Contents

Preface			vii	
1.	Introduction and Overview			1
	1.1	Introduction		1
	1.2	Histor	ical Perspective	2
		1.2.1	Pre-Industrial Revolution	2
		1.2.2	Post-Industrial Revolution	2 2 3 5
	1.3	Theori	ies of Warranty	5
		1.3.1	Exploitative Theory	5 5
		1.3.2	Signal Theory	
		1.3.3	Investment Theory	6
	1.4	Warra	nty and Manufacturing	6
		1.4.1	Impact of Warranty	6
		1.4.2		7
		1.4.3	Warranty Management	8
			tives of the Book	10
			e of the Book	10
	Ref	erences		13
2.	Pro	ducts a	nd Product Quality	15
	2.1 Introduction		15	
	2.2 Products		ets	15
		2.2.1	Product Classification	16
		2.2.2	Product Decomposition	20
		2.2.3	Perspectives	22
		2.2.4	Product-Service Bundling	22
	2.3 Product Quality		ct Quality	23
		2.3.1	Perspectives	23
		2.3.2	Definitions of Quality	23
		2.3.3	Notions of Quality	24
		2.3.4	Product Quality and Customer Satisfaction	25
	2.4	Produc	ct Life Cycle	27
		2.4.1	Manufacturer's Point of View	27

xii Contents

		2.4.2 2.4.3 2.4.4 Produc 2.5.1 2.5.2 erences	Product Performance Product Cost t Reliability	28 29 29 30 30 31 32
3.	Pro	duct W	Varranty	35
	3.1	Introdu	action	35
	3.2	Warran	nty Concept	36
			f Warranty	40
		3.3.1		40
		3.3.2		40
		3.3.3		40
		3.3.4	Societal Viewpoint	41
	3.4	Descrip	otion of Warranty Policies	41
		3.4.1	One-dimensional Policies	42
		3 4 2	Two-dimensional Policies	46
		3.4.3	Cumulative Warranties	50
		3.4.4	Reliability Improvement Warranties	51
	3.5	Classif	ication of Warranties	52
	3.6	Extend	ed Warranties	54
	3.7	Study o	of Warranty	55
	App	endix. S	Selected Warranty Policies	56
	Ref	erences		60
4.	Wa	rranty N	Management	63
	4.1	Introdu	action	63
	4.2	Framev	work for Strategic Warranty Management	65
		4.2.1	Technical Issues	67
		4.2.2	Commercial Issues	68
		4.2.3		69
		4.2.4	Product Life Cycle Approach to Warranty Management	70
		4.2.5	Formulation of Warranty Strategy	71
		4.2.6	Strategy Implementation	72
	4.3	Pre-La	unch Stage	72
		4.3.1	Front-End [Pre-Design or Feasibility] Phase	72
		4.3.2	Design and Development Phase	74
		4.3.3	Production Phase	76
		4.3.4	Formulating Warranty Strategy in the Pre-Launch Stage	76
		4 Launch Window		78
	4.5		aunch Stage	79
		4.5.1	Warranty as a Marketing Strategy	79
		4.5.2	Warranty Servicing Strategy	79
		4.5.3	Other Issues	80
		4.5.4	Warranty Related Data	80
		4.5.5	Use of Warranty Claims Data	81
		4.5.6	Modifications to Warranty Policy	82
		4.5.7	Dealing with Customer Dissatisfaction	82

			Contents	xiii
		4.5.8 Warranty Administration		83
		Conclusions		84
	Ref	erences		84
5.	Sys	tems Approach to Warranty Management		87
	5.1	Introduction		87
	5.2	The Systems Approach		87
		5.2.1 Step 1: Define the Objective		88
		5.2.2 Step 2: System Characterization		89
		5.2.3 Step 3: Build Models		89
		5.2.4 Step 4: Derive Solutions		90
		5.2.5 Step 5: Implement Solution		90
		5.2.6 Step 6: Measure Outcomes and Evaluate Modifications		90
		Characterizing Uncertainty		90
	5.4	Decision-making in the Front-end Phase		92
		5.4.1 Define Objective		92
		5.4.2 System Characterization5.4.3 Modeling		93 95
	5.5	Systems Approach to Warranty Cost Analysis		93 97
	5.5	5.5.1 Define Objective		97
		5.5.2 System Characterization		97
	5.6	Modeling Product Failures		98
		5.6.1 The Black-box Approach		100
		5.6.2 The White-box Approach		102
		5.6.3 Modeling Component and System Failures		103
	Ref	erences		106
6.	The	Role and Use of Data in Warranty Management		109
	6.1	Introduction		109
		Types of Data		110
		6.2.1 Data on Earlier Similar Products		111
		6.2.2 Data from External Sources		111
		6.2.3 Product and Process Related Data		111
	6.3	Sources of Data		112
		6.3.1 Historical (Archival) Records		112
		6.3.2 Business Management Systems		112
		6.3.3 Scientific Journals and Conference Papers		112
		6.3.4 Vendors		112
		6.3.5 Test and Experimental Results		113
		6.3.6 Scientific and Technical Handbooks		113
		6.3.7 Experts 6.3.8 Market Surveys		113 113
		6.3.9 Warranty Servicing and Field Support		113
		6.3.10 Consumer Reports and Magazines		113
	6.4	The Nature of Data		114
	J. 1	6.4.1 Randomness		114
		6.4.2 Probability and Statistics		115
		6.4.3 Modeling Randomness		115
	6.5	E		116
		6.5.1 Data Structures		116

xiv Contents

		6.5.2 Graphical Presentation of Data	117
		6.5.3 Averages	120
		6.5.4 Measures of Variability	12
		6.5.5 Measures of Relationship and Trend	122
	6.6	Inferences from Data	124
		6.6.1 The Role and Methods of Statistical Inference	124
		6.6.2 Parameter Estimation	124
		6.6.3 Hypothesis Testing	126
		Data-based Decision Models	129
	6.8	Analysis of Warranty Claims Data	132
		6.8.1 Warranty Data	132
		6.8.2 Data Analysis	133
		Computerized Data Analysis	134
		endix. Data for Example 1	136
	Ref	erences	137
7.	Wa	rranty Cost Analysis	139
	7.1	Introduction	139
		Basis for Warranty Cost Analysis	139
		7.2.1 Warranty Cost per Unit Sale	140
		7.2.2 Life Cycle Cost per Unit Sale	141
		7.2.3 Life Cycle Cost over Repeat Purchases	141
	7.3	Methodology for Warranty Cost Analysis	142
		7.3.1 System Characterization	142
		7.3.2 Modeling	143
		7.3.3 Some Comments on Analysis	145
	7.4	Warranty Cost Analysis – Cost per Unit Sold	146
		7.4.1 Cost Analysis of the Non-renewing FRW Policy	147
		7.4.2 Cost Analysis of the Non-renewing PRW Policy	151
		7.4.3 Cost Analysis of the Non-renewing Two-dimensional FRW	153
	7.5	Life Cycle Cost Analysis	155
		7.5.1 Life Cycle Cost, Non-renewing FRW Policy	156
		7.5.2 Life Cycle Cost, Non-renewing PRW Policy	157
		7.5.3 Life Cycle Cost – Dynamic Sales Model	157
	Ref	erences	157
8.	Wa	rranty Considerations in Product Design and Development	159
	8.1	Introduction	159
	8.2		160
	o. _	8.2.1 Product Performance / Specification	161
	8.3	Conceptual Design	163
		8.3.1 Product Reliability Specification	163
		8.3.2 Alternate Design Options	165
	8.4	Detail Design	166
		8.4.1 Reliability Allocation	166
		8.4.2 Achieving Desired Component Reliability	167
		8.4.3 Additional Topics	169
	8.5	Development Process	170
		8.5.1 Component-level Development	170

		Contents xv
	8.5.2 Product-level Development	171
	8.5.3 Development Testing	171
	8.5.4 Testability	172
	8.5.5 Reliability Assessment	172
	8.5.6 Decision Problems	172
	8.6 Some Illustrative Examples	173
	References	176
9.	Implications of Warranty on Production Decisions	179
	9.1 Introduction	179
	9.2 Product Nonconformance	180
	9.2.1 Types of Nonconformance	180
	9.2.2 Implication of Nonconformance	182
	9.3 Effect of Production Process on Nonconformance	184
	9.3.1 Production Process	184
	9.3.2 Process State	185
	9.3.3 Process Design	186
	9.4 Quality Control	186
	9.5 Input Control	187
	9.6 Process Control	188
	9.7 Output Control	191
	9.7.1 Burn-in	191
	9.7.2 Releasing with No Testing	192
	9.8 Optimal Quality Control	193
	9.9 Illustrative Examples	193
	References	195
10.	The Role of Warranty in Marketing	197
	10.1 Introduction	197
	10.2 An Overview	198
	10.3 Consumer Purchase Process	199
	10.4 Pre-purchase Behavior	200
	10.4.1 Purchase Uncertainty and Perceived Risks	201
	10.4.2 Information, Cues and Signals	202
	10.4.3 Warranty and Product Choice	202
	10.4.4 Warranty and Brand	204
	10.4.5 Warranty and Reputation	204
	10.4.6 Warranty and Hybrid Products	204
	10.5 Post-purchase Behavior and Warranty	205
	10.5.1 Evaluation of Product and Service	205
	10.5.2 Satisfaction and Dissatisfaction	206
	10.5.3 Intentions of Consumers	208
	10.5.4 Customer Loyalty	209
	10.6 Market Outcome [Marketing Perspective]	210
	10.6.1 Total Sales	210
	10.6.2 Dynamic Sales	211
	10.6.3 Pricing Warranty	211
	10.7 Market Outcome [Microeconomics Perspective]	211
	10.8 Warranty Strategy	212

xvi Contents

	References		214
11.	Warranty L	ogistics	217
	11.1 Introduc		217
	11.2 Logistic	cs: An Overview	217
	11.2.1		217
		Logistics Management	218
		t Warranty Servicing	220
		Warranty Claims	221
		Warranty Logistics	222
	11.4 Strategi		222
	11.4.1	Location of Service Centers and Warehouses	223
	11.4.2	1	224
	11.4.3	Service Channels	225
		l and Operational Issues	227
	11.5.1	Spare Parts Inventory	227
	11.5.2	Material Transportation	228
	11.5.3	Scheduling of Jobs, Repairs and the Traveling	
		Repairman Problem	228
	11.5.4	Replace versus Repair Strategies	229
	11.5.5	Strategies Bases on Age (and/or Usage) at Failure	229
	11.5.6	Cost Repair Limit Strategy	230
	11.6 Other Is		230
	11.6.1	Dispute Resolution	230
	11.6.2	Customer Satisfaction	231
		Service Recovery Use of Loaners	232
			234
		Product Recall	234
	11.6.6	Data Collection and Analysis	234
	References		235
12.	Reliability I	mprovement Warranties	239
	12.1 Introduc	ction	239
	12.2 RIW Ba	ackground	240
	12.2.1	History	240
	12.2.2	RIW Concept	241
	12.2.3	RIW Features	241
	12.2.4	Assurance versus Incentive Warranties	242
	12.3 RIW Pr	rocess	242
	12.4 Bid Pro	posal [Stage 1]	244
	12.4.1	Contract	245
	12.4.2	Costs	246
	12.4.3	Risks	246
	12.4.4	Dispute Resolution	247
	12.4.5	Models	248
		d Implementation [Stages 5(b) and 6]	248
	_	ement of the RIW Process	250
	12.6.1	Warranty Negotiations	250
	12.6.2	Project Management	250
	12.6.3	Data Management	250

		Contents	xvii
	12.6.4 Warranty Administration		250
	References		251
13.	Financial, Societal, and Legal Aspects of Warranty		253
	13.1 Introduction		253
	13.2 Warranty and Accounting		254
	13.2.1 Introduction		254
	13.2.2 Financial Accounting and Reporting		254
	13.2.3 External versus Internal Accounting		256
	13.2.4 Product Warranty versus Quality Costs		257
	13.2.5 Strategic Warranty Cost Management		257
	13.2.6 Estimating Warranty Costs		258 258
	13.3 The Impact of Consumerism on Warranty 13.3.1 Introduction		258
	13.3.2 Consumerist Warranty Concerns		259
	13.3.3 Impact of Consumer Movements on Product V	Warrants	259
	13.3.4 Passage of the Magnuson-Moss Act	vv arranty	260
	13.4 Warranty Legislation (USA)		261
	13.4.1 Introduction		261
	13.4.2 The Uniform Commercial Code (UCC)		261
	13.4.3 The Magnuson-Moss act		261
	13.4.4 Other Legislation		262
	13.4.5 The TREAD Act		264
	13.4.6 Implications of Warranty Legislation for Busi	ness	264
	13.5 Warranty-related Litigation		265
	13.5.1 Introduction		265
	13.5.2 Litigation Under the UCC and Other State La	ws	265
	13.5.3 Litigation under Magnuson-Moss		266
	13.5.4 Implications for Business		268
	References		268
14.	Warranty Management Systems		271
	14.1 Introduction		271
	14.2 Warranty Management		271
	14.2.1 Evolution of Warranty Management		271
	14.2.2 Current Scene		274
	14.3 Designing a Warranty Management System		274
	14.4 Databases		275
	14.4.1 Database Management		276
	14.4.2 Data Warehousing		277
	14.5 Models		278
	14.5.1 Design and Development Stage		278
	14.5.2 Production Stage		278
	14.5.3 Marketing Stage		278
	14.5.4 Post-sale Servicing Stage		279
	14.6 Mathematical Tools and Techniques		279
	14.7 Interfaces 14.7.1 User Interface		280
	14.7.1 User Interface 14.7.2 Application Interface		280 281
	14.8 Commercial Software Packages		281

xviii Contents

	14.8.1	WarrantyNet	281
	14.8.2	SAP	282
	14.8.3	Entigo/SAS	283
	14.8.4	Jetliner Warranty Management	284
	References		284
15.	Conclusion		287
Aut	hor Index		293
Sub	ject Index		297