

# Contents

<b>Preface</b>	<b>5</b>
<b>Summary</b>	<b>6</b>
<b>Table of Contents</b>	<b>7</b>
<b>List of Tables</b>	<b>11</b>
<b>1 Basic Principles of Model Building</b>	<b>13</b>
1.1 Empirical and Theoretical Concepts . . . . .	13
1.1.1 Levels of Theory and Data . . . . .	13
1.2 Causation and Prediction . . . . .	16
1.3 Data Modeling vs. Covariance Modeling . . . . .	22
1.4 Notation . . . . .	23
<b>2 The Basic and the Extended PLS Method</b>	<b>27</b>
2.1 Wold's Basic Method of Soft Modeling . . . . .	28
2.1.1 Model Specification . . . . .	28
2.1.2 The Basic PLS Algorithm . . . . .	30
2.1.3 Extensions and Properties . . . . .	31
2.2 The Extended Method: Specification and Properties . . . . .	31
2.2.1 Formal Specification . . . . .	31
2.2.2 Deductive Properties of the LVP Model . . . . .	32
2.2.3 Inductive Properties of the LVP Model . . . . .	33
2.2.4 Specification of an LVP Model . . . . .	35
2.3 Estimation in the Extended Method . . . . .	37
2.3.1 Partial Least Squares . . . . .	37
2.3.2 LS Modules for PLS Algorithms . . . . .	39
2.3.3 The Inner Weighting Modes . . . . .	41
2.3.4 Patterned Orthogonalization of LVs . . . . .	43
2.3.5 Weights and Loadings . . . . .	46
2.3.6 Three Solutions for Conflicting Constraints . . . . .	47
2.4 Assessment of Results . . . . .	49
2.4.1 Information from the Model . . . . .	49
2.4.2 Five Predictions, Five Residuals . . . . .	50
2.4.3 Fit Indices . . . . .	52

2.4.4	Reliability Indices . . . . .	53
2.4.5	Some Advice . . . . .	55
2.5	Application: Home Environment and Intelligence . . . . .	56
<b>3</b>	<b>Foundations of Partial Least Squares</b>	<b>63</b>
3.1	Conditional Expectation and Predictor Specification . . . . .	63
3.1.1	The Notion of Conditional Expectation . . . . .	64
3.1.2	Properties of the Conditional Expectation . . . . .	67
3.1.3	The Linear Expectation . . . . .	69
3.1.4	Predictor Specification . . . . .	72
3.1.5	Estimation . . . . .	73
3.1.6	Interlocking Conditional Expectation . . . . .	75
3.1.7	Eigenvalue Problem and Power Method . . . . .	77
3.1.8	Convergence of Power Algorithm . . . . .	80
3.2	Principal and Other Components . . . . .	81
3.2.1	Concepts and Notations . . . . .	82
3.2.2	Aggregates, Composites . . . . .	86
3.2.3	Factors . . . . .	86
3.2.4	Components . . . . .	88
3.2.5	Principal Components . . . . .	91
3.2.6	The Principal Components Model . . . . .	94
3.3	Factor Score Estimation . . . . .	99
3.3.1	Properties of Factor Scores . . . . .	99
3.3.2	Factor Estimation ModeB . . . . .	102
3.3.3	Factor Estimation ModeB, Reestimated Loadings . . . . .	104
3.3.4	Factor Estimation ModeA . . . . .	106
3.3.5	Factor Estimation ModeA, Reestimated Loadings . . . . .	108
3.3.6	Summary of Factor Estimation . . . . .	109
3.4	Predictive Two-Block Models . . . . .	110
3.4.1	The Two-Block Factor Model . . . . .	111
3.4.2	The Canonical Correlation Model . . . . .	112
3.4.3	The Principal Predictor Model . . . . .	117
3.4.4	The Interbattery Factor Model . . . . .	121
3.4.5	Fortier's Simultaneous Linear Prediction Model . . . . .	124
3.4.6	The MIMIC Model . . . . .	125
3.4.7	Discussion . . . . .	127
3.5	Split Principal Components . . . . .	128
3.5.1	Hierarchical Component Model . . . . .	128
3.5.2	Splitting Principal Components . . . . .	133
3.5.3	Horst's Maximum Variance Algorithm . . . . .	137
3.5.4	The Principle of Constant Proportionality . . . . .	137
3.5.5	Principal Component, One Variable Omitted. . . . .	139
3.5.6	Hierarchical Component Model, One Block Omitted . . . . .	141
3.5.7	Applications of the Split PC Theorem . . . . .	144
3.6	Split Multiple Regression . . . . .	147
3.6.1	Split Multiple Regression and PLS Approach . . . . .	147

3.6.2	How Great is the Loss in $R^2$ ?	149
3.6.3	Conclusions and Recommendations	152
3.7	Uncorrelated Dimensions in Generalized Canonical Correlation Analysis	153
<b>4</b>	<b>Mixed Measurement Level Multivariate Data</b>	<b>155</b>
4.1	Categorical Variables and LS Methods	155
4.1.1	Super Contingency Tables	156
4.1.2	Canonical Analysis of Contingency Tables	162
4.1.3	Principal Components of Contingency Tables	165
4.1.4	Categorical Scaling	167
4.1.5	LV Path Analysis of Super Contingency Tables	169
4.2	Mixture of Categorical and Interval-Scaled Variables	172
4.2.1	The Mixed Product Moment Matrix	172
4.2.2	One Categorical Predictor	173
4.2.3	Two Categorical Predictors	175
4.2.4	One Categorical Predictand	177
4.2.5	More Variables	180
4.3	Application: SES and Educational Aspiration	181
4.4	Different Slopes in Different Groups	185
4.4.1	MV Path Models with Product Variables	185
4.4.2	LV Path Models with Product Variables	189
4.4.3	Metric of Product Variables	190
4.5	Application: TV Consumption and Fear of Crime	193
4.6	Conclusion	197
<b>5</b>	<b>Predictive vs. Structural Modeling: PLS vs. ML</b>	<b>199</b>
5.1	Covariance vs. Data Structure Models	200
5.2	Scored and Unscored LVs	204
5.3	Consistency and Bias in a Two-Block Model	209
5.4	The Interpretation of Consistency at Large	213
5.5	Some PLS - LISREL Comparisons	216
5.6	The PLS Solution of the Identification Problem	222
5.6.1	Restriction for Scale Unambiguity (RSU)	222
5.6.2	Restrictions for Identifiability	225
5.6.3	Identifiability in PLS Model	225
<b>6</b>	<b>Latent Variables Three-Mode Path (LVP3) Analysis</b>	<b>227</b>
6.1	Three-Way Data Models	227
6.2	The Kronecker Principal Component (KPC) Model	228
6.3	The Three-Mode LV Path (LVP3) Model	232
6.4	Special Cases and Properties	233
6.5	The PLS Estimation of LVP3 Models	235
6.6	Application: Longitudinal Data	236
6.7	Concluding Remarks	239

<b>7 PLS Programs and Applications</b>	<b>241</b>
7.1 PLS Programs . . . . .	241
7.2 Applications . . . . .	242
7.2.1 Applications to Non-Individual Data . . . . .	242
7.2.2 Applications in Psychological and Educational Research . .	245
<b>Bibliography</b>	<b>249</b>
<b>Author Index</b>	<b>273</b>
<b>Subject Index</b>	<b>277</b>