Table of Contents

1 Introduction	. 1
1.1 Benchmarking	2
1.2 Interpolation and Temporal Distribution	5
1.3 Signal Extraction and Benchmarking	7
1.4 A Unified View	8
1.5 Calendarization	8
1.6 Data Requirements for Benchmarking and Calendarization	10
1.7 Reconciliation or Balancing Systems of Time Series	11
1.8 Book Outline	12
2 The Components of Time Series	15
2.1 Introduction	15
2.2 Time Series Decomposition Models	16
2.3 The Secular or Long-Term Trend	20
2.3.1 Deterministic Trend Models (21)	
2.3.2 Stochastic Trends (24)	
2.4 The Business Cycle	25
2.4.1 Deterministic and Stochastic Models for the Business Cycle (26)
2.4.2 Limitations of Same-Month Comparisons (27)	• •
2.5 Seasonality	30
2.5.1 The Causes and Costs of Seasonality (30)	
2.5.2 Models for Seasonality (33)	a -
2.6 The Moving-Holiday Component	35
2.7 The Trading-Day Component	39
2.7.1 Causes and Costs of Daily Patterns of Activity (39)	
2.7.2 Models for Trading-Day Variations (42)	
2.7.3 Sunday Opening of Stores (43)	4.5
2.8 The Irregular Component	45
2.8.1 Redistribution Outliers and Strikes (46)	
2.8.2 Models for the Irregular Component and Outliers (47)	
3 The Cholette-Dagum Regression-Based Benchmarking Method	
- The Additive Model	51
3.1 Introduction	51
3.2 Simple Benchmarking Methods	57
3.3 The Additive Benchmarking Model	60
3.4 A Conservative Specification of Deterministic Trends	65
3.5 Flow, Stock and Index Series	68
3.6 Matrix Representation of the Model	69
3.6.1 Temporal Sum Operators (70)	
3.6.2 Solution of the Model (71)	

x Contents

3.7	Other Properties of the Regression-Based Benchmarking Method	75
3.8	Proportional Benchmarking with the Regression-Based Model	80
3.9	A Real Data Example: the Canadian Total Retail Trade Series	82
4	Covariance Matrices for Benchmarking and Reconciliation	
	Methods	. 85
4.1	Introduction	85
4.2	Minimization of an Objective Function	87
4.3	Weak versus Strong Movement Preservation	93
4.4	Weak versus Strong Proportional Movement Preservation	103
4.5	Minimizing the Size of the Corrections	104
4.6	Other ARMA Error Models and Movement Preservation	105
4.7	Guidelines on the Selection of Sub-Annual Error Models	110
4.8	The Covariance Matrix of the Benchmarks	111
5	The Cholette-Dagum Regression-Based Benchmarking Method	
	- The Multiplicative Model	113
5.1	Introduction	113
5.2	The Multiplicative Benchmarking Model	114
5.3	Matrix Representation	117
5.4	Non-Linear Estimation of the Multiplicative Model	118
5.5	Other Properties of the Regression-Based	
	Multiplicative Benchmarking Model	122
5.6	A Real Data Example: The Canadian Total Retail Trade Series	128
6	The Denton Method and its Variants	135
6.1	Introduction	135
6.2	The Original and Modified Additive First Difference Variants	
	of the Denton Method	136
6.2.	1 Preserving Continuity with Previous Benchmarked Values (141)
6.2.2	2 Approximation of the Original and Modified Denton Variants	
	by the Additive Regression-Based Model (143)	
6.2.	3 Preferred Variant of Movement Preservation (145)	
6.3	The Proportional First Difference Variants	
	of the Denton Method	146
6.3.	1 Approximation of the Original and Modified Proportional	
	Variants by the Additive Regression-Based Model (149)	
6.3.2	2 Preferred Variant of Proportional Movement Preservation (150))

Contents	s xi
6.4 Other Variants of the Denton Method6.4.1 The Additive Second Difference Variants (154)6.4.2 The Proportional Second Different Variants (157)	153
7 Temporal Distribution, Interpolation and Extrapolation	159
7.1 Introduction 7.2 Ad Use Intermediation and Distribution Matheda	159
7.2 Ad Hoc Interpolation and Distribution Methods7.3 Interpolation and Temporal Distribution Based	162
on Regression Methods 7.4 The Chow-Lin Regression-Based Method	165
and Dynamic Extensions	174
7.5 ARIMA Interpolation, Temporal Distribution	
and Extrapolation	178
7.5.1 Trend Stationary Models (179)	
7.5.2 Difference Stationary Models (180)	
7.6 Combining Sub-Annual and Annual Forecasts	187
7.0 Combining Sub-Annual and Annual Forecasts	107
8 Signal Extraction and Benchmarking	193
8.1 Introduction	193
8.2 ARIMA Model-Based Signal Extraction and Benchmarking:	105
2 State Space Signal Extraction and Danahmarking :	195
The Durbin and Quenneville Method	199
8 3 1 State-Snace Model for Signal Extraction (199)	177
8.3.2 Two-Stage Benchmarking: the Additive Model (202)	
8.3.3 Single-Stage Benchmarking: Additive Model (203)	
8.4 Non-Parametric Signal Extraction and Benchmarking:	
The Chen, Cholette and Dagum Method	206
0 Color devicestion	200
9 Calendarization	209
9.1 Introduction 9.2 The Assignment Calendarization Procedure	209
9.3 The Fractional Calendarization Method and its Variants	217
9.4 Model-Based Calendarization Methods	219
9.4.1 Denton-Based Methods (219)	
9.4.2 Regression-Based Method (223)	
9.5 Calendarizing Multi-Weekly Data Covering 4 or 5 Weeks	228
9.6 Calendarizing Payroll Deductions	234

xii Contents

10 A	Unified Regression-Based Framework for	
Si	ignal Extraction, Benchmarking and Interpolation	235
10.1	Introduction	235
10.2	The Generalized Dynamic Stochastic Regression Model	235
10.3	Signal Extraction	239
10.4	Benchmarking With and Without Signal Extraction	241
10.5	Interpolation, Temporal Distribution and Extrapolation	243
10.6	Multiplicative Models for Signal Extraction	
	and Benchmarking	246
10.7	A Real Case Example: the Canadian Total Retail Trade Series	250
10.7.1	Method 1: Multiplicative Benchmarking Without	
	Signal Extraction (250)	
10.7.2	Method 2: Benchmarking with Signal Extraction,	
	Interpolation and Extrapolation (256)	
11	Reconciliation and Balancing Systems of Time Series	263
11.1	Introduction	263
11.2	General Regression-Based Reconciliation Method	269
11.3	Choosing the Covariance Matrices	272
11.4	Data Problems	277
11.5	Strategies for Reconciliation	280
10		a a c
12	Reconciling One-Way Classified Systems of Time Series	285
12.1	Introduction	285
12.2	The Reconciliation Model for One-Way Classified	•
10.0	Systems of Series	286
12.3	Implementation of the Analytical Solution	290
12.4	Redundant Constraints in the One-Way Reconciliation Model	293
12.5	An Example of One-Way Reconciliation	294
12.6	A Real Data Example: One-Way Reconciliation Model	202
	of The Seasonally Adjusted Canadian Retail Trade Series	303
12	Decencilize the Marginal Totals of Two Way Classified	
13	Reconciling the Marginal Totals of Two-way Classified	200
12.1	Systems of Series	200
13.1	Introduction The Marsinel Two Way Deconciliation Model	211
13.2 12.2.1	Deriving on Analytical Solution in Terms of the Main	511
13.2.1	Deriving an Analytical Solution in Terms of the Main Partitions (313)	
1222	1 aluullis (313) Doriving on Analytical Solution for Each Series (214)	
13.2.2	Deriving an Analytical Solution for Each Series (314)	

	Contents	xiii		
13.2.3	General Analytical Solution of the Marginal			
	Two-Way Reconciliation Model (317)			
13.3	Implementation of the Analytical Solution	319		
13.4	Redundant Constraints	322		
13.5	A Real Data Example: the Seasonally Adjusted			
	Canadian Retail Trade Series	324		
13.5.1	The Indirect Seasonal Adjustment (326)			
13.5.2	The Direct Seasonal Adjustment (330)			
14	Reconciling Two-Way Classifed Systems of Series	337		
14.1	Introduction	337		
14.2	The Reconciliation Model for Two-Way Classified Systems			
	of Time Series	338		
14.2.1	Deriving an Analytical Solution in Terms of the Main Partitions (341)			
14.2.2	Deriving an Analytical Solution for Each Series (342)			
14.2.3	Analytical Solution of the Two-Way Reconciliation			
	Model (346)			
14.3	Particular Cases of the Two-Way Reconciliation Model	347		
14.3.1	The One-Way Model as a Particular Case (347)			
14.3.2	The Marginal Two-Way Model as a Particular Case (347)			
14.3.3	The Two-Way Model Without the Grand Total (348)			
14.4	Input-Output Models	350		
14.5	Implementation of the Two-Way Reconciliation Model	353		
14.6	Redundant Constraints in the Two-Way Reconciliation Model	358		
14.7	A Real Data Example of a Large Two-Way System of Series	359		
Appen	dix A: Extended Gauss-Markov Theorem	363		
Appendix B: An Alternative Solution for the Cholette-Dagum				
	Model for Binding Benchmarks	369		
Appen	dix C: Formulae for Some Recurring Matrix Products	373		
Appen	dix D: Seasonal Regressors	377		
Appen	dix E: Trading-Day Regressors	387		
References				
Index		403		