

TECHNISCHE HOCHSCHULE DARMSTADT  
Fachbereich 1  
Gesamtbibliothek  
Betriebswirtschaftslehre  
Inventar-Nr. : 37.319  
Abstell-Nr. : A 25 / 528  
Sachgebiete :  
4  
00227070

# ANALYSIS AND CONTROL OF PRODUCTION SYSTEMS

Elsayed A. Elsayed  
Thomas O. Boucher

*Rutgers University*

# CONTENTS

PREFACE      xiii

## 1 Introduction      2

- 1.1 The Production System      2
- 1.2 Production System Analysis      3
- 1.3 The Information Base      5
- 1.4 Organization of this Book      6
- References      7

## 2 Forecasting and Time-Series Analysis      8

- 2.1 Introduction      8
- 2.2 Forecasting      9
- 2.3 Forecasting Procedures      10
  - 2.3.1 Gregory–Newton Interpolation Formulas      11
  - 2.3.2 Regression Methods      13
  - 2.3.3 Moving-Average Methods      28
  - 2.3.4 Exponential Smoothing      35
  - 2.3.5 Double-Exponential Smoothing      38
  - 2.3.6 Choice of  $\alpha$       41
  - 2.3.7 Winters' Method for Seasonal Variation      44

2.4	Comparison of Time-Series Forecasts	48
	Problems	48
	References	52
<b>3</b>	<b>Inventory Systems</b>	<b>54</b>
3.1	Introduction	54
3.2	Inventory Costs	55
	3.2.1 Inventory Carrying Costs	55
	3.2.2 Shortage Costs	55
	3.2.3 Ordering Cost	56
3.3	The Terminology of Inventory Systems	56
	3.3.1 Demand	56
	3.3.2 Lead Time and Replenishment Rate	56
	3.3.3 Reorder Level	57
	3.3.4 Safety Stock	57
3.4	Inventory Policies	58
	3.4.1 Periodic-Review Policy	58
	3.4.2 Order up to $I_{\max}$ Policy	59
	3.4.3 Continuous-Review Policy	59
	3.4.4 Fixed-Reorder Quantity Policy	59
	3.4.5 Base Stock Policy	60
3.5	Demand Characteristics and Inventory Models	60
3.6	Analysis of Deterministic Inventory Models	61
	3.6.1 Single-Product Model	61
	3.6.2 Sensitivity Analysis	67
	3.6.3 Quantity Discounts	68
	3.6.4 Multi-item Inventory Systems with Constraints	70
3.7	Probabilistic Inventory Models	77
	3.7.1 A Continuous-Review Model	78
	3.7.2 Periodic-Review Models	82
	3.7.3 Single-Period Models	87
3.8	Inventory System Control Practices	92
	3.8.1 The ABC Classification System	92
	Problems	93
	References	98
<b>4</b>	<b>Aggregate Production Planning</b>	<b>100</b>
4.1	The Purpose of Aggregate Production Planning	100
4.2	A Simple Network Model with Linear Production and Inventory Cost	102
	4.2.1 Production Plan Disaggregation	105
4.3	Linear Production Planning Models: Changing Work-Force Levels and Backlogging	107
4.4	Disaggregation of An Aggregate Plan	111
	4.4.1 Constant Production and Demand Rates	113
	4.4.2 Time-Varying Production and Demand Rates	119

4.5	A Quadratic Cost Model	125
4.6	Dynamic Programming Production Planning Models	129
4.6.1	Backlogging Prohibited	130
4.6.2	Backlogging Allowed	133
4.7	Summary	137
	Problems	138
	References	142

## 5 Material Requirements Planning 144

5.1	Introduction	144
5.2	Parts Explosion Requirements	146
5.3	Computing Direct Dependent Demand	149
5.4	Computing Total Requirements	150
5.5	Computing Requirements Using Submatrix Structure	153
5.6	Engineering Changes	155
5.7	Material Requirements Planning System	156
5.8	Lot Sizing	164
5.9	Software Structure of MRP	167
	Problems	170
	References	174

## 6 Project Planning and Scheduling 176

6.1	Introduction	176
6.2	Project Planning and Scheduling: Unlimited Resources	177
6.2.1	CPM: Background	177
6.2.2	PERT: Background	177
6.2.3	The Use of CPM/PERT in Industry	178
6.2.4	Construction of Project Networks	178
6.2.5	Common Errors in Network Construction	181
6.2.6	Checking the Consistency of Precedence Relationships	182
6.2.7	Critical Path Algorithm	184
6.2.8	Linear Programming Formulation	190
6.2.9	Cost Models	192
6.2.10	Program Evaluation and Review Technique (PERT)	197
6.2.11	Limitations of PERT and/or CPM	198
6.3	Project Planning and Scheduling: Limited Resources	199
6.3.1	ROT Algorithm	199
6.3.2	ACTIM Criterion	202
6.3.3	ACTRES and TIMRES Criteria	203
6.3.4	Modification of the TIMRES Criterion—GENRES	204
6.3.5	Modification of ROT (ROT-ACTIM, ROT-ACTRES)	206

6.3.6	TMROS	206
6.3.7	TG2	207
6.3.8	Performance of the Algorithms	209
6.3.9	Multiple-Project, Multiple-Resource Algorithm	209
	Problems	216
	References	223

## 7 Job Sequencing and Operations Scheduling 226

7.1	Introduction	226
7.2	Job Sequencing	226
7.3	$n$ Jobs, One Machine	230
7.4	$n$ Jobs, Two Machines	233
7.5	$n$ Jobs, Three Machines	236
	7.5.1 Johnson's Algorithm for $n$ Jobs, Three Machines	236
	7.5.2 Branch-and-Bound Algorithm	238
7.6	Two Jobs, $M$ Machines	243
7.7	$n$ Jobs, $M$ Machines	245
	7.7.1 Campbell et al. Algorithm	245
	7.7.2 Stinson-Smith Algorithm	247
7.8	Minimization of Setup Costs (Traveling Salesman Problem)	252
7.9	Job Shop Scheduling	258
7.10	Assembly Line Balancing	259
	7.10.1 Definitions	260
	7.10.2 Kilbridge-Wester Heuristic Method	262
	7.10.3 Moodie-Young Method	266
	7.10.4 Helgeson-Birnie Method or Positional Weight Technique	268
7.11	Probabilistic Assembly Line Balancing	270
	7.11.1 Method 1: The Probability Distribution is Normal	270
	7.11.2 Method 2: Distribution Free	271
7.12	Automatic Transfer Lines	274
	Problems	277
	References	284

## 8 New Directions in Batch and Discrete-Parts Production Systems 286

8.1	Introduction	286
8.2	Kanban	287
	8.2.1 Inventory Control and Operations Scheduling Under Kanban	289
	8.2.2 Some Issues in the Implementation of Kanban	290
8.3	Group Technology	291
	8.3.1 Lot Sizing under Group Technology	294

8.3.2	Operations Scheduling Under Group Technology	296
8.3.3	Some Issues in the Implementation of Group Technology	297
8.4	Flexible Manufacturing Systems: An Introduction	298
8.4.1	The FMS Concept	298
8.4.2	Issues in FMS	299
8.4.3	FMS and Computer-Integrated Manufacturing Systems	300
8.4.4	Production Control in the Automated Factory	305
	References	306

APPENDIX A: Proof of Equation 3.65 309

APPENDIX B: Tables of Standard Normal Distribution  
and  $t$ -Distribution 311

INDEX 315