



second edition

PRODUCTION MANAGEMENT

SYSTEMS AND SYNTHESIS

TECHNISCHE HOCHSCHULE
GARMSTADT
INSTITUT FÜR
BETRIEBSWIRTSCHAFTSLEHRE

MARTIN K. STARR

Columbia University

contents

part **PRODUCTION-**
one **SYSTEMS**
MODELS

chapter one
the systems concept

3

PRODUCTION MANAGEMENT CYCLE	4
OPTIMALITY AND MULTIPLE OBJECTIVES	6
THE TOTAL SYSTEM	7
EFFECTIVENESS VS. EFFICIENCY	8
OBJECTIVES AND CONSTRAINTS	10
TEMPORAL SUBOPTIMIZATION	11
SUBOPTIMIZATION BY CONFLICTION	12
SUBOPTIMIZATION AND OPPORTUNITY COSTS	13
THE PRODUCTION SYSTEM	15
ORGANIZATIONAL RELATIONS	16
CONCLUSIONS	19

chapter two
models of the system

23

INPUT-OUTPUT MODELS 24
OUTPUTS AND REVENUE 25
THE PROCESS AND FIXED COSTS 26
INPUTS AND VARIABLE COSTS 27
FIXED- AND VARIABLE-COST SYSTEMS 27
THE BREAK-EVEN CHART 28
MATHEMATICAL FORM 32
THE NONLINEAR BREAK-EVEN CHART 35
CONCLUSIONS 38

chapter three
decision models

41

DECISION THEORY 41
ANALYSIS AND SYNTHESIS 42
THE NATURE OF ALTERNATIVES 43
STRATEGIC DECISION LEVELS 44
TACTICAL DECISION LEVELS 45
GLOBAL STRATEGIES 48
STRATEGIC INNOVATION 49
DETERMINING OUTCOME RELATIONS 57
USING THE DECISION MATRIX 59
(DMUR) DECISION MAKING UNDER RISK 61
DECISION MATRIX AND THE BREAK-EVEN CHART 62
(DMUC) DECISION MAKING UNDER CERTAINTY 66
(DMUU) DECISION MAKING UNDER UNCERTAINTY 67

chapter four
project planning models

71

PROJECT PLANNING 71
DEGREE OF REPETITION 73
DEGREE OF REVERSIBILITY 73
SENSITIVITY ANALYSIS 74
UTILITY TRANSFORMS 76
THE GANTT PROJECT PLANNING CHART 78
CRITICAL PATH METHODS 82
NETWORK REPRESENTATION 86
TIME ESTIMATION 88
CRITICAL PATH COMPUTATIONS 90
MEASURE OF SLACK 91
DISTRIBUTION OF COMPLETION TIMES 91
SCHEDULE CONTROL 92
TRADING-OFF RESOURCES 93
PERT COSTS 94
NETWORK SIMULATION 95
CONTINGENCY PLANNING 97
PLANNING HORIZONS 98

chapter five
control models; forecasting and feedback

106

A CLASSIFICATION BASIS 106
ENVIRONMENTAL CONTROL—TYPE 1 107
FORECAST CONTROL—TYPE 2 108

CORRECTIVE CONTROL—TYPE 3	109
TYPES OF FORECASTS	110
CONTROL INSTRUMENTATION	111
CONTROL DYNAMICS	112
FEEDBACK CONTROL	113
CONTROL POLICIES	115
OPEN AND CLOSED SYSTEMS	117
THE SHEWHART CONTROL MODEL	119
THE CONTROL MATRIX WHEN THE STATES OF NATURE ARE UNKNOWN	120
PREDICTIONS AND FORECASTS	122
PROBABILITY DISTRIBUTIONS	124
BINOMIAL DISTRIBUTION	124
NORMAL DISTRIBUTION	126
OTHER THEORETICAL DISTRIBUTIONS	127
EMPIRICAL DISTRIBUTIONS	128
MARKOVIAN FORECASTS	130
HISTORICAL AND SEASONAL FORECASTS	132
LEAST-SQUARES, LAG-LEAD PREDICTION	133
PERSONAL PREDICTIONS	135
HEURISTIC CONTROL	136

part **INPUT-**
two **OUTPUT**
MANAGEMENT

chapter six
information management

143

INFORMATION SYSTEMS	143
THE AGE OF INFORMATION	145
THE MEASUREMENT OF INFORMATION	147
HUMAN INFORMATION PROCESSING	148
ERROR AND FAULT DETECTION	148
INPUT-OUTPUT SPECIFICATIONS	152
ANALYSIS OF INFORMATION SYSTEMS	156

chapter seven
product management

166

PRODUCTS AND SERVICES	166
DESIGNING THE SYSTEMS OUTPUT	168
PURE AND APPLIED RESEARCH	169
RESEARCH AND DEVELOPMENT (R&D)	169
PRODUCTIVITY OF PRODUCT DEVELOPMENT	173
OVERSTAFFED PRODUCT DEVELOPMENT	174
COORDINATED PRODUCT MANAGEMENT	176
DECENTRALIZED PRODUCT MANAGEMENT	177
PROTOTYPES	178
PATENTS	180
THE ECONOMIC ADVANTAGES OF VARIETY	186
L.P. PRODUCT MIX-MODEL AND THE VARIETY PROBLEM	187
THE PROGRAMMING ALGORITHM	194
MODULARITY	194
THE NEW CAPACITY	195
NATURE OF METAMORPHOSIS	196
DEMAND FOR VARIETY	198
BEGINNINGS OF THE TREND	201
PLANNING AND CONTROL	203

MEETING THE CHALLENGE	207
PRODUCT QUALITIES	209
FUNCTIONAL QUALITIES	210
NONFUNCTIONAL QUALITIES	213
TECHNOLOGICAL CHANGE	214
INNOVATION	217

chapter eight
process management

223

TECHNOLOGICAL DIFFERENTIATION	224
THE FLOW SHOP AND THE JOB SHOP	224
LINE BALANCING	225
AGGREGATE SCHEDULING	226
SHOP LOADING	230
GANTT SHOPLOADING CHARTS	230
GANTT SEQUENCING CHARTS	230
SHOP LOADING FOR (RELATIVELY) CONTINUOUS PRODUCTION FACILITIES —THE ASSIGNMENT METHOD	232
THE TRANSPORTATION ALGORITHM	239
SHOPLOADING USING THE TRANSPORTATION METHOD	245
SEQUENCING MODELS	253
GRAPHICAL SEQUENCING MODELS	255
RELEVANT QUESTIONS FOR PROCESS DESIGN	258

chapter nine
materials management

265

THE MATERIALS SYSTEM	265
PURCHASING OR PROCUREMENT	267
THE NATURE OF HEDGING	268
COMMODITY BUYING	268
BIDDING	270
MAINTENANCE INVENTORIES	271
A DECISION MODEL FOR MAINTENANCE INVENTORIES	272
CLASSIFICATION OF INVENTORY SYSTEMS	273
INVENTORY COSTS	274
ECONOMIC-ORDER-QUANTITY MODEL	277
ECONOMIC LOT SIZE MODEL	282
LEAD TIME	283
QUANTITY-DISCOUNT MODEL	284
MULTIPLE ITEMS AND AGGREGATE INVENTORIES	286
PERPETUAL INVENTORY SYSTEMS	289
PERIODIC INVENTORY SYSTEMS	291
VALUE ANALYSIS	292
JOB SHOP MATERIALS CONTROL	293

chapter ten
quality management

299

INPUT QUALITY	300
Cost of Defective Inputs	300
One Hundred Percent Inspection	301
Sampling Inspection Terminology	301
Proportional Sampling	302
Producer's and Consumer's Risks	303
Constructing Acceptance Sampling Plans	305
Average Outgoing Quality Limit (AOQL)	306

Multiple Sampling	308
OUTPUT QUALITY	310
The Shewhart Output Quality Monitor	310
Assignable and Chance Causes of Variation	311
Inspection Standards	312
Sequenced Inspection	313
SQC Calculations	314
Sample Design	315
Statistical Quality Control Theory	317
The Range Measure	318
The Control Chart	318
Monitoring Variables	320
Symptoms and Diagnosis	321
Monitoring Attributes	323
Design of Limits	325
Other Applications	326

chapter eleven

facilities management

330

PLANT LOCATION	330
Plant Construction Factors	330
Plant Location Factors	333
Plant Location Cost Determinants	340
Facility Selection Using Dimensional Analysis	343
Locating Multiple Facilities	346
Programming Approaches to Location	352
PLANT LAYOUT	352
Basic Approaches to Layout	352
Assembly Layout	358
Multiple-Item Layout Analysis	358
The String-Layout Model	358
The Layout Problem	359
An Assignment-Type Model	360
The Fundamental Complexity of the Layout Problem	362
EQUIPMENT SELECTION	362
An Aspect of Equipment Selection	362
Discounting Analyses for Equipment Selection	364
Equipment Queues	367
Measures of Service Effectiveness	368
Service Configurations	370
Replacement of Facilities	371

chapter twelve

manpower management

381

A TWO-PART PROBLEM: FAIR OUTPUT—FAIR WAGE	382
PRODUCTION COST ESTIMATES FOR LABOR	382
TIME STUDIES	383
PRODUCTIVITY STANDARD	386
TIME STUDY SAMPLE SIZE	388
WORK SAMPLING	390
WORK SAMPLE SIZE	392
SYNTHETIC TIME STANDARDS	394
INCREASED SCOPE OF PREDETERMINED TIME VALUES	399
WORK SIMPLIFICATION	399
MAN-MACHINE SYSTEMS	402
WAGE PLANS AND INCENTIVES	404
DESIGN OF THE JOB AND THE WORKPLACE	408
SAFETY	408

THE MAN-MACHINE INTERFACE 410
HUMAN FACTORS 413
ANATOMICAL MODELS 414
SENSORY SYSTEMS 416

part **SYNTHESIS**
three **OF**
SYSTEMS

chapter thirteen
some history of production management 427

chapter fourteen
the financial context of production management decisions 436

INTRODUCTION 436
THE FINANCIAL FUNCTION TODAY 437
A HISTORY OF THE FINANCE-PRODUCTION INTERACTION 438
THE MANAGEMENT OF CASH FLOWS WITHIN THE FINANCIAL SYSTEM 442
An Overview 442
The Flow of Cash Through a Business 443
The Cash Budget 444
The Timing of Production Decisions 446
CAPITAL BUDGETING 447
Introduction 447
The Determination of Relevant Cash Flows 448
The Concept of Present Value 451
The Riskiness of an Investment 452
Computer Simulation as a Means of Assessing Risk 453
The Evaluation of Alternatives 455
A Risk-Premium Approach to Ranking Investments 456
The Portfolio of Investments 458
The Decision Faced by the FPM Company 459
Some Concluding Comments 459

chapter fifteen
marketing-production interaction 463

THE VALUE OF PRODUCT MANAGEMENT 464
The Declining Importance of Efficiency 464
The New Opportunity—Market Segmentation 465
Utilitarian and Nonutilitarian Functions Cannot be Categorized 466
Quality Standards are Unevenly Distributed 467
There Are No Universally Better Designs 468
PRODUCTS PERFORM SERVICES 468
The Value of Services Performed is Equivalent to the Value Received 468
The Interchangeability of Production and Service 468
Combining Services Enhances Value of Production 469
Processing Reduces Range of Use 469
Production Stores Services 470
Service Combinations and Product Proliferation 470
Birth and Death: Product Life Expectations 470
WHAT IS THE BOUNDARY OF A PRODUCT? 471
Product Attributes Cannot be Categorized as Primary and Secondary 471
A Product's Attributes are Its Utilities, Its Services 471
A Service Economy Requires Changed Financial Concepts 472

PROFIT AND COST ANALYSES	474
Market Segmentation Modifies the Relationship of Profits to Sales Volume	474
Promotion Costs Behave Differently from Other Costs	474
ECONOMIC INTERACTION IN A FIRM FOR A SINGLE PRODUCT	476
Product Changes Alter the Potential Market and, Therefore, the Spectrum of Competing Products	477
The Key Objective: Maximize Potential Market While Minimizing Competition	478
Heavy Purchasers are Not Necessarily the Most Profitable Customers	478
MARKETING OBJECTIVE AND MANAGEMENT CONTROL	479
Estimating the Profit Effect of Design and Marketing Decisions	480
How Should Marketing Decisions be Made?	480
Packaging	486
Inventory and Distribution Lines	487
Pricing	490
Advertising Promotion	490
Choosing the Promotional Identity	492
Holding and Switching Strategies	495
Patterns of Production Scheduling	501
The Stated Conditions	502
CONCLUSION	506