u>O</u> K	Cancel	
Data 0 W 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	Hep A Display TYPE non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca non-echoloca	ting bats ting bats ting bats ting bats ting birds ting birds	ebat 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	nebat 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	bird 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	<u>O</u> K	Cancel	

Step 5: Create Interaction Variables ebat*LMASS and bird*LMASS, by going to Calc. Save the Interaction variables in columns C9 and C10.

0

1

20 echolocating bats

Step 6: Multiple Regression Modeling. As discussed in *R&S sec. 10.2*, we fit three different Multiple Regression Models.

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1. *Model* (1). Go to Stat \rightarrow Regression; select LENERGY into Response window and select ebat and bird into the Predictors window; select Residuals Plots for graphs and click ok.

Regre	ssion		×
C1 C3 C4 C5 C6	Mass Energy ebat nebat bird	R <u>e</u> sponses: 'LN(Energy)'	A
C7 C8 C9 C10	LNMass ebat * LNMass bird * LNMass LN(Energy)	<u>C</u> ontinuous predictors: ebat bird	<u>_</u>
		C <u>a</u> tegorical predictors:	×
		Model Options Coding	Stepwise
	Select	<u>G</u> raphs <u>R</u> esults	S <u>t</u> orage
	Help	<u>о</u> к	Cancel

Regression Analysis: LNENERGY versus ebat, bird

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	17.844	8.9222	12.50	0.000
ebat	1	15.051	15.0511	21.09	0.000
bird	1	1.112	1.1118	1.56	0.229
Error	17	12.130	0.7135		
Total	19	29.975			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.844718	59.53%	54.77%	45.06%

Coefficients

TermCoefSECoefT-ValueP-ValueVIFConstant3.3960.4228.040.000

ebat-2.7430.597-4.590.0001.60bird-0.6090.488-1.250.2291.60

Regression Equation

LNENERGY = 3.396 - 2.743 ebat - 0.609 bird

Fits and Diagnostics for Unusual Observations

Obs	LNENERGY	Fit	Resid	Std Resid	
5	0.900	2.787	-1.887	-2.33	R
17	2.178	0.653	1.525	2.09	R

R Large residual



2. *Model* (2). Go to Stat \rightarrow Regression; select LENERGY into Response window and select LMASS into the Predictors window; select Residuals Plots for graphs and click ok.

Regression		×
C1 Mass C3 Energy C4 ebat C5 nebat	R <u>e</u> sponses: 'LN(Energy)'	 ▼
C6 bird C7 LNMass C8 ebat * LNMass C9 bird * LNMass C10 LN(Energy)	Continuous predictors:	A
		_
	Categorical predictors:	*
	Model Optio <u>n</u> s Co <u>d</u> ing	Stepwise
Select	<u>G</u> raphs <u>R</u> esults	S <u>t</u> orage
Help	<u>Q</u> K	Cancel
egression Analysis: LN(I	Energy) versus LNMass	

Analysis of	Varia	nce				
Source Regression LNMass Error Total	DF 2 1 29 1 29 18 0 19 29	Adj SS 9.3919 9.3919 0.5829 9.9748	Adj MS 29.3919 29.3919 0.0324	F-Value 907.64 907.64	P-Value 0.000 0.000	
Model Summa:	ry					
S 0.179952 98	R-sq 8.06%	R-sq(ac 97.9	lj) R-sq 95%	(pred) 97.65%		
Coefficient	3					
Term Constant - LNMass 0	Coef 1.468 .8086	SE Coet 0.137 0.0268	T-Valu 7 -10.7 3 30.1	e P-Value 0 0.000 3 0.000	<pre>vif 0 1.00</pre>	
Regression Equation						
LN(Energy) = -1.468 + 0.8086 LNMass						
Fits and Diagnostics for Unusual Observations						

				Std	
Obs	LN(Energy)	Fit	Resid	Resid	
14	3.7773	3.4004	0.3769	2.18	R

R Large residual



3. *Model* (3). Go to Stat → Regression; select LENERGY into Response window and select ebat, bird and LMASS into the Predictors window; select Residuals Plots for graphs and click ok.

Regression		×
C1 Mass C3 Energy C4 ebat C5 nebat C6 bird	R <u>e</u> sponses: 'LN(Energy)'	4
C7 LNMass C8 ebat * LNMass C9 bird * LNMass C10 LN(Energy) C11 FITS	<u>C</u> ontinuous predictors: ebat bird LNMass	*
	C <u>a</u> tegorical predictors:	×
	Model Ontions Coding	
Select	<u>G</u> raphs <u>R</u> esults	Storage
Help	<u>_</u> K	Cancel

Regression Analysis: LNENERGY versus ebat, bird, LNMASS

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	29.4215	9.8072	283.59	0.000
ebat	1	0.0052	0.0052	0.15	0.703
bird	1	0.0277	0.0277	0.80	0.384
LNMASS	1	11.5770	11.5770	334.77	0.000
Error	16	0.5533	0.0346		
Total	19	29.9748			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.185963	98.15%	97.81%	97.30%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-1.576	0.287	-5.49	0.000	
ebat	0.079	0.203	0.39	0.703	3.80
bird	0.102	0.114	0.90	0.384	1.81
LNMASS	0.8150	0.0445	18.30	0.000	2.58

Regression Equation

LNENERGY = -1.576 + 0.079 ebat + 0.102 bird + 0.8150 LNMASS



 Model (3). Go to Stat → Regression; select LENERGY into Response window and select ebat, bird, LMASS, ebat*LMASS and bird*LMASS into the Predictors window; select Residuals Plots for graphs and click ok.

Regression			×
C1 MASS C3 ENERGY C4 LMASS C5 LENERGY C6 ebat C7 nebat C8 bird C9 ebat*LMASS C10 bird*LMASS C11 FITS1 C12 FITS2	Response: Predictors:	ENERGY ebat bird LMASS 'ebat' 'bird*LMASS'	*LMASS'
		Graphs	Options
Select		Results	Storage
Help		ОК	Cancel
,			- IL

Regression Analysis: LNENERGY versus ebat, bird, LNMASS, ebat * LMASS, bird * LMASS

Regression	n						×
C1 Ma	SS	Responses:					
C3 En C4 eb C5 nel	ergy at bat	'LN(Energy)'				<u> </u>
C6 bir C7 LN	d Mass		h				
C8 eb	at * LNMass	Continuous	predictors:	5 I.U			
C10 LN C11 FI	d * LINMass I(Energy) TS	ebat bird L	NMASS EDAT ~I	LINMASS DIFC] ~ LINMass		<u>_</u>
							-
		C <u>a</u> tegorical	predictors:				
			-				A
							-
				1	. 1		E 1
I			Model	Opt	tio <u>n</u> s	Coding	Stepwise
	Select			Gra	aphs	<u>R</u> esults	S <u>t</u> orage
Help						<u>о</u> к	Cancel
Analysis	of Varianc	e					
Source	DF	Adj SS	Adj MS	F-Value	P-Value		
Regressi ebat	on 5 1	29.4699 0.0351	5.89399 0.03509	163.44 0.97	0.000 0.341		

bird		1	0.0408	0.04084	1.13	0.305
LNMASS		1	0.2952	0.29520	8.19	0.013
ebat *	LMASS	1	0.0333	0.03330	0.92	0.353
bird *	LMASS	1	0.0477	0.04775	1.32	0.269
Error		14	0.5049	0.03606		
Total		19	29.9748			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.189900	98.32%	97.71%	96.29%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-0.20	1.26	-0.16	0.875	
ebat	-1.27	1.29	-0.99	0.341	146.62
bird	-1.38	1.30	-1.06	0.305	223.30
LNMASS	0.590	0.206	2.86	0.013	52.97
ebat * LMASS	0.215	0.224	0.96	0.353	37.56
bird * LMASS	0.246	0.213	1.15	0.269	180.67

Regression Equation

LNENERGY = -0.20 - 1.27 ebat -1.38 bird +0.590 LNMASS +0.215 ebat * LMASS +0.246 bird * LMASS

Fits and Diagnostics for Unusual Observations

				Std	
Obs	LNENERGY	Fit	Resid	Resid	
17	2.178	2.177	0.001	0.15	Х

X Unusual X

