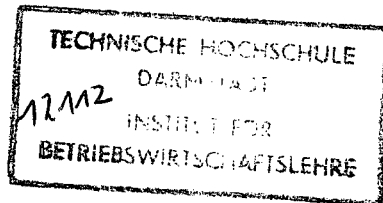


SUKHAMOY CHAKRAVARTY

# Capital and Development Planning

Foreword by Paul A. Samuelson



The M.I.T. Press  
Cambridge, Massachusetts, and London, England

<b>1</b>	<b>Fundamentals of a Theory of Planning over Time</b>	<b>1</b>
1.1.	The Nature and Relevance of the Present Exercise for Planning	1
1.2.	How Much Should a Nation Save?	2
1.3.	Consistency Models Versus Utility-Maximization Models	7
1.4.	The Assumption of a Labor-Surplus Economy	10
1.5.	The Scheme of Analysis	12
1.6.	The Role of Variational Principles in Economics	13
1.7.	Observations on the Problems of Social Choice	15
<b>2</b>	<b>Basic Choice Variables in the Theory of Optimal Economic Growth</b>	<b>19</b>
2.1.	The Length of the Planning Horizon	19
2.2.	Infinite Horizons	29
2.3.	The Concept of Time Preference	34
2.4.	The Strotz Phenomenon	41
<b>3</b>	<b>Optimal Growth Paths for Finite Horizons</b>	<b>46</b>
3.1.	Introduction	46
3.2.	The Setup of the Problem	47
3.3.	Some Observations on the Method of Solution	49
3.4.	The Structure of the Optimal Growth Paths	56
3.5.	Different Methods of Setting Terminal Conditions and the Sensitivity of Optimal Growth Paths	66
3.6.	Full-Employment Terminal Conditions with or Without an Implicit Wage Constraint	71
3.7.	The Model with Explicit Wage Restrictions	72
3.8.	An Optimal Savings Problem with Growing Population and an Institutional Wage Rate	74
3.9.	A Numerical Illustration of the Optimal Savings Path with Full-Employment Terminal Conditions	75
<b>4</b>	<b>Optimal Growth Paths for an Infinite Planning Horizon</b>	<b>80</b>
4.1.	Introduction	80
4.2.	The Ramsey Case with Utility Satiation	80
4.3.	The Ramsey Model with Production Satiation	86
4.4.	The Ramsey Model with an Arbitrary Utility Function	47
4.5.	The Golden Rule of Accumulation	89
4.6.	A Modified Ramsey Problem	94

4.7. Finite and Infinite Programs	98
4.8. The Consumption Turnpike Theorem	100
4.9. Utility Maximization over an Infinite Horizon with Total Utility as the Maximand	102
Appendix to Chapter 4. Quantitative Analysis for Time-Dependent Utility Functions and Nonlinear Production Relationships	105
<b>5 Optimal Programs of Capital Accumulation in a Two-Sector Model</b>	<b>111</b>
5.1. Introduction	111
5.2. The Shiftable Case	112
5.3. The Nonshiftable Case	114
5.4. A Nonshiftable Two-Sector Model with a Time-Minimization Objective	128
5.5. Conclusion	136
<b>6 The Leontief System</b>	<b>138</b>
6.1. Introduction	138
6.2. The Static Input–Output Model: Basic Features	138
6.3. Patterns of Interconnectedness	143
6.4. A Mathematical Existence Theorem	145
6.5. A Nonsubstitution Theorem	149
6.6. A Numerical Illustration with Indian Data	157
6.7. The Dynamic Leontief Model	158
6.8. The Leontief Dynamic Model with Inequality Constraints	171
6.9. The Significance of the Leontief Dynamic Model with Equality Constraints from the Planning Point of View	178
Appendix to Chapter 6. The von Neumann Models of an Expanding Economy	185
<b>7 Multisectoral Numerical Planning Models with Linear Technologies</b>	<b>204</b>
7.1. Introduction	204
7.2. A Simple Linear Maximization Problem over Time	205
7.3. The Multisector Linear Model	206
7.4. Boundary Conditions	210
7.5. Dual Variables of the Model	213
7.6. The Sandee–Manne Model	214

<b>8</b>	<b>Optimal Accumulation in Multisector Models with Nonlinear Utility Functions</b>	<b>221</b>
	8.1. Introduction	221
	8.2. Finite-Horizon Multisectoral Models with Heterogeneous Capital	221
	8.3. A Special Case Involving a Linear Logarithmic Utility Function	228
	8.4. Heterogeneous Capital Models with an Infinite Planning Horizon	232
	8.5. The Leontief Model with Exogenously Growing Labor	235
	8.6. The Pontryagin Approach	240
	Appendix to Chapter 8. A Time-Minimizing Model for Full Employment	242
<b>9</b>	<b>Conclusion</b>	<b>246</b>
	9.1. An Overall Assessment of the Current Models	246
	9.2. Some Observations on Possible Methods of Solution	256
	9.3. Perfect Foresight and an Infinite Time Horizon	261
	9.4. The Question of Technical Progress	263
<b>A</b>	<b>The Classification of Variational Problems in Economics</b>	<b>267</b>
	A.1. The Simplest Problem in Variational Calculus: The Necessary Condition for a Weak Interior Extremum Without Corners	267
	A.2. The Problem Involving $n$ Dependent Variables	272
	A.3. The Necessary Conditions for a Weak Extremum for Variable End Points	273
	A.4. The Weierstrass–Erdmann Corner Conditions	275
	A.5. Second-Order Conditions for Variational Problems	276
	A.6. The Lagrange Multiplier Rule for a Finite-Dimensional Maximization Problem	285
	A.7. Constrained-Maximum Problems in the Calculus of Variations	289
	A.8. Boundary Solutions	296
	A.9. The Valentine Formulation	298
	A.10. The Pontryagin Maximum Principle	303
<b>B</b>	<b>Basic Ideas in the Theory of Optimal Control</b>	<b>306</b>
	B.1. Introduction	306
	B.2. Formulation of the Optimal Control Problem	307

B.3. The Maximum Principle	308
B.4. Constraints on the Terminal Set of State Variables	309
B.5. Some Special Cases	309
B.6. Derivation of the Maximum Principle	311
B.7. Derivation of the Classical Calculus of Variations from the Maximum Principle	315
B.8. An Economic Example Involving Interregional Allocation of Investment	317
<b>C Nonnegative Indecomposable Square Matrices</b>	<b>319</b>
C.1. General Properties	319
C.2. Characteristic Roots and Vectors of Indecomposable Non- negative Square Matrices	320
<b>D Separation Theorems on Convex Sets</b>	<b>325</b>
<b>Bibliography</b>	<b>329</b>
<b>Index</b>	<b>341</b>