CONTENTS

PREFACE xi

1. THEORY OF DEA MODELS 1

1.1 Statics and Dynamics 3
A. Short-run vs. long run 7
B. Adjustment cost model 9
C. Technological change 9
D. A control system model 11
1.2 Types of Efficiency 12
A. Scale efficiency 13
B. Allocative efficiency 15
C. Structural efficiency 17
D. Stochastic efficiency 22
1.3 Models of Systems Efficiency 25
1.4 Efficiency Distributions 30
1.5 Applying DEA Models 32
1.6 Outline of the Book 34

2. DYNAMICS OF EFFICIENCY 38

2.1 Expansion Frontier and Allocative Efficiency 39
2.2 Dynamic Production Frontiers 43
2.3 Comparing Statics and Dynamics 47
2.4 Concept of Efficiency in DEA Models 55
A. Efficiency in control systems 55
B. Efficiency with integrated processes 57
C. System reliability and efficiency 58
D. Vector efficiency 60
2.5 Efficiency Analysis by Optimal Control 65
2.6 Transformations of the Dynamic Model 74

3. TECHNICAL CHANGE AND EFFICIENCY 86

3.1 Forms of Technical Change 86
A. Change in input parameters 87
B. Cumulative output and efficiency 94
3.2 A Continuous Model of Efficiency 100
3.3 A Model of Cumulative Output 110
3.4 Scope of Applications 113
3.5 Structural Change 119
3.6 Dynamics of Capacity Utilization 121

4. STOCHASTIC EFFICIENCY 133

4.1 Efficiency Distribution Under Outliers 136
4.2 Chance-constrained Efficiency 142
4.3 Models of Efficiency Distribution 144
4.4 Econometrics of Efficiency Frontier 147
4.5 Efficiency Based on Stochastic Control 162
A. Risk sensitivity of DEA efficiency 162
B. Estimation of time-varying parameters 166
C. Estimation with non-stationary data 169
4.6 Efficiency Under Goal Programming 171

5. THEORY OF SYSTEMS EFFICIENCY 179

5.1 Input-Output and Control Systems 180
5.2 Flexible Manufacturing Systems 187
Example 1: A model of flexible investment 191
Example 2: An entropy model of flexibility 193
Example 3: Production planning under learning 196
Example 4: A DEA model of economies of scope 200
5.3 Stochastic Efficiency and Reliability 202
Example 5: A DEA model of reliability and efficiency 203
Example 6: Model of reliability improvement 205
5.4 Technical Change and Diffusion 207
Example 7: Dynamic production frontier 208
Example 8: A model of evolutionary efficiency 209

6. ENTROPY, EFFICIENCY AND THE INDEX NUMBERS 216

6.1 Types of Efficiency Distributions 217
6.2 Entropy and Efficiency 224
Example 1: Maximum entropy models 225
Example 2: A seismic reliability problem 227
Example 3: Application to a DEA model 229
6.3 Measuring TFP 231
Example 4: Test for technical change 233
6.4 Index Number Comparison 234
6.5 Tests of Efficiency in DEA Models 237

7. ECONOMIC THEORY AND DEA 250

7.1 Economic Theory and DEA Efficiency 251
7.2 Dynamic Production Frontiers and Efficiency 260
7.3 Econometric Issues in Efficiency Analysis 267

7.4 Policy Implications of DEA Models 269
7.5 Externalities and Interdependence 272

8. FRONTIERS OF EFFICIENCY RESEARCH 277

8.1 Entropy and Efficiency 278
8.2 Dynamic Efficiency and Heteroscedasticity 280
8.3 Efficiency, Externality and Indivisibility 282

INDEX 285