Contents

De	dicatio	on		v		
Lis	sist of Figures x					
Lis	st of T	ables		xxi		
Pr	eface			xxv		
Ac	knowle	edgmen	ts	xxxi		
I. INTRODUCTION						
	1.1	What	Is "RM"?	1		
		1.1.1	Demand-Management Decisions	2		
		1.1.2	What's New About RM?	4		
	1.2	The O	rigins of RM	6		
		1.2.1	Airline History	6		
		1.2.2	Consequences of the Airline History	10		
	1.3	A Con	ceptual Framework for RM	11		
		1.3.1	The Multidimensional Nature of Demand	11		
		1.3.2	Linkages Among Demand-Management Decisions	12		
		1.3.3	Business Conditions Conducive to RM	13		
		1.3.4	Industry Adopters Beyond the Airlines	16		
	1.4	An Ov	verview of a RM System	17		
	1.5	The St	tate of the RM Profession	18		
	1.6	Chapt	er Organization and Reading Guide	20		
		1.6.1	Chapter Organization	20		
		1.6.2	Reading Guide	22		
	1.7	Notes	and Sources	23		

Part I Quantity-based Riv	Part I	Quantity-based	RM
---------------------------	--------	----------------	----

2.		LE-RE TROL	SOURCE CAPACITY	27
	2.1	Introd	uction	27
		2.1.1	Types of Controls	28
		2.1.2	Displacement Cost	32
	2.2	Static	Models	33
		2.2.1	Littlewood's Two-Class Model	35
		2.2.2	n-Class Models	36
		2.2.3	Computational Approaches	41
		2.2.4	Heuristics	44
	2.3	Adapt	ive Methods	50
		2.3.1	Adaptive Algorithm	50
		2.3.2	A Numerical Comparison with EMSR and Censored Forecasting	52
	2.4	Group	Arrivals	56
	2.5	Dynar	nic Models	57
		2.5.1	Formulation and Structural Properties	58
		2.5.2	Optimal Policy	59
	2.6	Custo	mer-Choice Behavior	62
		2.6.1	Buy-Up Factors	62
		2.6.2	Discrete-Choice Models	64
	2.7	Notes	and Sources	75
3.	NET	WORK	CAPACITY CONTROL	81
	3.1	Introd	luction	81
		3.1.1	The Promise and Challenge of Network Control	82
		3.1.2	Types of Controls	83
	3.2	The T	Theory of Optimal Network Controls	87
		3.2.1	The Structure of Optimal Controls	88
		3.2.2	Bid Price Controls	89
		3.2.3	Nonoptimality of Bid-Price Controls	90
		3.2.4	Evidence in Support of Bid Prices	91
		3.2.5	Bid Prices and Opportunity Cost	91
	3.3	Appro	eximations Based on Network Models	92
		3.3.1	The Deterministic Linear Programming Model	93
		3.3.2	The Probabilistic Nonlinear Programming Model	95
		3.3.3	The Randomized Linear Programming Model	98

Contents

	3.4	Appro	eximations Based on Decomposition	100
		3.4.1	OD Factors Method	101
		3.4.2	Prorated EMSR	102
		3.4.3	Displacement-Adjusted Virtual Nesting (DAVN)	103
		3.4.4	Dynamic Programming Decomposition	107
		3.4.5	Iterative Decomposition Methods	108
	3.5	Stocha	astic Gradient Methods	111
		3.5.1	Continuous Model with Gradient Estimates	112
		3.5.2	Discrete Model with First-Difference Estimates	116
	3.6	Asym	ptotic Analysis of Network Problems	118
		3.6.1	Asymptotic Optimality of Partitioned Controls	118
		3.6.2	Asymptotic Optimality of Bid-Price Controls	120
		3.6.3	Comments on Asymptotic Optimality	120
	3.7	Decen	tralized Network Control: Airline Alliances	121
	3.8	Notes	and Sources	122
4.	OVE	RBOO	KING	129
	4.1	Busine	ess Context and Overview	130
		4.1.1	A History of Legal Issues in Airline Overbooking	131
		4.1.2	Managing Denied-Service Occurrences	135
		4.1.3	Lessons Beyond the Airline Industry	137
	4.2	Static	Overbooking Models	138
		4.2.1	The Binomial Model	139
		4.2.2	Static-Model Approximations	147
		4.2.3	Customer Class Mix	149
		4.2.4	Group Cancellations	150
	4.3	Dynar	nic Overbooking Models	152
		4.3.1	Exact Approaches	152
		4.3.2	Heuristic Approaches Based on Net Bookings	154
	4.4	Comb	ined Capacity-Control and Overbooking Models	155
		4.4.1	Exact Methods for No-Shows	156
		4.4.2	Class-Dependent No-Show Refunds	158
		4.4.3	Exact Methods for Cancellations	159
		4.4.4	Class-Dependent Cancellation Refunds	160
	4.5	Substi	tutable Capacity	161
		4.5.1	Model and Formulation	162
		4.5.2	Joint Optimal Overbooking Levels	164
	16	Notwo	rk Overhooking	166

THE THEORY	AND	PRACTICE	OF	REVENUE	MANAGEMENT

x

	4.7	Notes a	and Sources	168
Par	t II	Price-ba	ased RM	
5.	DYN	AMIC F	PRICING	175
	5.1	Introdu	action and Overview	175
		5.1.1	Price versus Quantity-Based RM	176
		5.1.2	Industry Overview	177
		5.1.3	Examples of Dynamic Pricing	179
		5.1.4	Modeling Dynamic Price-Sensitive Demand	182
	5.2	Single-	Product Dynamic Pricing Without Replenishment	187
		5.2.1	Deterministic Models	188
		5.2.2	Stochastic Models	200
	5.3	Single-	Product Dynamic Pricing with Replenishment	209
		5.3.1	Deterministic Models	209
		5.3.2	Stochastic Models	212
	5.4	Multip	product, Multiresource Pricing	215
		5.4.1	Deterministic Models Without Replenishment	216
		5.4.2	Deterministic Models with Replenishment	218
		5.4.3	Stochastic Models	219
		5.4.4	Action-Space Reductions	220
	5.5	Finite-	Population Models and Price Skimming	223
		5.5.1	Myopic Customers	223
		5.5.2	Strategic Customers	226
	5.6		otions Optimization	229
		5.6.1	0.01.00.0000000000000000000000000000000	229
			Retailer Promotions	232
		5.6.3	22000 I TOTALOUION INTOGORS	234
	5.7	Notes	and Sources	235
6.	AU	CTIONS		241
	6.1	Introd	uction and Industry Overview	241
		6.1.1	An Overview of Auctions in Practice	242
		6.1.2	Types of Auctions	245
	6.2	Indepe	endent Private-Value Theory	247
		6.2.1	Independent Private-Value Model and Assumptions	247
		6.2.2	An Informal Analysis of Sealed-Bid, First- and Second-Price Auctions	248

Contents

	6.2.3	Formal Game-Theoretic Analysis
	6.2.4	Revenue Equivalence
	6.2.5	Optimal Auction Design
	6.2.6	Relationship to List Pricing
	6.2.7	Departures from the Independent Private-Value Model
6.3	Optin	nal Dynamic Single-Resource Capacity Auctions
	6.3.1	
	6.3.2	Optimal Dynamic Allocations and Mechanisms
	6.3.3	
6.4	Optin	nal Dynamic Auctions with Replenishment
	6.4.1	Dynamic Programming Formulation
	6.4.2	
	6.4.3	Average-Profit Criterion
	6.4.4	Comparison with a List-Price Mechanism
6.5	Netwo	ork Auctions
	6.5.1	Problem Definition and Mechanism
	6.5.2	Equilibrium Analysis
	6.5.3	Relationship to Traditional Auctions
	6.5.4	Relationship to Traditional Network RM
	6.5.5	Revenue Maximization and Reserve Prices
6.6	Notes	and Sources
Part III	Comn	non Elements
7. CUS	ГОМЕ	R-BEHAVIOR AND
		ESPONSE MODELS
7.1	The In	ndependent-Demand Model
7.2		s of Individual Customer Choice
	7.2.1	Reservation-Price Models
	7.2.2	Random-Utility Models
	7.2.3	
7.3	Model	s of Aggregate Demand
	7.3.1	Demand Functions and Their Properties
	7.3.2	Multiproduct-Demand Functions
	7.3.3	Common Demand Functions
	7.3.4	Stochastic-Demand Functions
	7.3.5	Rationing Rules
7.4		and Sources

kii	THE THEORY	AND	PRACTICE OF	REVENUE	MANAGEMENT
-----	------------	-----	-------------	---------	------------

8.	THE	ECON	OMICS OF RM	333
	8.1	Introd	uction	333
	8.2	Perfec	t Competition	336
		8.2.1	Perfectly Competitive Markets	336
		8.2.2	Firm-Level Decisions Under Perfect Competition	338
		8.2.3	Precommitment and Demand Uncertainty	338
		8.2.4	Peak-Load Pricing Under Perfect Competition	341
		8.2.5	Identifiable Peak Periods	341
		8.2.6	Uncertainty over the Timing of Peak Loads	343
		8.2.7	Advance Purchases in Competitive Markets	345
	8.3	Monor	ooly Pricing	349
		8.3.1	Single-Price Monopoly	350
		8.3.2	Monopoly with Capacity Constraints	351
		8.3.3	Multiple-Price Monopoly and Price Discrimination	1352
		8.3.4	Strategic Customer Behavior	363
		8.3.5	Optimal Mechanism Design for a Monopolist	369
		8.3.6	Advance Purchases and Peak-Load Pricing Un-	
			der Monopoly	372
	8.4	Price	and Capacity Competition in an Oligopoly	375
		8.4.1	Static Models	376
		8.4.2	Dynamic Models	388
		8.4.3	Product Differentiation	395
	8.5	Notes	and Sources	402
9.	EST	IMATI(ON AND FORECASTING	407
	9.1	Introd	luction	407
		9.1.1	The Forecasting Module of RM Systems	408
		9.1.2	What Forecasts Are Required?	410
		9.1.3	Data Sources	412
		9.1.4	Design Decisions	415
	9.2	Estim	ation Methods	419
		9.2.1	Estimators and Their Properties	420
		9.2.2	MSE Estimators	422
		9.2.3	Maximum-Likelihood (ML) Estimators	425
		9.2.4	Method of Moments and Quantile Estimators	427
		9.2.5	Endogeneity, Heterogeneity, and Competition	428
	9.3	Foreca	asting Methods	433
		9.3.1	Ad-Hoc Forecasting Methods	434
		9.3.2	Time-Series Forecasting Methods	439

<i>~ , ,</i>	***
Contents	XIII
	38444

		9.3.3	Stationary Time-Series Models	442
		9.3.4	Nonstationary Time-Series Models	447
		9.3.5	Box-Jenkins Identification Process	449
		9.3.6	Bayesian Forecasting Methods	450
		9.3.7	State-Space Models and Kalman Filtering	458
		9.3.8	Machine-Learning (Neural-Network) Methods	464
		9.3.9	Pick-up Forecasting Methods	470
		9.3.10	Other Methods	472
		9.3.11	Combining Forecast Methods	472
	9.4	Data I	ncompleteness and Unconstraining	473
		9.4.1	Expectation-Maximization (EM) Method	474
		9.4.2	Gibbs Sampling	481
		9.4.3	Kaplan-Meir Product-Limit Estimator	483
		9.4.4	Plotting Procedures	484
		9.4.5	Projection-Detruncation Method	485
	9.5	Error 7	Tracking and System Control	486
		9.5.1	Estimation Errors	487
		9.5.2	Forecasting Errors and System Control	496
	9.6	Indust	ry Models of RM Estimation and Forecasting	499
		9.6.1	Airline No-Show and Cancellations Forecasting	499
		9.6.2	Groups Demand and Utilization Forecasting	502
		9.6.3	Sell-Up and Recapture Forecasting	504
		9.6.4	Retail Sales Forecasting	505
		9.6.5	Media Forecasting	508
		9.6.6	Gas-Load Forecasting	510
	9.7	Notes	and Sources	511
10.	INDU	JSTRY	PROFILES	515
	10.1	Airline	s	515
		10.1.1	History	515
		10.1.2	Customers, Products, and Pricing	516
		10.1.3	RM Practice	521
	10.2	Hotels		524
		10.2.1	Customers, Products, and Pricing	524
		10.2.2	RM Practice	526
	10.3	Rental	Car	531
	·		Customers, Products, and Pricing	531
			RM Practice	532

10.4.1 Customers, Products, and Pricing

10.5.1 Customers, Products, and Pricing

10.4 Retailing

10.4.2 RM Practice

10.5 Media and Broadcasting

533

534

541

542

543

10.5.2 RM Practice	545
10.6 Natural-Gas Storage and Transmission	546
10.6.1 Customers, Products, and Pricing	547
10.6.2 RM Practice	550
10.7 Electricity Generation and Transmission	551
10.7.1 Industry Structure	552
10.7.2 Customers, Products, and Pricing	554
10.7.3 RM Practice	554
10.8 Tour Operators	555
10.8.1 Customers, Products, and Pricing	556
10.8.2 Capacity Management and Base-Price Sett	
10.8.3 RM Practice	558
10.9 Casinos	559
10.9.1 Customers, Products, and Pricing	559
10.9.2 RM Practice	559
10.10 Cruise Ships and Ferry Lines	560
10.10.1 Customers, Products, and Prices	560
10.10.2 RM Practice	561
10.11 Passenger Railways	561
10.11.1 Customers, Products, and Pricing	561
10.11.2 RM Practice	563
10.12 Air Cargo	563
10.12.1 Customers, Products, and Pricing	563
10.12.2 RM Practice	563
10.13 Freight	564
10.13.1 Customers, Products, and Pricing	565
10.13.2 RM Practice	566
10.14 Theaters and Sporting Events	567
10.14.1 Customers, Products, and Pricing	567
10.14.2 Ticket Scalping and Distribution	567
10.14.3 RM Practice	571
10.15 Manufacturing	574

Contents xv

		10.15.1 Customers, Products, and Pricing	574 575			
	10.15.2 RM Practice					
	10.16	10.16 Notes and Sources				
11.	IMPLEMENTATION					
	11.1	Segmentation and Product Design				
		11.1.1 Segmentation	580			
		11.1.2 Product Design	585			
	11.2	System Architecture, Hardware, Software, and Interfaces				
	11.2.1 Hardware Requirements					
		11.2.2 User-Interface Design	594			
		11.2.3 GDS, CRS, and PMS Interfaces	598			
		11.2.4 Retail Management Systems	605			
	11.3	Revenue-Opportunity Assessment and Revenue-Benefits				
		Measurement	608			
		11.3.1 Revenue-Opportunity Assessment	608			
		11.3.2 Revenue-Benefits Measurement	610			
	11.4	RM Simulation	611			
		11.4.1 Generating Aggregate Number of Customers	613			
		11.4.2 Generating the Customer-Arrival Pattern	613			
	11.5	Customer Perceptions and Reactions	614			
		11.5.1 RM Perception Problems	614			
		11.5.2 Managing Perceptions	618			
		11.5.3 Overbooking Perceptions	619			
	11.6	Cultural, Organizational, and Training Issues	620			
		11.6.1 Changes in Responsibility by Function	620			
		11.6.2 Project and Organizational Structure	623			
		11.6.3 Training	627			
	11.7	Notes and Sources	628			
Ap	Appendices					
A	Notation					
В	Probability					
C	Convexity and Optimization					
	Convexity and Optimization Dynamic Programming					
E	The Theory of Choice 6					
F	Game Theory					
_		···· · · · · · · · · · · · · · · · · ·				

xvi	THE THEORY	AND PR	ACTICE OF	REVENUE	MANAGEMENT
Referen	ices				671

Index 709

References