Chapter 4

Linear Integer Programming Techniques for Portfolio Design Problem: Linear Programming Approaches

ABSTRACT

This chapter introduces Integer Linear Programming (ILP) approaches for solving efficiently a financial portfolio design problem. The authors proposed a matricial model in Chapter 3, which is a mathematical quadratic model. A linearization step is considered necessary to apply linear programming techniques. The corresponding matricial model shows clearly that the problem is strongly symmetrical. The row and column symmetries are easily handled by adding a negligible number of new constraints. The authors propose two linear models, which are given in detail and proven. These models represent the problem as linear constraint systems with 0-1 variables, which will be implemented in ILP solver. Experimental results in non-trivial instances of portfolio design problem are given.

INTRODUCTION

As given in Chapter 3, the financial problem tackled in this book is modeled in a 0-1 matricial model, which is linear and has quadratic constraints. Since the problem is quadratic, applying linear programming techniques turns out
to be impossible without transforming the problem into a linear problem. A linear model which is thoroughly equivalent to the quadratic model, without relaxing the space of solutions. Applying Linear Programming (LP) complete techniques provides us the desired optimum of the financial portfolio, which is a critical and crucial problem in finance. Financial institutions and clients should be satisfied through an optimized profit.

In this chapter, via the 0-1 quadratic model all the features of the portfolio are totally and precisely modeled, which allows us to reach the best overlapping rate. An efficient linearization method is applied to the model, in order to solve the problem with (LP) approaches.

Due to the strong symmetrical nature of the problem, we found that breaking the corresponding symmetries is achievable if we apply the Constraint (CP) static Symmetry Breaking techniques, which should be efficient in eliminating the no consistent values, and thus minimizing the CPU time.

This chapter is organized as follows. In section 2, we present the Linear Programming discipline and especially Simplex algorithm, the most useful algorithm on LP problems. In section 3, we present the linearization approach and its application result on the quadratic (PD) model. Row and column symmetries are broken and handled via lexicographic ordering constraints. In section 4, experimental results are presented and analyzed in depth. Finally, we conclude the chapter.

**BACKGROUND**

Linear Programming was used implicitly by Fourier in the early 1800s. However, it was at first formalized and applied to economic problems, by Leonid Kantorovich in the 1930s. Later, it was rediscovered and applied by Tjalling Koopmans, by tackling shipping problems in the 1940s. The first complete algorithm to solve linear programming problems was published by George Dantzig in 1947. Nevertheless, Koopmans was the one who proposed the name “Linear Programming” in discussion with Dantzig in 1948. Kantorovich and Koopmans shared the 1975 Nobel Prize in Economics for their contributions to the theory of optimum allocation of resources (Erickson, 2015). Whereas George Dantiz, who is the recognized inventor of the Simplex algorithm, was simply passed over by the Nobel awards committee, an act of stunning
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