An Introduction to Decision Theory

Second Edition

MARTIN PETERSON

Texas ASM University



Contents

| Preface | page ix |
|--|---------|
| Preface to the Second Edition | x |
| 1 Introduction | 1 |
| 1.1 Normative and Descriptive Decision Theory | 3 |
| 1.2 Rational and Right Decisions | 4 |
| 1.3 Risk, Ignorance and Uncertainty | 5 |
| 1.4 Social Choice Theory and Game Theory | 8 |
| 1.5 A Very Brief History of Decision Theory | 10 |
| 2 The Decision Matrix | 17 |
| 2.1 States | 19 |
| 2.2 Outcomes | 22 |
| 2.3 Acts | 28 |
| 2.4 Rival Formalizations | 31 |
| 3 Decisions under Ignorance | 41 |
| 3.1 Dominance | 42 |
| 3.2 Maximin and Leximin | 44 |
| 3.3 Maximax and the Optimism-Pessimism Rule | 47 |
| 3.4 Minimax Regret | 50 |
| 3.5 The Principle of Insufficient Reason | 54 |
| 3.6 Randomized Acts | 57 |
| 4 Decisions under Risk | 65 |
| 4.1 Maximizing What? | 66 |
| 4.2 Why is it Rational to Maximize Expected Utility? | 72 |
| 4.3 The Axiomatic Approach | 75 |
| 4.4 The Allais Paradox | 80 |
| 4.5 The Ellsberg Paradox | 82 |

| | 4.6 The St. Petersburg Paradox | 84 |
|----|--|-----|
| | 4.7 The Pasadena Paradox | 88 |
| | 4.8 The Two-Envelope Paradox | 91 |
| 5 | Utility | 97 |
| | 5.1 How to Construct an Ordinal Scale | 98 |
| | 5.2 Von Neumann and Morgenstern's Interval Scale | 101 |
| | 5.3 Can Utility be Measured on a Ratio Scale? | 113 |
| | 5.4 Can We Define Utility Without BeingAble to Measure It? | 117 |
| 6 | The Mathematics of Probability | 124 |
| | 6.1 The Probability Calculus | 125 |
| | 6.2 Conditional Probability | 130 |
| | 6.3 Bayes' Theorem | 132 |
| | 6.4 The Problem of Unknown Priors | 134 |
| 7 | The Philosophy of Probability | 141 |
| | 7.1 The Classical Interpretation | 142 |
| | 7.2 The Frequency Interpretation | 144 |
| | 7.3 The Propensity Interpretation | 147 |
| | 7.4 Logical and Epistemic Interpretations | 149 |
| | 7.5 Subjective Probability | 151 |
| 8 | Bayesianism and Pragmatic Arguments | 174 |
| | 8.1 Why Should We Accept the Axioms? | 177 |
| | 8.2 Must a Rational Preference be Transitive? | 179 |
| | 8.3 Must a Rational Preference be Complete? | 183 |
| | 8.4 Must a Rational Preference Satisfy the Independence | |
| | Axiom? | 190 |
| | 8.5 Can Bayesians be Money Pumped? | 194 |
| | 8.6 Do Bayesians Put the Cart Before the Horse? | 197 |
| | 8.7 Non-Bayesian Decision Theory | 200 |
| 9 | Causal vs. Evidential Decision Theory | 206 |
| | 9.1 Newcomb's Problem | 206 |
| | 9.2 Causal Decision Theory | 209 |
| | 9.3 Evidential Decision Theory | 211 |
| 10 | Risk Aversion | 220 |
| | 10.1 Actuarial Risk Aversion | 220 |
| | 10.2 Aversion Against Utility Risks | 225 |
| | 10.3 Epistemic Risk Aversion | 228 |

| 11 Game Theoty I: Basic Concepts and Zero-sum Games | 234 |
|--|-----|
| 11.1 The Prisoner's Dilemma | 236 |
| 11.2 A Taxonomy of Games | 242 |
| 11.3 Common Knowledge and Dominance Reasoning | 246 |
| 11.4 Two-Person Zero-sum Games | 252 |
| 11.5 Mixed Strategies and the Minimax Theorem | 254 |
| 12 Game Theory II: Nonzero-sum and Cooperative Games | 263 |
| 12.1 The Nash Equilibrium | 263 |
| 12.2 The Battle of the Sexes and Chicken | 267 |
| 12.3 The Bargaining Problem | 270 |
| 12.4 Iterated Games | 274 |
| 12.5 Game Theory and Evolution | 279 |
| 12.6 Game Theory and Ethics | 281 |
| 13 Social Choice Theory | 287 |
| 13.1 The Social Choice Problem | 289 |
| 13.2 Arrow's Impossibility Theorem | 292 |
| 13.3 Sen on Liberalism and the Pareto Principle | 298 |
| 13.4 Harsanyi's Utilitarian Theorems | 301 |
| 14 Overview of Descriptive Decision Theory | 311 |
| 14.1 Observed Violations of the Expected Utility Principle | 311 |
| 14.2 Prospect Theoiy | 314 |
| 14.3 Violations of Transitivity and Completeness | 316 |
| 14.4 The Relevance of Descriptive Decision Theory | 318 |
| Appendix: Glossary | 323 |
| Further Reading | 329 |
| Index | 336 |