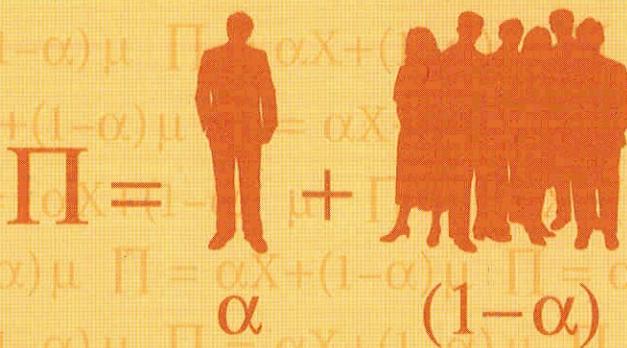


**Universitext**

Hans Bühlmann  
Alois Gisler

# A Course in Credibility Theory and its Applications



**Springer**

# Contents

<b>1</b>	<b>Introduction</b>	1
1.1	Rating of Risks and Claims Experience in Insurance	1
1.2	Mathematical Formulation of the Problem of Rating Risks	7
1.2.1	Individual Risk	7
1.2.2	The Correct Individual Premium	8
1.2.3	The Risk Rating Problem in the Collective	9
1.2.4	Formulating the Rating Problem in the Language of Bayesian Statistics	11
1.2.5	Summary	14
<b>2</b>	<b>The Bayes Premium</b>	15
2.1	Basic Elements of Statistical Decision Theory	15
2.2	Bayes Risk and Bayes Estimator	16
2.3	Bayesian Statistics and the Premium Rating Problem	18
2.4	The Bayes Premium in Three Special Cases	21
2.4.1	The Poisson–Gamma Case	21
2.4.2	The Binomial–Beta Case	31
2.4.3	The Normal–Normal Case	34
2.4.4	Common Features of the Three Special Cases Considered	36
2.5	Conjugate Classes of Distributions	38
2.5.1	The Exponential Class and Their Associated Conjugate Families	39
2.5.2	Construction of Conjugate Classes	46
2.6	Another Type of Example: the Pareto–Gamma Case	47
2.7	Summary	49
2.8	Exercises	50
<b>3</b>	<b>Credibility Estimators</b>	55
3.1	Credibility Estimators in a Simple Context	56
3.1.1	The Credibility Premium in a Simple Credibility Model	56
3.1.2	A General Intuitive Principle	58

3.1.3	The Quadratic Loss of the Credibility Premium . . . . .	59
3.1.4	The Simple Bühlmann Model and the Homogeneous Credibility Estimator . . . . .	60
3.2	Credibility Estimators in a General Set-Up . . . . .	64
3.2.1	Credibility Estimators as Orthogonal Projections in the $\mathcal{L}^2$ Hilbert Space . . . . .	67
3.3	Orthogonality Conditions and Normal Equations . . . . .	71
3.4	Exercises . . . . .	74
<b>4</b>	<b>The Bühlmann–Straub Model . . . . .</b>	<b>77</b>
4.1	Motivation . . . . .	77
4.2	Model Assumptions . . . . .	79
4.3	The Credibility Premium in the Bühlmann–Straub Model . .	81
4.4	Discussion and Interpretation of the Credibility Estimator .	84
4.5	Quadratic Loss of the Credibility Estimator . . . . .	86
4.6	The Homogeneous Credibility Estimator in the Bühlmann– Straub Model . . . . .	86
4.7	Quadratic Loss of the Homogeneous Credibility Estimator .	91
4.8	Estimation of the Structural Parameters $\sigma^2$ and $\tau^2$ . . . .	93
4.9	Empirical Credibility Estimator . . . . .	95
4.10	Credibility for Claim Frequencies . . . . .	97
4.11	Credibility for Claim Sizes . . . . .	106
4.12	Credibility for Risk Groups of Known Individual Contracts .	110
4.13	Modification for the Case of Known a Priori Differences . .	111
4.14	Example of Another Kind of Application . . . . .	113
4.15	Exercises . . . . .	117
<b>5</b>	<b>Treatment of Large Claims in Credibility . . . . .</b>	<b>125</b>
5.1	Motivation . . . . .	125
5.2	Semi-Linear Credibility with Truncation in the Simple Bühlmann Model . . . . .	125
5.3	Semi-Linear Credibility with Truncation in a Model with Weights . . . . .	130
5.4	Further Methods for Treating Large Claims . . . . .	135
5.5	Exercises . . . . .	136
<b>6</b>	<b>Hierarchical Credibility . . . . .</b>	<b>143</b>
6.1	Motivation . . . . .	143
6.2	The Hierarchical Credibility Model . . . . .	145
6.3	Relevant Quantities and Notation . . . . .	146
6.4	Credibility Estimator in the Hierarchical Model . . . . .	148
6.5	Quadratic Loss in the Hierarchical Model . . . . .	159
6.6	Estimation of the Structural Parameters in the Hierarchical Model . . . . .	162
6.7	Exercises . . . . .	165

<b>7 Multidimensional Credibility</b>	167
7.1 Motivation	167
7.2 The Abstract Multidimensional Credibility Model	169
7.2.1 Model	169
7.2.2 The (Inhomogeneous) Multidimensional Credibility Estimator	170
7.2.3 The Homogeneous Credibility Estimator	173
7.2.4 The Quadratic Loss of the Multidimensional Credibility Estimators	174
7.3 The Multidimensional Bühlmann–Straub Model	177
7.3.1 Motivation and Interpretation	177
7.3.2 Definition of the Model	178
7.3.3 Credibility Formulae in the Multidimensional Bühlmann–Straub Model	180
7.3.4 Quadratic Loss	185
7.3.5 Estimation of Structural Parameters	185
7.4 General Remarks About Data Compression and Its Optimality	187
7.4.1 Introduction	187
7.4.2 General Multidimensional Data Structure	187
7.4.3 Optimal Data Compression	189
7.5 Exercises	193
<b>8 Credibility in the Regression Case</b>	199
8.1 Motivation	199
8.2 The Classical Statistics Point of View	199
8.3 The Regression Credibility Model	201
8.3.1 The Standard Regression Model	202
8.3.2 The General Regression Case (Hachemeister)	205
8.3.3 Homogeneous Credibility Estimator and Quadratic Loss	208
8.4 The Simple Linear Regression Case (Linear Trend Model)	208
8.5 Exercises	217
<b>9 Evolutionary Credibility Models and Recursive Calculation</b>	219
9.1 Motivation	219
9.2 Recursive Credibility	220
9.3 Evolutionary Credibility Models	223
9.4 Evolutionary Models and Recursive Credibility	226
9.5 Recursive Calculation Method (Kalman Filter)	230
9.6 The Evolutionary Credibility Regression Model	238
9.7 Recursive Calculation in the Evolutionary Regression Model	239

<b>10 Multidimensional Evolutionary Models and Recursive Calculation</b> .....	251
10.1 Introduction .....	251
10.2 On the Embedding of the Individual Risk in a Collective .....	252
10.3 Multidimensional Evolutionary Models .....	253
10.4 Modelling a Collective with Both Joint and Individual Movements .....	255
10.5 Multidimensional Evolutionary Regression Models .....	262
10.6 Decomposition into an Individual and a Common Component .....	264
<b>A Appendix A:</b>	
<b>Basic Elements from Probability Theory</b> .....	275
A.1 Random Variables, Distribution Functions and Moments .....	275
A.2 Special Functions .....	276
A.3 Multidimensional Distributions .....	277
A.4 Conditional Probability and Conditional Expectation .....	278
A.5 Two Useful Results .....	280
<b>B Appendix B:</b>	
The Hilbert Space $\mathcal{L}^2$ .....	283
<b>C Appendix C:</b>	
<b>Solutions to the Exercises</b> .....	287
C.1 Exercises to Chapter 2 .....	287
C.2 Exercises to Chapter 3 .....	293
C.3 Exercises to Chapter 4 .....	296
C.4 Exercises to Chapter 5 .....	305
C.5 Exercises to Chapter 6 .....	311
C.6 Exercises to Chapter 7 .....	314
C.7 Exercises to Chapter 8 .....	318
<b>References</b> .....	323
<b>Index</b> .....	329