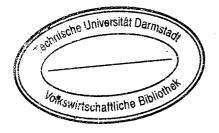
Applied Linear Regression SECOND EDITION

SANFORD WEISBERG

University of Minnesota St. Paul, Minnesota





JOHN WILEY & SONS

New York • Chichester • Brisbane • Toronto • Singapore

CONTENTS

1. Simple linear regression

- **1.1** Building a simple regression model, 4
- 1.2 Least squares estimation, 7
- **1.3** Estimating σ^2 , 12
- 1.4 Properties of least squares estimates, 13
- 1.5 Comparing models: The analysis of variance, 15
- **1.6** The coefficient of determination, R^2 , 19
- 1.7 Confidence intervals and tests, 20
- **1.8** The residuals, 23
 - Problems, 27

2. Multiple regression

- 2.1 Adding a predictor to a simple regression model, 37
- **2.2** Regression in matrix notation, 41
- 2.3 The analysis of variance, 48
- 2.4 Added variable plots, 52
- 2.5 Regression through the origin, 54 Problems, 55

3. Drawing conclusions

3.1 Interpreting parameter estimates, 64

33

1

64

xii Contents

- 3.2 Sampling models, 70
- **3.3** Predictors measured with error, 76 Problems, 78

4.	Weighted least squares, testing for lack of fit, general <i>F</i> -tests, and confidence ellipsoids		80
	4.1	Generalized and weighted least squares, 80	
	4.2	Testing for lack of fit, variance known, 88	
	4.3	Testing for lack of fit, variance unknown, 89	
	4.4	General F testing, 95	
	4.5	Joint confidence regions, 97	
		Problems, 99	
5.	Dia	gnostics I: Residuals and influence	106
	5.1	The residuals, 109	
	5.2	Outliers, 114	
	5.3	Influence of cases, 118	
		Problems, 125	
6.	Dia	gnostics II : Symptoms and remedies	128
	6.1	Scatter plots, 129	
	6.2	Nonconstant variance, 133	
	6.3	Nonlinearity, 140	
	6.4	Transforming the response, 147	
	6.5	Transforming the predictors, 152	
	6.6	Normality assumption, 156	
		Problems, 160	
7.	Model building I: Defining new predictors		164
	7.1	Polynomial regression, 164	

	7.2	Dummy variables: Dichotomous, 169	
	7.3	Dummy variables: Polytomous, 177	
	7.4	Comparing regression lines, 179	
	7.5	Scaling of variables, 185	
	7.6	Linear transformations and principal components, 186	
		Problems, 190	
8.	Mod	el building II: Collinearity and variable selection	196
	8.1	What is collinearity?, 196	
	8.2	Why is collinearity a problem?, 198	
	8.3	Measuring collinearity, 199	
	8.4	Variable selection, 203	
	8.5	Assumptions and notation, 208	
	8.6	Selecting subsets on substantive grounds, 210	
	8.7	Finding subsets I: Stepwise methods, 211	
	8.8	Criteria for selecting a subset, 215	
	8.9	Subset selection II: All possible regressions, 218	
		Problems, 221	
9.	Pred	liction	226
	9.1	Making predictions, 228	
	9.2	Interpolation versus extrapolation, 235	
	9.3	Additional comments, 237	
		Problems, 239	
10.	Inco	mplete data	243
	10.1	Missing at random, 243	
	10.2	Handling incomplete data by filling-in or deleting, 245	
	10.3	Maximum likelihood estimates assuming normality, 248	

xiv Contents

10.4 Missing observation correlation, 249

10.5 General recommendations, 250

11.	Nonle	ast squares estimation	251
	11.1	Robust regression, 252	
	11.2	Biased estimation regression, 253	
12.	Gener	alizations of Linear Regression	260
	12.1	Nonlinear regression, 260	
	12.2	Logistic regression, 267	
	12.3	Generalized linear models, 271	
		Problems, 274	
Арр	endix		276
	1A.1	A formal development of the simple regression model,	276
	1A.2	Means and variances of random variables, 277	
	1A.3	Least squares, 279	
	1A.4	Means and variances of least squares estimates, 279	
	1A.5	Rounding, round-off error, and accuracy of regression calculations, 282	
	2A.1	A brief introduction to matrices and vectors, 284	
	2A.2	Random vectors, 290	
	2A.3	Least squares, 292	
	5A.1	Relating regression equations, 293	•
	8A.1	Derivation of C_p , 293	
Tab	les		296
References			307
Author Index			317

Subject Index

321