The Analytics Edge in Asset Management

Book Chapter Review | JM0100 Business Analytics Assignment 3

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Management Summary

The main focus of the chapter 20 (Bertsimas et al., 2016) is on quantitative approach of asset management. The authors aim to familiarize the reader to two key concepts in asset management, namely alpha models and portfolio construction. It achieves this by explaining an approach of optimization modelling to construct a stock portfolio. They also provide an example based on the experience of Riversource Investments in using the strategy of alpha models combined with mixed-integer optimization modelling technique.

The new ideas proposed in this chapter orient around the three key ingredients necessary for the quantitative asset management process. The first being a quantitative alpha model to build the target portfolio. Two types of alpha models are described: value and momentum investing. Value investing primarily concern about the earning of a company whereas momentum emphasizes the short-term return of investment. By calculating the alpha values of listed companies, one can determine the ideal fraction of the portfolio that should be invested in each company.

Secondly, they developed a mixed integer optimization model to construct a portfolio taking into account real-world conditions. Risks such as sectors exposure, illiquidity and transaction costs were modelled as constraints in this approach. A fund manager could implement this model to minimize the discrepancy between the working portfolio to a defined target portfolio, which can also be based on an alternative of alpha models. Finally, a simulation method is important to verify an asset management model. With the simulation, the model can be compared to the benchmark S&P 500 using historical US stock market data.

In terms of applied optimization technique, the chapter delves on how to model the stock portfolio management as a mixed-integer quadratic optimization problem. It is mentioned that, as the model belongs to this class of mixed-integer quadratic optimization problems, standard commercial solvers should be sufficient to solve it. Thus, state-of-the-art software can be advantageous for optimizing the model quickly. Additionally, they simulate the model using historical data between 1970 – 2003 to find the optimal user-defined parameters required by the constraints of the model.

As a conclusion, they claim a promising result of the quantitative approach and suggested that the presented optimization problem can be applied to a variety of asset allocation cases regardless of the volume of capitalizations, the sector of the fund and the country. Despite these supporting arguments of the applicability of the model, it is mentioned that there is still room for improvement on the quantitative asset management research. In particular, the simulation shows there were certain periods when the performance was not as strong, such as the credit crisis of 2008. Moreover, it is also stated that more research is necessary on alternatives to the alpha model in building a target portfolio.

Applied Optimization Technique

A portfolio is defined by a set of weights $w(i)$ as the fraction of the portfolio invested in stock $i \in \{1, 2, 3, ..., N\}$. The variables in this model are w_t and w_f, representing target portfolio and final portfolio weights, respectively:

$$w_t = [w_t(1), w_t(2), ..., w_t(N)]$$
$$w_f = [w_f(1), w_f(2), ..., w_f(N)]$$

In this chapter, the target portfolio w_t is calculated with alpha models. Alpha models help determine which company is the most valuable to invest by measuring the market capitalisation, earnings per month, and return of investment in the last 3 months. Based on the ideal portfolio, we want to have w_f as close as possible to w_t. Thus, the objective function in this portfolio construction is

$$min \sum_{i=1}^{N} \left| w_f(i) - w_t(i) \right|$$

Alpha is a naive approach to construct a portfolio because it does not take real-world situations into consideration. Those limitations are modelled instead by the constraints, which include:

1. Sectors diversification should be similar between the final portfolio and the target portfolio
2. Maximum number of stocks that is still possible to be managed
3. The final portfolio should produce a desired return
4. Avoid stocks that are hard to sell
5. Maximum transaction costs
6. Maximum number of transactions
7. An acceptable discrepancy with benchmark index, such as S&P 500

The implementation of this optimization involves quadratic function and the overall model belongs to the *mixed-integer quadratic optimization problem*. A commercial solvers software should be capable of calculating the solution to this type of problem. The technique was tested with historical data of the US Stock Market. From 1970 until 2003, simulation outperformed more than 4% (or 400 basis points) relative to the S&P 500. From 2002 until 2010, the proposed model yields 4,48% return, while for the same period for S&P was 2,24%.

Technical Background

In this section, we discuss a supplementary article by (Lobo et al., 2006). We chose this paper because of the similarity of the topic covered, i.e. portfolio optimization, but focusing on fixed transaction costs, which are related to the fifth and the sixth constraint in the previous section. The authors demonstrate portfolio optimization by applying convex optimization and describe a heuristic approach that is effective to find a high-quality solution.

The paper explains how portfolio optimization problems can be approached as convex optimization problems. Specifically, if the problem includes only linear transaction costs, it can be solved easily by a typical quadratic program because the constraint formulations are convex. However, nonlinear fixed transaction costs exist and we have to deal with a difficult combinatorial program which cannot be solved using convex optimization. We can solve this by using an approximation method introduced in the paper.

Initially, we compute a global upper bound from convex relaxation. Afterwards, an approximate solution is calculated using an iterative procedure. This iterative heuristic is responsible for finding a feasible portfolio based on the same method used to find the upper bound on the previous step. Although the computed portfolio might be sub-optimal, it has a lower bound and shown to produce solutions of consistently high quality.

The methodology for portfolio construction in chapter 20 models the objective function and the cost constraints in a linear way. On the contrary, the main contribution of the selected paper is that it performs portfolio optimization by taking into account nonlinear parameters (fixed transaction costs). Concretely, it describes a method for solving much larger portfolio optimization problems by solving a small number of convex optimization problems. Although there is no guarantee that the produced solution is optimal, the paper proves that the difference between the global optimum and the calculated lower bound is small. In addition, it suggests that if higher accuracy is needed it can be achieved by embedding the presented methodology in a branch and bound algorithm (Taylor, 2009).

To summarize, the methodology demonstrated in the selected paper supplements the approach presented in chapter 20 since it takes into account nonlinear parameters for performing portfolio optimization.

Remarks

The chapter illustrates an application of optimization for portfolio construction in a well-written manner. The high-level concept is briefly introduced at the beginning to help readers understand how a fund management work. They build on an existing body of research, such as embedding alpha models in the proposed model as the target portfolio. All in all, this chapter provides a sound example on how to consider real-world constraints of the stock market and transform them into a standard optimisation problem.

The primary strength of the chapter is that the proposed model has been tested by a real investment company. Barring it is only in a simulation, they mentioned an important point that we should always put a model into the trial before applying it to the real world. We also suggest a supplementary article that explores nonlinear fixed transaction cost to enrich the model generalization. Given most of the constraints in the chapter are linear, the flexibility to include nonlinear constraints can provide better parallelism with real-world conditions.

Nevertheless, background knowledge regarding investing terms is required to fully grasp the reasoning behind the method. It is also remains unclear what is the importance of benchmark risk because of the limited elaboration. Another improvement is to disclose the tuning of user-defined parameters done through the simulation. We can learn more by analysing the parameter of preferred number of stocks, the transaction cost, and the number of transactions that yield the best outcome.

Since the method has been tested for the US stock market, there is not much to argue about the conclusion. Nonetheless, it is intriguing to review the proposed model in an emerging stock market setting. Some area of exploration including additional constraints that we should examine and what could be used as an alternative when there is no equivalence of S&P 500 as a benchmark.

References

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