Monte Carlo Simulation and Finance
Founded in 1807, John Wiley & Sons is the oldest independent publishing company in the United States. With offices in North America, Europe, Australia, and Asia, Wiley is globally committed to developing and marketing print and electronic products and services for our customers’ professional and personal knowledge and understanding.

The Wiley Finance series contains books written specifically for finance and investment professionals as well as sophisticated individual investors and their financial advisors. Book topics range from portfolio management to e-commerce, risk management, financial engineering, valuation and financial instrument analysis, as well as much more.

Dedication

To those who make us laugh and think. To Charles William McLeish, James Allen McLeish, Michael Lewis. Their laughter has since dissolved, but the smiles and thoughts they generated live on. To my family, Cynthia, Erin, Jen, Marianne, William, Grace, Shirley, Joanne and David, Rob and Laurie, Bill and Christina. To the many others family and friends, whose unfailing support, encouragement and love is so clearly unconstrained by my due.
CHAPTER 5
Simulating the Value of Options 206
Asian Options 206
Pricing a Call Option under Stochastic Interest Rates 215
Simulating Barrier and Lookback Options 218
Survivorship Bias 236
Problems 242

CHAPTER 6
Quasi–Monte Carlo Multiple Integration 244
Introduction 244
Errors in Numerical Integration 247
Theory of Low-Discrepancy Sequences 249
Examples of Low-Discrepancy Sequences 252
Problems 262

CHAPTER 7
Estimation and Calibration 264
Introduction 264
Finding a Root 267
Maximization of Functions 272
Maximum-Likelihood Estimation 280
Using Historical Data to Estimate the Parameters in Diffusion Models 300
Estimating Volatility 304
Estimating Hedge Ratios and Correlation Coefficients 317
Problems 322

CHAPTER 8
Sensitivity Analysis, Estimating Derivatives, and the Greeks 325
Estimating Derivatives 333
The Score Function Estimator 335
Infinitesimal Perturbation Analysis (IPA):
Pathwise Differentiation 347
Calibrating a Model Using Simulations 355
Problems 362
I am grateful to all of the past students of Statistics 906 and the Master’s of Finance program at the University of Waterloo for their patient reading and suggestions to improve this material, especially Keldon Drudge and Hristo Sendov. I am also indebted to my colleagues, Adam Kolkiewicz and Phelim Boyle, for their contributions to my understanding of this material.
Experience, how much and of what, is a valuable commodity. It represents a major difference between an airline pilot and a New York cab driver, a surgeon and a butcher, and a successful financier and a cashier at your local grocer’s. Experience with data and its analysis, experience constructing portfolios, experience in trading, and even experience losing money (one experience we could all do without) are part of the education of the financially literate. Of course, few of us have the courage to approach the manager of the local bank and ask for a few million so that we can acquire this experience, and fewer bank managers have the courage to accede to our request. The “joy of simulation” is that you do not need to have a Boeing 767 to fly one, and you don’t need millions of dollars to acquire considerable experience in valuing financial products, constructing portfolios, and testing trading rules. Of course, if your trading rule is to buy condos in Florida because you expect that all boomers will wish to retire there, a computer simulation will do little to help you since the ingredients of your decision are based largely on psychology (yours and theirs). But if your rule is that you should hedge your current investment in condos using financial derivatives written on real estate companies, the methods of computer simulation become relevant.

This book concerns the simulation and analysis of models for financial markets, particularly traded assets such as stocks and bonds. We pay particular attention to financial derivatives such as options. These are financial instruments that derive their value from some associated asset. For example, a call option is written on a particular stock, and its value depends on the price of the stock at expiry. But there are many other types of financial derivatives, traded on assets such as bonds, currency markets or foreign exchange markets, and commodities. Indeed, there is a growing interest in so-called real options, those written on some real-world physical process such as the temperature or the amount of rainfall.