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Introduction

This volume on portfolio optimization and construction originated from conversations between a number of the contributors and the editors. We were inspired to write by the common realization that a lot of exciting unrecognized new work is being done by both academics and practitioners.

Initial concerns that we would not find enough contributors to fill a volume changed rapidly to wondering whether this book, should be in one, two, or *n* volumes.

This selection of papers presents an excellent overview of a wide variety of new developments in portfolio construction methods. Everybody, but particularly newcomers to the field, can profitably read Chapter 1, an overview by Professor Gautam Mitra. The next eight chapters present practitioners approaches to portfolio issues. Topics covered include how to build portfolios robustly, how to simulate, how to account for tax issues, how to use sophisticated mathematical tools, how to include multiple asset classes, such as fixed income and hedge funds, and how to address index issues. The order in which they appear having no necessary relationship with intrinsic merit.

The academic contributions occur in Chapters 10 to 17; the theory covered here is demanding in places, covering advanced mathematical statistics and subtleties of optimization. The topics covered in this section address absolute and relative optimization, higher moment portfolio efficient frontiers, exact distributions, reverse optimization, robust optimization and some advances based on different choices of gain and loss. This volume comprehensively addresses a wide range of portfolio construction issues and it will be profitably added to both practitioner and academic book collections.

Chapter 1

A review of portfolio planning: models and systems

GAUTAM MITRA (CO-AUTHORS: TRIPHONAS KYRIAKIS, CORMAC LUCAS, MEHNDI PIRBHAI)

ABSTRACT

In this chapter, we first provide an overview of a number of portfolio planning models which have been proposed and investigated over the last fifty years. We revisit the mean-variance (MV) model of Markowitz and the construction of the risk-return efficient frontier. A piecewise linear approximation of the problem through a reformulation involving diagonalization of the quadratic form into a variable separable function is also considered. A few other models, such as, the Mean Absolute Deviation (MAD), the Weighted Goal Programming (WGP) and the Minimax (MM) model which use alternative metrics for risk are also introduced, compared and contrasted. Recently asymmetric measures of risk have gained in importance; we consider a generic representation and a number of alternative symmetric and asymmetric measures of risk which find use in the evaluation of portfolios. There are a number of modelling and computational considerations which have been introduced into practical portfolio planning problems. These include: (a) buy-in thresholds for assets, (b) restriction on the number of assets (cardinality constraints), (c) transaction roundlot restrictions. Practical portfolio models may also include: (d) dedication of cash-flow streams, and (e) immunization which involves duration matching and convexity constraints. The modelling issues in respect of these features are discussed. Many of these features lead to discrete restrictions involving zero-one and general integer variables which make the resulting model a quadratic mixed-integer programming model (QMIP). The QMIP is a NP-hard problem; the algorithms and solution methods for this class of problem are also discussed. The issues

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of preparing the analytic data (financial datamarts) for this family of portfolio planning problems are examined. We finally present computational results which provide some indication of the state-of-the-art in the solution of portfolio optimization problems.

1.1 INTRODUCTION AND OVERVIEW

The mean-variance (MV) model of Markowitz is a single period static portfolio planning model and, in recent times, it has become the core decision engine of many portfolio analytics and planning systems in the construction of the risk-return efficient frontier.

Markowitz shows that for a rational investor maximizing expected utility, a chosen portfolio is optimal with respect to both expected return and variance of return. He defines such a non-dominated portfolio as *efficient*, that is, it offers the highest level of expected return for a given level of risk and the lowest level of risk for a given level of return. His normative MV rule for investor behaviour both implies and justifies the observable phenomenon of diversification in investment. Determining the efficient set from the investment opportunity set, the set of all possible portfolios, requires the formulation and solution of a parametric quadratic program (QP). Plotted in risk-return space the *efficient* set traces out the *efficient frontier.*

Hanoch and Levy (1969) show that the MV criterion is a valid efficiency criterion, for any individual's utility function, when the distributions considered are Gaussian normal. A study comparing alternative utility functions appears in Kallberg and Ziemba (1983). They show that portfolios with 'similar' absolute risk-aversion indices have 'similar' optimal compositions, regardless of the functional form and parameters of the utility function. Hence, MV analysis is justified for any general concave utility function of the Von Neumann–Morgenstern type (Von Neumann and Morgenstern, 1944).

The estimation of the underlying parameters (returns, variances and covariances) which are required as the input to MV analysis is an important modelling step. Small changes in the input can have a large impact on the optimal asset weights. Chopra and Ziemba (1993) found that, for a typical investor's risk tolerance level, errors in the forecast means are more than ten times as important as errors in the variance and about twenty times as important as errors in covariances. For practical aspects of portfolio analysis see Perold (1984), Hensel and Turner (1998) and Grinold and Kahn (1995). The modern portfolio theory has developed in tandem with simplifications to the QP required by MV analysis; these simplifications centre around linearizing the quadratic objective function