



Quantitative models in marketing research

Philip Hans Franses · Richard Paap

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Quantitative Models in Marketing Research

Recent advances in data collection and data storage techniques enable marketing researchers to study the characteristics of a large range of transactions and purchases, in particular the effects of household-specific characteristics and marketing-mix variables.

This book presents the most important and practically relevant quantitative models for marketing research. Each model is presented in detail with a self-contained discussion, which includes: a demonstration of the mechanics of the model, empirical analysis, real-world examples, and interpretation of results and findings. The reader of the book will learn how to apply the techniques, as well as understand the latest methodological developments in the academic literature.

Pathways are offered in the book for students and practitioners with differing statistical and mathematical skill levels, although a basic knowledge of elementary numerical techniques is assumed.

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Contents

<i>List of figures</i>	<i>page ix</i>
<i>List of tables</i>	<i>xi</i>
<i>Preface</i>	<i>xiii</i>
1 Introduction and outline of the book	1
1.1 Introduction	1
1.1.1 <i>On marketing research</i>	2
1.1.2 <i>Data</i>	4
1.1.3 <i>Models</i>	5
1.2 Outline of the book	6
1.2.1 <i>How to use this book</i>	6
1.2.2 <i>Outline of chapter contents</i>	7
2 Features of marketing research data	10
2.1 Quantitative models	10
2.2 Marketing performance measures	12
2.2.1 <i>A continuous variable</i>	13
2.2.2 <i>A binomial variable</i>	15
2.2.3 <i>An unordered multinomial variable</i>	18
2.2.4 <i>An ordered multinomial variable</i>	19
2.2.5 <i>A limited continuous variable</i>	21
2.2.6 <i>A duration variable</i>	24
2.2.7 <i>Summary</i>	26
2.3 What do we exclude from this book?	26
3 A continuous dependent variable	29
3.1 The standard Linear Regression model	29
3.2 Estimation	34
3.2.1 <i>Estimation by Ordinary Least Squares</i>	34
3.2.2 <i>Estimation by Maximum Likelihood</i>	35

3.3	Diagnostics, model selection and forecasting	38
3.3.1	<i>Diagnostics</i>	39
3.3.2	<i>Model selection</i>	41
3.3.3	<i>Forecasting</i>	43
3.4	Modeling sales	44
3.5	Advanced topics	47
4	A binomial dependent variable	49
4.1	Representation and interpretation	49
4.1.1	<i>Modeling a binomial dependent variable</i>	50
4.1.2	<i>The Logit and Probit models</i>	53
4.1.3	<i>Model interpretation</i>	55
4.2	Estimation	58
4.2.1	<i>The Logit model</i>	59
4.2.2	<i>The Probit model</i>	60
4.2.3	<i>Visualizing estimation results</i>	61
4.3	Diagnostics, model selection and forecasting	61
4.3.1	<i>Diagnostics</i>	62
4.3.2	<i>Model selection</i>	63
4.3.3	<i>Forecasting</i>	65
4.4	Modeling the choice between two brands	66
4.5	Advanced topics	71
4.5.1	<i>Modeling unobserved heterogeneity</i>	71
4.5.2	<i>Modeling dynamics</i>	73
4.5.3	<i>Sample selection issues</i>	73
5	An unordered multinomial dependent variable	76
5.1	Representation and interpretation	77
5.1.1	<i>The Multinomial and Conditional Logit models</i>	77
5.1.2	<i>The Multinomial Probit model</i>	86
5.1.3	<i>The Nested Logit model</i>	88
5.2	Estimation	91
5.2.1	<i>The Multinomial and Conditional Logit models</i>	92
5.2.2	<i>The Multinomial Probit model</i>	95
5.2.3	<i>The Nested Logit model</i>	95
5.3	Diagnostics, model selection and forecasting	96
5.3.1	<i>Diagnostics</i>	96
5.3.2	<i>Model selection</i>	97
5.3.3	<i>Forecasting</i>	99

5.4	Modeling the choice between four brands	101
5.5	Advanced topics	107
5.5.1	<i>Modeling unobserved heterogeneity</i>	107
5.5.2	<i>Modeling dynamics</i>	108
5.A	EViews Code	109
5.A.1	<i>The Multinomial Logit model</i>	110
5.A.2	<i>The Conditional Logit model</i>	110
5.A.3	<i>The Nested Logit model</i>	111
6	An ordered multinomial dependent variable	112
6.1	Representation and interpretation	113
6.1.1	<i>Modeling an ordered dependent variable</i>	113
6.1.2	<i>The Ordered Logit and Ordered Probit models</i>	116
6.1.3	<i>Model interpretation</i>	117
6.2	Estimation	118
6.2.1	<i>A general ordered regression model</i>	118
6.2.2	<i>The Ordered Logit and Probit models</i>	121
6.2.3	<i>Visualizing estimation results</i>	122
6.3	Diagnostics, model selection and forecasting	122
6.3.1	<i>Diagnostics</i>	123
6.3.2	<i>Model selection</i>	124
6.3.3	<i>Forecasting</i>	125
6.4	Modeling risk profiles of individuals	125
6.5	Advanced topics	129
6.5.1	<i>Related models for an ordered variable</i>	130
6.5.2	<i>Selective sampling</i>	130
7	A limited dependent variable	133
7.1	Representation and interpretation	134
7.1.1	<i>Truncated Regression model</i>	134
7.1.2	<i>Censored Regression model</i>	137
7.2	Estimation	142
7.2.1	<i>Truncated Regression model</i>	142
7.2.2	<i>Censored Regression model</i>	144
7.3	Diagnostics, model selection and forecasting	147
7.3.1	<i>Diagnostics</i>	147
7.3.2	<i>Model selection</i>	149
7.3.3	<i>Forecasting</i>	150
7.4	Modeling donations to charity	151
7.5	Advanced Topics	155

8 A duration dependent variable	158
8.1 Representation and interpretation	159
8.1.1 <i>Accelerated Lifetime model</i>	165
8.1.2 <i>Proportional Hazard model</i>	166
8.2 Estimation	168
8.2.1 <i>Accelerated Lifetime model</i>	169
8.2.2 <i>Proportional Hazard model</i>	170
8.3 Diagnostics, model selection and forecasting	172
8.3.1 <i>Diagnostics</i>	172
8.3.2 <i>Model selection</i>	174
8.3.3 <i>Forecasting</i>	175
8.4 Modeling interpurchase times	175
8.5 Advanced topics	179
8.A EViews code	182
8.A.1 <i>Accelerated Lifetime model</i> <i>(Weibull distribution)</i>	182
8.A.2 <i>Proportional Hazard model</i> <i>(loglogistic distribution)</i>	183
 Appendix	 184
A.1 Overview of matrix algebra	184
A.2 Overview of distributions	187
A.3 Critical values	193
 <i>Bibliography</i>	 196
<i>Author index</i>	202
<i>Subject index</i>	204

Figures

2.1	Weekly sales of Heinz tomato ketchup	<i>page</i> 14
2.2	Histogram of weekly sales of Heinz tomato ketchup	14
2.3	Histogram of the log of weekly sales of Heinz tomato ketchup	15
2.4	Histogram of the choice between Heinz and Hunts tomato ketchup	17
2.5	Histogram of the choice between four brands of saltine crackers	18
2.6	Histogram of ordered risk profiles	20
2.7	Histogram of the response to a charity mailing	22
2.8	Histogram of the amount of money donated to charity	23
2.9	Histogram of the number of days between two liquid detergent purchases	25
3.1	Density function of a normal distribution with $\mu = \sigma^2 = 1$	30
3.2	Scatter diagram of y_t against x_t	31
3.3	Scatter diagram of $\log S_t$ against $\log P_t$	45
3.4	Scatter diagram of $\log S_t$ against $\log P_t - \log P_{t-1}$	45
4.1	Scatter diagram of y_i against x_i , and the OLS regression line of y_i on x_i and a constant	51
4.2	Scatter diagram of y_i^* against x_i	53
4.3	Graph of $\Lambda(\beta_0 + \beta_1 x_i)$ against x_i	56
4.4	Probability of choosing Heinz	69
4.5	Quasi price elasticity	70
5.1	Choice probabilities versus price	106
5.2	Price elasticities	107
6.1	Scatter diagram of y_i^* against x_i	115
6.2	Quasi-elasticities of type 2 funds for each category	128
6.3	Quasi-elasticities of type 3 transactions for each category	129
7.1	Scatter diagram of y_i against x_i given $y_i > 0$	136

7.2	Scatter diagram of y_i against x_i for censored y_i	138
8.1	Hazard functions for a Weibull distribution	163
8.2	Hazard functions for the loglogistic and the lognormal distributions with $\alpha = 1.5$ and $\gamma = 1$	163
8.3	Empirical integrated hazard function for generalized residuals	178

Tables

2.1	Characteristics of the dependent variable and explanatory variables: weekly sales of Heinz tomato ketchup	<i>page</i> 16
2.2	Characteristics of the dependent variable and explanatory variables: the choice between Heinz and Hunts tomato ketchup	17
2.3	Characteristics of the dependent variable and explanatory variables: the choice between four brands of saltine crackers	19
2.4	Characteristics of the dependent variable and explanatory variables: ordered risk profiles	21
2.5	Characteristics of the dependent variable and explanatory variables: donations to charity	23
2.6	Characteristics of the dependent variable and explanatory variables: the time between liquid detergent purchases	26
2.7	Characteristics of a dependent variable and the names of relevant models to be discussed in chapters 3 to 8	27
4.1	Estimation results for Logit and Probit models for the choice between Heinz and Hunts	67
5.1	Parameter estimates of a Conditional Logit model for the choice between four brands of saltine crackers	101
5.2	Parameter estimates of a Nested Logit model for the choice between four brands of saltine crackers	103
6.1	Estimation results for Ordered Logit and Ordered Probit models for risk profiles	126
6.2	Estimation results for two binomial Logit models for cumulative risk profiles	127
7.1	Estimation results for a standard Regression model (including the 0 observations) and a Type-1 Tobit model for donation to charity	152

7.2	Estimation results for a Type-2 Tobit model for the charity donation data	152
7.3	A comparison of target selection strategies based on the Type-1 and Type-2 Tobit models and the Probit model	155
8.1	Some density functions with expressions for their corresponding hazard functions	161
8.2	Parameter estimates of a Weibull Accelerated Lifetime model for purchase timing of liquid detergents	176
8.3	Parameter estimates of a loglogistic Proportional Hazard model for purchase timing of liquid detergents	177
A.1	Density functions (pdf), cumulative distribution functions (cdf), means and variances of the univariate discrete distributions used in this book	188
A.2	Density functions, means and variances of J -dimensional discrete distributions used in this book	189
A.3	Density functions (pdf), cumulative distribution functions (cdf), means and variances of continuous distributions used in this book	190
A.4	Density functions, cumulative distribution functions, means and variances of continuous distributions used in chapter 8	192
A.5	Some critical values for a normally distributed test statistic	194
A.6	Some critical values for a $\chi^2(\nu)$ distributed test statistic	194
A.7	Some critical values for an $F(k, n)$ distributed test statistic	195

Preface

In marketing research one sometimes considers rather advanced quantitative (econometric) models for revealed preference data (such as sales and brand choice). Owing to an increased availability of empirical data, market researchers can choose between a variety of models, such as regression models, choice models and duration models. In this book we summarize several relevant models and deal with these in a fairly systematic manner. It is our hope that academics and practitioners find this book useful as a reference guide, that students learn to grasp the basic principles, and, in general, that the reader finds it useful for a better understanding of the academic literature on marketing research.

Several individuals affiliated with the marketing group at the School of Economics, Erasmus University Rotterdam, helped us with the data and presentation. We thank Dennis Fok and Jedid-Jah Jonker for making some of the data accessible to us. The original data were provided by ROBECO and the Astmafonds and we thank these institutions for their kind assistance. Paul de Boer, Charles Bos, Bas Donkers, Rutger van Oest, Peter Verhoef and an anonymous reviewer went through the entire manuscript and made many useful comments. Finally, we thank the Rotterdam Institute for Business Economic Studies (RIBES) and the Econometric Institute for providing a stimulating research environment and the Netherlands Organization for Scientific Research (NWO) for its financial support.

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RICHARD PAAP

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1 Introduction and outline of the book

Recent advances in data collection and data storage techniques enable marketing researchers to study the characteristics of many actual transactions and purchases, that is, revealed preference data. Owing to the large number of observations and the wealth of available information, a detailed analysis of these data is possible. This analysis usually addresses the effects of marketing instruments and the effects of household-specific characteristics on the transaction. Quantitative models are useful tools for this analysis. In this book we review several such models for revealed preference data. In this chapter we give a general introduction and provide brief introductions to the various chapters.

1.1 Introduction

It is the aim of this book to present various important and practically relevant quantitative models, which can be used in present-day marketing research. The reader of this book should become able to apply these methods in practice, as we provide the data which we use in the various illustrations and we also add the relevant computer code for EViews if it is not already included in version 3.1. Other statistical packages that include estimation routines for some of the reviewed models are, for example, LIMDEP, SPSS and SAS. Next, the reader should come to understand (the flavor of) the latest methodological developments as these are put forward in articles in, for example, *Marketing Science*, the *Journal of Marketing Research*, the *Journal of Consumer Research* and the *International Journal of Research in Marketing*. For that matter, we also discuss interesting new developments in the relevant sections.

The contents of this book originate from lecture notes prepared for undergraduate and graduate students in Marketing Research and in Econometrics. Indeed, it is our intention that this book can be used at different teaching levels. With that aim, all chapters have the same format, and we indicate

which sections correspond with which teaching level. In section 1.2, we will provide more details. For all readers, however, it is necessary to have a basic knowledge of elementary regression techniques and of some matrix algebra. Most introductory texts on quantitative methods include such material, but as a courtesy we bring together some important topics in an Appendix at the end of this book.

There are a few other books dealing with sets of quantitative models similar to the ones we consider. Examples are Maddala (1983), Ben-Akiva and Lerman (1985), Cramer (1991) and Long (1997). The present book differs from these textbooks in at least three respects. The first is that we discuss the models and their specific application in marketing research concerning revealed preference data. Hence, we pay substantial attention to the interpretation and evaluation of the models in the light of the specific applications. The second difference is that we incorporate recent important developments, such as modeling unobserved heterogeneity and sample selection, which have already become quite standard in academic marketing research studies (as may be noticed from many relevant articles in, for example, the *Journal of Marketing Research* and *Marketing Science*). The third difference concerns the presentation of the material, as will become clear in section 1.2 below. At times the technical level is high, but we believe it is needed in order to make the book reasonably self-contained.

1.1.1 *On marketing research*

A useful definition of marketing research, given in the excellent introductory textbook by Lehmann et al. (1998, p. 1), is that “[m]arketing research is the collection, processing, and analysis of information on topics relevant to marketing. It begins with problem definition and ends with a report and action recommendations.” In the present book we focus only on the part that concerns the analysis of information. Additionally, we address only the type of analysis that requires the application of statistical and econometric methods, which we summarize under the heading of quantitative models. The data concern revealed preference data such as sales and brand choice. In other words, we consider models for quantitative data, where we pay specific attention to those models that are useful for marketing research. We do not consider models for stated preference data or other types of survey data, and hence we abstain from, for example, LISREL-type models and various multivariate techniques. For a recent treatment of combining revealed and stated preference data, see Hensher et al. (1999). Finally, we assume that the data have already been collected and that the research question has been clearly defined.

The reasons we focus on revealed preference data, instead of on stated preference data, are as follows. First, there are already several textbooks on LISREL-type models (see, for example, Jöreskog and Sörbom, 1993) and on multivariate statistical techniques (see, for example, Johnson and Wichern, 1998). Second, even though marketing research often involves the collection and analysis of stated preference data, we observe an increasing availability of revealed preference data.

Typical research questions in marketing research concern the effects of marketing instruments and household-specific characteristics on various marketing performance measures. Examples of these measures are sales, market shares, brand choice and interpurchase times. Given knowledge of these effects, one can decide to use marketing instruments in a selective manner and to address only apparently relevant subsamples of the available population of households. The latter is usually called segmentation.

Recent advances in data collection and data storage techniques, which result in large data bases with a substantial amount of information, seem to have changed the nature of marketing research. Using loyalty cards and scanners, supermarket chains can track all purchases by individual households (and even collect information on the brands and products that were not purchased). Insurance companies, investment firms and charity institutions keep track of all observable activities by their clients or donors. These developments have made it possible to analyze not only what individuals themselves state they do or would do (that is, stated preference), but also what individuals actually do (revealed preference). This paves the way for greater insights into what really drives loyalty to an insurance company or into the optimal design for a supermarket, to mention just a few possible issues. In the end, this could strengthen the relationship between firms and customers.

The large amount of accurately measured marketing research data implies that simple graphical tools and elementary modeling techniques in most cases simply do not suffice for dealing with present-day problems in marketing. In general, if one wants to get the most out of the available data bases, one most likely needs to resort to more advanced techniques. An additional reason is that more detailed data allow more detailed questions to be answered. In many cases, more advanced techniques involve quantitative models, which enable the marketing researcher to examine various correlations between marketing response variables and explanatory variables measuring, for example, household-specific characteristics, demographic variables and marketing-mix variables.

In sum, in this book we focus on quantitative models for revealed preference data in marketing research. For conciseness, we do not discuss the various issues related to solving business problems, as this would require an

entirely different book. The models we consider are to be viewed as helpful practical tools when analyzing marketing data, and this analysis can be part of a more comprehensive approach to solving business problems.

1.1.2 Data

Marketing performance measures can appear in a variety of formats. And, as we will demonstrate in this book, these differing formats often need different models in order to perform a useful analysis of these measures.

To illustrate varying formats, consider “sales” to be an obvious marketing performance measure. If “sales” concerns the number of items purchased, the resultant observations can amount to a limited range of count data, such as 1, 2, 3, However, if “sales” refers to the monetary value in dollars (or cents) of the total number of items purchased, we may consider it as a continuous variable. Because the evaluation of a company’s sales may depend on all other sales, one may instead want to consider market shares. These variables are bounded between 0 and 1 by construction.

Sales and market shares concern variables which are observed over time. Typically one analyzes weekly sales and market shares. Many other marketing research data, however, take only discrete (categorical) values or are only partially observed. The individual response to a direct mailing can take a value of 1 if there is a response, and 0 if the individual does not respond. In that case one has encountered a binomial dependent variable. If households can choose between three or more brands, say brands A, B, C and D, one has encountered a multinomial dependent variable. It may then be of interest to examine whether or not marketing-mix instruments have an effect on brand choice. If the brands have a known quality or preference ranking that is common to all households, the multinomial dependent variable is said to be ordered; if not, it is unordered. Another example of an ordered categorical variable concerns questionnaire items, for which individuals indicate to what extent they disagree, are indifferent, or agree with a certain statement.

Marketing research data can also be only partially observed. An example concerns donations to charity, for which individuals have received a direct mailing. Several of these individuals do not respond, and hence donate nothing, while others do respond and at the same time donate some amount. The interest usually lies in investigating the distinguishing characteristics of the individuals who donate a lot and those who donate a lesser amount, while taking into account that individuals with perhaps similar characteristics donate nothing. These data are called censored data. If one knows the amount donated by an individual only if it exceeds, say, \$10, the corresponding data are called truncated data.

Censoring is also a property of duration data. This type of observation usually concerns the time that elapses between two events. Examples in marketing research are interpurchase times and the duration of a relationship between a firm and its customers. These observations are usually collected for panels of individuals, observed over a span of time. At the time of the first observations, it is unlikely that all households buy a product or brand at the same time, and hence it is likely that some durations (or relationships) are already ongoing. Such interpurchase times can be useful in order to understand, for example, whether or not promotions accelerate purchasing behavior. For direct marketing, one might model the time between sending out the direct mailing and the response, which perhaps can be reduced by additional nationwide advertising. In addition, insurance companies may benefit from lengthy relationships with their customers.

1.1.3 Models

As might be expected from the above summary, it is highly unlikely that all these different types of data could be squeezed into one single model framework. Sales can perhaps be modeled by single-equation linear regression models and market shares by multiple-equation regression models (because market shares are interconnected), whereas binomial and multinomial data require models that take into account that the dependent variable is not continuous. In fact, the models for these choice data usually consider, for example, the probability of a response to a direct mailing and the probability that a brand is selected out of a set of possible brands. Censored data require models that take into account the probability that, for example, households do not donate to charity. Finally, models for duration data take into account that the time that has elapsed since the last event has an effect on the probability that the next event will happen.

It is the purpose of this book to review quantitative models for various typical marketing research data. The standard Linear Regression model is one example, while the Multinomial Logit model, the Binomial Logit model, the Nested Logit model, the Censored Regression model and the Proportional Hazard model are other examples. Even though these models have different names and take account of the properties of the variable to be explained, the underlying econometric principles are the same. One can summarize these principles under the heading of an econometric modeling cycle. This cycle involves an understanding of the representation of the model (what does the model actually do? what can the model predict? how can one interpret the parameters?), estimation of the unknown parameters, evaluation of the model (does the model summarize the data in an adequate

way? are there ways to improve the model?), and the extension of the model, if required.

We follow this rather schematic approach, because it is our impression that studies in the academic marketing research literature are sometimes not very explicit about the decision to use a particular model, how the parameters were estimated, and how the model results should be interpreted. Additionally, there are now various statistical packages which include estimation routines for such models as the Nested Logit model and the Ordered Probit model (to name just a few of the more exotic ones), and it frequently turns out that it is not easy to interpret the output of these statistical packages and to verify the adequacy of the procedures followed. In many cases this output contains a wealth of statistical information, and it is not always clear what this all means and what one should do if statistics take particular values. By making explicit several of the modeling steps, we aim to bridge this potential gap between theory and practice.

1.2 Outline of the book

This book aims to describe some of the main features of various potentially useful quantitative models for marketing research data. Following a chapter on the data used throughout this book, there are six chapters, each dealing with one type of dependent variable. These chapters are subdivided into sections on (1) representation and interpretation, (2) the estimation of the model parameters, (3) model diagnostics and inference, (4) a detailed illustration and (5) advanced topics.

All models and methods are illustrated using actual data sets that are or have been effectively used in empirical marketing research studies in the academic literature. The data are available through relevant websites. In chapter 2, we discuss the data and also some of the research questions. To sharpen the focus, we will take the data as the main illustration throughout each chapter. This means that, for example, the chapter on a multinomial dependent variable (chapter 5) assumes that such a model is useful for modeling brand choice. Needless to say, such a model may also be useful for other applications. Additionally, to reduce confusion, we will consider the behavior of a household, and assume that it makes the decisions. Of course this can be replaced by individuals, customers or other entities, if needed.

1.2.1 *How to use this book*

The contents of the book are organized in such a way that it can be used for teaching at various levels or for personal use given different levels of training.

The first of the five sections in each of chapters 3 to 8 contains the representation of the relevant model, the interpretation of the parameters, and sometimes the interpretation of the full model (by focusing, for example, on elasticities). The fourth section contains a detailed illustration, whose content one should be able to grasp given an understanding of the content of the first section. These two sections can be used for undergraduate as well as for graduate teaching at a not too technical level. In fact, we ourselves have tried out these sections on undergraduate students in marketing at Erasmus University Rotterdam (and, so far, we have not lost our jobs).

Sections 2 and 3 usually contain more technical material because they deal with parameter estimation, diagnostics, forecasting and model selection. Section 2 always concerns parameter estimation, and usually we focus on the Maximum Likelihood method. We provide ample details of this method as we believe it is useful for a better understanding of the principles underlying the diagnostic tests in section 3. Furthermore, many computer packages do not provide diagnostics and, using the formulas in section 2, one can compute them oneself. Finally, if one wants to program the estimation routines oneself, one can readily use the material. In many cases one can replicate our estimation results using the relevant standard routines in EViews (version 3.1). In some cases these routines do not exist, and in that case we give the relevant EViews code at the end of the relevant chapters. In addition to sections 1 and 4, one could consider using sections 2 and 3 to teach more advanced undergraduate students, who have a training in econometrics or advanced quantitative methods, or graduate students in marketing or econometrics.

Finally, section 5 of each chapter contains advanced material, which may not be useful for teaching. These sections may be better suited to advanced graduate students and academics. Academics may want to use the entire book as a reference source.

1.2.2 Outline of chapter contents

The outline of the various chapters is as follows. In chapter 2 we start off with detailed graphical and tabulated summaries of the data. We consider weekly sales, a binomial variable indicating the choice between two brands, an unordered multinomial variable concerning the choice between four brands, an ordered multinomial variable for household-specific risk profiles, a censored variable measuring the amount of money donated to charity and, finally, interpurchase times in relation to liquid detergent.

In chapter 3 we give a concise treatment of the standard Linear Regression model, which can be useful for a continuous dependent variable. We assume some knowledge of basic matrix algebra and of elementary