

# Option Pricing and Hedging for Discrete Time Regime-Switching Models

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## Abstract

We propose optimal mean variance dynamic hedging strategies in discrete time under a multivariate Gaussian regime switching model. The methodology, which also performs pricing, is robust to time varying and clustering risk observed in financial time series. As such, it overcomes the main theoretical drawbacks of the Black Scholes model. To support our approach, we provide goodness of fit tests to validate the model and for choosing the appropriate number of regimes, and we illustrate the methodology using monthly S & P 500 vanilla options prices. Then, we present the associated out of sample hedging results in the context of harvesting the implied versus realized volatility premium. Using the proposed methodology, the Sharpe ratio derived from the strategy doubles over the Black Scholes delta hedging methodology.

## Keywords

Option Pricing, Dynamic Hedging, Regime Switching, Goodness of Fit, Hidden Markov Models

## 1. Introduction

In complete, frictionless capital markets with no transaction costs and where the underlying securities follow geometric Brownian motions, the Black Scholes framework [1] provides an elegant and tractable solution for pricing and hedging derivative securities, typically vanilla calls and puts. Unfortunately, actual financial markets are far more complex and empirical testing of the Black Scholes model has highlighted its many shortcomings. Indeed, it is well documented [2] [3] [4] that the observed properties of financial time series are not consistent with its underlying assumptions. Time varying volatility, the presence

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**Thomas Poufinas, Boris Mityagin**



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Discrete Time Option Pricing with High Moment Distributions Luiz Roque De Souza Vitiello Junior,2005

Discrete-Time and Continuous-Time Option Pricing with Fees Thomas Poufinas,Boris Mityagin,1996 On discrete time hedging in d-dimensional option pricing models Mika Hujo,2005 Convergence of Discrete Time Option Pricing Models Under Stochastic Interest Rates J. L. Prigent,Jean-Luc Prigent,Olivier Scaillet,Centre de recherche en économie et statistique (Paris, France),Université catholique de Louvain (1970- ). Institut de recherches économiques et sociales,1998 Discrete Time Option Pricing with High Moment Distributions Luiz Roque de Souza Vitiello (Jnr.),Richard Stapleton (Supervisor.),Ser-Huang Poon (Supervisor.),Manchester Business School,2005 Option Pricing in Discrete-Time Incomplete Market Models Lukasz Stettner,2001 Various aspects of pricing of contingent claims in discrete time for incomplete market models are studied Formulas for prices with proportional transaction costs are obtained Some results concerning pricing with concave transaction costs are shown Pricing by the expected utility of terminal wealth is also considered **Valuing Options in a Discrete Time Regime Switching Model with Jumps** Evgenia V. Chunikhina,2014 In this work we provide a detailed analysis of a discrete time regime switching financial market model with jumps We consider the model under two different scenarios known and unknown initial regime For each scenario we investigated conditions that guarantee the model's completeness We find that the model under consideration is arbitrage free and complete if the initial regime is known and the jump size satisfies specific condition Formulae for a unique risk neutral measure and arbitrage free pricing of derivative securities are provided Several numerical examples illustrate no arbitrage approach to pricing of derivative securities In the case of incomplete model the Esscher transform is considered to obtain one specific pricing measure In particular we show that the Esscher transformed prices are continuously differentiable as a function of the parameters at the interface of incompleteness and completeness **Option Pricing and Hedging for Discrete Time Regime-Switching Models** Bruno Remillard,2014 We propose optimal mean variance dynamic hedging strategies in discrete time under a multivariate Gaussian regime switching model The methodology which also performs pricing is robust to time varying and clustering risk observed in financial time series As such it overcomes the main theoretical drawbacks of the Black Scholes model To support our approach we provide univariate pricing results for monthly S P 500 vanilla options Then we present the associated out of sample hedging results in the context of harvesting the implied versus realized volatility premium Using the proposed methodology the Sharpe ratio derived from the strategy doubles over the classical Black Scholes delta hedging methodology A Time Series Approach to Option Pricing Christophe Chorro,Dominique Guégan,Florian Ielpo,2014-12-04 The current world financial scene indicates an intertwined and interdependent relationship between financial market activity and economic health This book explains how the economic messages delivered by the dynamic evolution of financial asset returns are strongly related to option prices The Black

Scholes framework is introduced and by underlining its shortcomings an alternative approach is presented that has emerged over the past ten years of academic research an approach that is much more grounded on a realistic statistical analysis of data rather than on ad hoc tractable continuous time option pricing models The reader then learns what it takes to understand and implement these option pricing models based on time series analysis in a self contained way The discussion covers modeling choices available to the quantitative analyst as well as the tools to decide upon a particular model based on the historical datasets of financial returns The reader is then guided into numerical deduction of option prices from these models and illustrations with real examples are used to reflect the accuracy of the approach using datasets of options on equity indices

**Discrete-time Option Pricing with Stochastic Liquidity** Markus Leippold, Steven Schärer, 2016  
*Preference-free Option Pricing with Path-dependent Volatility* Steven L. Heston, Saikat Nandi, 1998

**Option Pricing in a Discrete Time Model for the Limit Order Book** Clarence Simard, 2014 In this paper we build a discrete time model for the structure of the limit order book so that the price per share depends on the size of the transaction We deduce the value of a portfolio when the investor trades using market orders and a bank account with different interest rates for lending and borrowing In this setting we deduce conditions to rule out arbitrage and solve the problem of pricing and hedging an European call and put option with maturity one and physical delivery By using primal dual optimization we show that the price of European options can be written as an optimization problem over some set of probability measures

**Stochastic Dominance and Option Pricing in Discrete and Continuous Time** Ioan Mihai Oancea, 2007 This paper examines option pricing in a universe in which it is assumed that markets are incomplete It derives multiperiod discrete time option bounds based on stochastic dominance considerations for a risk averse investor holding only the underlying asset the riskless asset and possibly the option for any type of underlying asset distribution discrete or continuous It then considers the limit behavior of these bounds for special categories of such distributions as trading becomes progressively more dense tending to continuous time It is shown that these bounds nest as special cases most if not all existing arbitrage and equilibrium based option pricing models Thus when the underlying asset follows a generalized diffusion both bounds converge to a single value For jump diffusion processes stochastic volatility models and GARCH processes the bounds remain distinct and define several new option pricing results containing as special cases the arbitrage based results

**Introduction to Option Pricing Theory** Gopinath Kallianpur, Rajeeva L. Karandikar, 2012-12-06 Since the appearance of seminal works by R Merton and F Black and M Scholes stochastic processes have assumed an increasingly important role in the development of the mathematical theory of finance This work examines in some detail that part of stochastic finance pertaining to option pricing theory Thus the exposition is confined to areas of stochastic finance that are relevant to the theory omitting such topics as futures and term structure This self contained work begins with five introductory chapters on stochastic analysis making it accessible to readers with little or no prior knowledge of stochastic processes or stochastic analysis These chapters cover the

essentials of Ito's theory of stochastic integration with respect to semimartingales Girsanov's Theorem and a brief introduction to stochastic differential equations Subsequent chapters treat more specialized topics including option pricing in discrete time continuous time trading arbitrage complete markets European options Black and Scholes Theory American options Russian options discrete approximations and asset pricing with stochastic volatility In several chapters new results are presented A unique feature of the book is its emphasis on arbitrage in particular the relationship between arbitrage and equivalent martingale measures EMM and the derivation of necessary and sufficient conditions for no arbitrage NA it

Introduction to Option Pricing Theory is intended for students and researchers in statistics applied mathematics business or economics who have a background in measure theory and have completed probability theory at the intermediate level The work lends itself to self study as well as to a one semester course at the graduate level

*Stochastic Volatility Option Pricing in Discrete Time* Victor K. Ng, 1991

*A Discrete Time Approach to Option Pricing* Adam Majewski, 2016

The goal of the PhD thesis

**Extensions to the Boyle-Vorst Discrete-time Option Pricing Model with Transactions Costs** Ken Palmer, 2000 Working in a binomial framework Boyle and Vorst 1992 derive self financing strategies perfectly replicating the final payoffs to long positions in European call and put options assuming proportional transactions costs on trades in the stocks The initial cost of such a strategy yields by an arbitrage argument an upper bound for the option price A lower bound for the option price is obtained by replicating a short position However for short positions Boyle and Vorst have to impose three additional conditions The authors first aim in this paper is to remove Boyle and Vorst's conditions for the replication of short calls and puts Boyle and Vorst's algorithm calculates the current holdings in stocks and bonds in terms of those at the following period This is unlike the case of no transaction costs where the current cost of the option can be calculated directly from the costs at the following period The authors second aim is to show that even in the case of transactions costs the cost of replication can be directly calculated also As a by product the authors are able to derive upper bounds for the cost of replication which are valid for long positions and also for short positions when two of Boyle and Vorst's additional conditions hold The authors third aim is to show that the time of computation using the backward recursion can be halved This seems to be a new observation even in the case of no transactions costs

**The Adaptive Mesh Model** Amrit Summan, 2004

*Option pricing model on the discrete world* Carlos Lobao Gadelha, 2014

**Replication and Super Replicating Portfolios in the Boyle-Vorst Discrete-time Option Pricing Model with Transactions Costs**, 2001

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