

---

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	What Are Microdata?	1
1.2	Types of Microdata	4
1.2.1	Qualitative Data	4
1.2.2	Quantitative Data	6
1.3	Why Not Linear Regression?	8
1.4	Common Elements of Microdata Models	10
1.5	Examples	11
1.5.1	Determinants of Fertility	11
1.5.2	Secondary School Choice	16
1.5.3	Female Hours of Work and Wages	17
1.6	Overview of the Book	19
<b>2</b>	<b>From Regression to Probability Models</b>	<b>21</b>
2.1	Introduction	21
2.2	Conditional Probability Functions	23
2.2.1	Definition	23
2.2.2	Estimation	24
2.2.3	Interpretation	25
2.3	Probability and Probability Distributions	29
2.3.1	Axioms of Probability	29
2.3.2	Univariate Random Variables	30
2.3.3	Multivariate Random Variables	31
2.3.4	Conditional Probability Models	34
2.4	Further Exercises	39
<b>3</b>	<b>Maximum Likelihood Estimation</b>	<b>45</b>
3.1	Introduction	45
3.2	Likelihood Function	46
3.2.1	Score Function and Hessian Matrix	48
3.2.2	Conditional Models	50

## VIII Contents

3.2.3	Maximization . . . . .	50
3.3	Properties of the Maximum Likelihood Estimator . . . . .	53
3.3.1	Expected Score . . . . .	54
3.3.2	Consistency . . . . .	55
3.3.3	Information Matrix Equality . . . . .	56
3.3.4	Asymptotic Distribution . . . . .	59
3.3.5	Covariance Matrix . . . . .	60
3.4	Normal Linear Model . . . . .	63
3.5	Further Aspects of Maximum Likelihood Estimation . . . . .	67
3.5.1	Invariance and Delta Method . . . . .	67
3.5.2	Numerical Optimization . . . . .	69
3.5.3	Identification . . . . .	74
3.5.4	Quasi Maximum Likelihood . . . . .	76
3.6	Testing . . . . .	76
3.6.1	Introduction . . . . .	76
3.6.2	Restricted Maximum Likelihood . . . . .	79
3.6.3	Wald Test . . . . .	81
3.6.4	Likelihood Ratio Test . . . . .	83
3.6.5	Score Test . . . . .	86
3.6.6	Model Selection . . . . .	88
3.6.7	Goodness-of-Fit . . . . .	89
3.7	Pros and Cons of Maximum Likelihood . . . . .	89
3.8	Further Exercises . . . . .	90
<b>4</b>	<b>Binary Response Models . . . . .</b>	<b>95</b>
4.1	Introduction . . . . .	95
4.2	Models for Binary Response Variables . . . . .	97
4.2.1	General Framework . . . . .	97
4.2.2	Linear Probability Model . . . . .	98
4.2.3	Probit Model . . . . .	100
4.2.4	Logit Model . . . . .	102
4.2.5	Interpretation of Parameters . . . . .	104
4.3	Discrete Choice Models . . . . .	107
4.4	Estimation . . . . .	110
4.4.1	Maximum Likelihood . . . . .	110
4.4.2	Perfect Prediction . . . . .	113
4.4.3	Properties of the Estimator . . . . .	114
4.4.4	Endogenous Regressors in Binary Response Models . . . . .	116
4.4.5	Estimation of Marginal Effects . . . . .	118
4.5	Goodness-of-Fit . . . . .	122
4.6	Non-Standard Sampling Schemes . . . . .	127
4.6.1	Stratified Sampling . . . . .	127
4.6.2	Exogenous Stratification . . . . .	127
4.6.3	Endogenous Stratification . . . . .	128
4.7	Further Exercises . . . . .	130

<b>5 Multinomial Response Models . . . . .</b>	137
5.1 Introduction . . . . .	137
5.2 Multinomial Logit Model . . . . .	139
5.2.1 Basic Model . . . . .	139
5.2.2 Estimation . . . . .	140
5.2.3 Interpretation of Parameters . . . . .	144
5.3 Conditional Logit Model . . . . .	150
5.3.1 Introduction . . . . .	150
5.3.2 General Model of Choice . . . . .	151
5.3.3 Modeling Conditional Logits . . . . .	152
5.3.4 Interpretation of Parameters . . . . .	155
5.3.5 Independence of Irrelevant Alternatives . . . . .	159
5.4 Generalized Multinomial Response Models . . . . .	160
5.4.1 Multinomial Probit Model . . . . .	161
5.4.2 Mixed Logit Models . . . . .	163
5.4.3 Nested Logit Models . . . . .	164
5.5 Further Exercises . . . . .	166
<b>6 Ordered Response Models . . . . .</b>	171
6.1 Introduction . . . . .	171
6.2 Standard Ordered Response Models . . . . .	174
6.2.1 General Framework . . . . .	174
6.2.2 Ordered Probit Model . . . . .	176
6.2.3 Ordered Logit Model . . . . .	177
6.2.4 Estimation . . . . .	179
6.2.5 Interpretation of Parameters . . . . .	179
6.2.6 Single Indices and Parallel Regression . . . . .	186
6.3 Generalized Threshold Models . . . . .	188
6.3.1 Generalized Ordered Logit and Probit Models . . . . .	188
6.3.2 Interpretation of Parameters . . . . .	189
6.4 Sequential Models . . . . .	194
6.4.1 Modeling Conditional Transitions . . . . .	194
6.4.2 Generalized Conditional Transition Probabilities . . . . .	197
6.4.3 Marginal Effects . . . . .	197
6.4.4 Estimation . . . . .	198
6.5 Interval Data . . . . .	200
6.6 Further Exercises . . . . .	202
<b>7 Limited Dependent Variables . . . . .</b>	207
7.1 Introduction . . . . .	207
7.1.1 Corner Solution Outcomes . . . . .	208
7.1.2 Sample Selection Models . . . . .	209
7.1.3 Treatment Effect Models . . . . .	210
7.2 Tobin's Corner Solution Model . . . . .	211
7.2.1 Introduction . . . . .	211

7.2.2	Tobit Model . . . . .	212
7.2.3	Truncated Normal Distribution . . . . .	214
7.2.4	Inverse Mills Ratio and its Properties . . . . .	215
7.2.5	Interpretation of the Tobit Model . . . . .	218
7.2.6	Marginal Effects . . . . .	220
7.2.7	Comparing Tobit and OLS . . . . .	221
7.2.8	Further Specification Issues . . . . .	223
7.3	Sample Selection Models . . . . .	224
7.3.1	Introduction . . . . .	224
7.3.2	Censored Regression Model . . . . .	226
7.3.3	Estimation of the Censored Regression Model . . . . .	228
7.3.4	Truncated Regression Model . . . . .	230
7.3.5	Incidental Censoring . . . . .	231
7.3.6	Example: Estimating a Labor Supply Model . . . . .	237
7.4	Treatment Effect Models . . . . .	239
7.4.1	Introduction . . . . .	239
7.4.2	Endogenous Binary Variable . . . . .	242
7.4.3	Switching Regression Model . . . . .	243
7.5	Appendix: Bivariate Normal Distribution . . . . .	246
7.6	Further Exercises . . . . .	247
8	<b>Event History Models . . . . .</b>	251
8.1	Introduction . . . . .	251
8.2	Duration Models . . . . .	254
8.2.1	Introduction . . . . .	254
8.2.2	Basic Concepts . . . . .	254
8.2.3	Discrete Time Duration Models . . . . .	259
8.2.4	Continuous Time Duration Models . . . . .	262
8.2.5	Key Element: Hazard Function . . . . .	265
8.2.6	Duration Dependence . . . . .	267
8.2.7	Unobserved Heterogeneity . . . . .	271
8.3	Count Data Models . . . . .	279
8.3.1	The Poisson Regression Model . . . . .	279
8.3.2	Unobserved Heterogeneity . . . . .	284
8.3.3	Efficient versus Robust Estimation . . . . .	289
8.3.4	Censoring and Truncation . . . . .	289
8.3.5	Hurdle and Zero-Inflated Count Data Models . . . . .	291
8.4	Further Exercises . . . . .	294
	<b>References . . . . .</b>	297
	<b>Index . . . . .</b>	305