

# CONTENTS

Preface	xi
Introduction	xiii
1. Basic Concepts	1
1.1 What Are Dynamic Games? . . . . .	1
1.2 Open-loop Nash Equilibrium and Markov-perfect Nash Equilibrium . . . . .	2
1.2.1 A simple transboundary pollution game in discrete time . . . . .	4
1.2.2 Choice among equilibrium concepts . . . . .	11
1.2.3 Another simple dynamic game: non-cooperative cake eating . . . . .	12
1.2.4 An infinite horizon game of transboundary pollution in continuous time . . . . .	14
1.3 Stackelberg Equilibrium . . . . .	26
1.3.1 Open-loop Stackelberg Equilibrium . . . . .	27
1.3.2 Feedback Stackelberg Equilibrium . . . . .	31
2. Dynamic Games in Environmental Economics	35
2.1 Models of Transboundary Pollution and Global Warming . . . . .	35
2.2 Empirical Models of Transboundary Pollution Games . . .	37
2.3 Carbon Taxes under Bilateral Monopoly . . . . .	39
2.3.1 Nash equilibrium under costless extraction and non-decaying pollution . . . . .	40
2.3.2 Stagewise Stackelberg leadership by the seller under costless extraction and non-decaying pollution . . .	45
2.3.3 Bilateral monopoly under stock-dependent extraction cost and non-decaying pollution . . . . .	48
2.3.4 Models of carbon taxes with pollution decay . . . .	51
2.4 International Environmental Agreements . . . . .	51
2.4.1 IEA membership game . . . . .	52

2.4.2	Effects of delays . . . . .	53
2.4.3	Games under the Kyoto Protocol . . . . .	55
2.5	Taxation Issues . . . . .	56
2.5.1	Efficiency-inducing tax on emissions: monopoly or oligopoly as follower and government as leader . . . . .	56
2.5.2	Prices versus quantities . . . . .	61
2.5.3	Tax adjustment rule to achieve a long-run pollution target . . . . .	61
2.5.4	Non-point-source pollution taxes . . . . .	62
2.6	Environmental Games with Coupled Constraints . . . . .	63
2.6.1	A static model of global pollution with and without a coupled constraint . . . . .	63
2.6.2	Models of environmental games with coupled constraints . . . . .	69
3.	Dynamic Games in Natural Resources Economics . . . . .	71
3.1	Renewable Resources . . . . .	71
3.1.1	The tragedy of the commons . . . . .	71
3.1.2	Can Nash equilibria in renewable-resource exploitation be Pareto efficient? . . . . .	79
3.1.3	Some technical notes on feedback strategies in fishery problems . . . . .	82
3.1.4	Differential game models of an oligopolistic fishery . . . . .	89
3.1.5	Entry deterrence . . . . .	92
3.1.6	Further results . . . . .	93
3.2	Non-Renewable Resources . . . . .	94
3.2.1	Dynamic games with a non-renewable resource: open-loop equilibrium . . . . .	94
3.2.2	Dynamic games with a non-renewable resource: feedback equilibrium . . . . .	98
3.2.3	Optimal tariff on exhaustible resources: dynamic games . . . . .	99
3.2.4	Optimal taxation and principal-agent problems with extractive firms . . . . .	101
3.2.5	Dynamic games with investment in R&D for a substitute for a non-renewable resource . . . . .	102
3.2.6	Common property non-renewable resource and capital accumulation games . . . . .	103

3.3	Related Topics: Recycling, Drug Resistance, and Pesticide Resistance . . . . .	104
4.	Dynamic Games in Trade and Development Economics . . . . .	107
4.1	International Oligopoly and Trade Policies . . . . .	107
4.2	Feedback Trade Policies under Bilateral Monopoly . . . . .	113
4.3	Time-inconsistency of Open-loop Trade Policies . . . . .	115
4.4	Optimal Export Tax by a Resource-Exporting Country . . . . .	118
4.5	Optimal Tariff by Resource-Importing Countries . . . . .	120
4.5.1	Optimal tariff under rational expectations, when sellers are perfectly competitive . . . . .	120
4.5.2	Optimal tariff when the seller is a monopolist . . . . .	127
4.6	Foreign Aid and Capital Flight from Poor Countries to Rich Countries . . . . .	128
4.6.1	Foreign aid as a dynamic game . . . . .	128
4.6.2	Capital flights as a result of rent-seeking by powerful groups . . . . .	130
5.	Dynamic Games in Industrial Organization . . . . .	137
5.1	Dynamic Oligopoly . . . . .	137
5.1.1	The sticky price model . . . . .	138
5.1.2	Investment in capacity by Cournot oligopolists . . . . .	141
5.1.3	Bertrand rivalry with costly price adjustments . . . . .	147
5.1.4	Bertrand rivalry with costly output adjustments . . . . .	148
5.1.5	Going beyond the linear quadratic model . . . . .	149
5.2	Extensions of Dynamic Oligopoly Games . . . . .	149
5.2.1	Dynamic oligopoly with far-sighted consumers . . . . .	150
5.2.2	Oligopolistic extraction of natural resources . . . . .	154
5.3	R&D Races and Technology Adoption . . . . .	154
5.3.1	R&D races . . . . .	155
5.3.2	Technology-adoption games . . . . .	163
6.	Dynamic Games in Public Economics . . . . .	173
6.1	Contributions to a Stock of Public Good . . . . .	173
6.1.1	Tangible public goods . . . . .	173
6.1.2	Trust: an intangible stock of public good that promotes co-operative behavior . . . . .	178

6.2	Contributions to a Discrete Public Good . . . . .	184
6.2.1	The co-operative solution . . . . .	185
6.2.2	Open-loop Nash equilibria . . . . .	187
6.2.3	Markov-perfect Nash equilibria . . . . .	188
6.3	Corrective Taxation with Far-sighted Firms . . . . .	191
6.4	Redistributive Taxation . . . . .	196
6.5	Altruism, Distributive Justice, and Intergenerational Equity	197
6.6	Fiscal Competition and Electoral Incentives . . . . .	202
6.6.1	Factor mobility and fiscal competition . . . . .	202
6.6.2	Electoral incentives, corruption, and local public goods . . . . .	203
7.	Dynamic Games in Macroeconomics	211
7.1	Macroeconomic Policies . . . . .	211
7.1.1	Dynamic games between a policymaker and the private sector . . . . .	211
7.1.2	Political economy of monetary and fiscal policies . . . . .	218
7.1.3	Dynamic games of macroeconomic policies between two countries . . . . .	224
7.2	Wealth Distribution and Endogenous Property Rights . . .	229
7.3	Capitalists versus Workers . . . . .	236
	References	243
	Index	273