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Article

Index tracking and enhanced indexation using a parametric approach

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ABSTRACT

Based on the work of Brandt et al. (2009), we formulate an index tracking and enhanced indexation model using a parametric approach. The portfolio weights are modeled as functions of assets characteristics and similarity measures of the assets with the index to track. This approach permits handling nonlinear and nonconvex objectives functions that are difficult to incorporate in existing index tracking and enhanced indexation models. Additionally, this approach gives the investor more information about the portfolio holdings since the optimization is performed over portfolio strategies. Finally, an empirical implementation and an analysis of selected characteristics are presented for the S&P500 index.

Seguimiento de índices e indexación mejorada utilizando un enfoque paramétrico

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RESUMEN

Basándonos en el trabajo de Brandt et al. (2009), formulamos un modelo de seguimiento de índices e indexación mejorada utilizando un enfoque paramétrico. Los pesos de cartera se modelan como funciones de características de activos y medidas de similitud de los activos con el índice objeto de seguimiento. Este enfoque permite tratar funciones de objetivos no lineales y no convexos, difíciles de incorporar en modelos de indexación mejorada y seguimiento de índices existentes. Además, proporciona al inversor más información sobre los valores en cartera porque la optimización se lleva a cabo en torno a estrategias de portafolio. Por último, se presenta una implementación empírica y un análisis de características seleccionadas del índice S&P500.

1. Introduction

Index tracking is a type of passive management strategy which consists of designing a portfolio (tracking portfolio or index fund) to replicate the behavior of a broad market index. The popularity of index funds, as mentioned in Cornuejols and Tütüncü (2007), relies on both theoretical (market efficiency) and empirical (performance and costs) reasons. If the market is efficient, it is not possible to obtain superior risk-adjusted returns by active management portfolio strategies. Because the market portfolio captures the efficiency of the market through diversification, it is a theoretically reasonable strategy to invest in an index fund. Moreover, many empirical studies show that, on average, active portfolio managers do not outperform the major indices. Also, active management generally incurs costly research activities and compensation to the fund managers. These costs can be avoided by an index tracking strategy.

Index tracking also has two sub-strategies: full replication and partial replication. In a full replication strategy, all the names in the index are bought (and held) in the exact proportions as they appear in the index. On the other hand, the partial replication strategy holds fewer assets than the total number of assets in the index; however, the assets to include and their weights need to be determined. For example, Cornuejols and Tütüncü (2007) and Canakgoz

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and Beasley (2008), for example, mention that the main disadvantages of the full replication strategy are the high transaction costs to rebalance all the positions in the index, the difficulty to hold very small proportions of some stocks, and the illiquidity of certain stocks (especially in small-cap indices). For Rudd (1980), the main advantage of partial replication is the decrease in administrative overhead and administration costs (custodial and accounting).

Enhanced indexation or enhanced index tracking, in the words of Canakgoz and Beasley (2008) "aims to reproduce the performance of a stock market index, but to generate excess return (return over and above the return achieved by the index)". Usually, the objective in the enhanced indexation problem is to maximize alpha while the beta of the portfolio remains close to one, or to maximize excess return (over the index) by keeping the tracking error bounded to some quantity. The main distinction with the tracking problem is that enhanced indexation can be seen as an active strategy to beat a benchmark under the same risk.

Different from the index tracking approach, enhanced indexation (using fewer assets than the index) lacks the theoretical foundation of the market efficiency, since holding fewer assets cannot ensure full diversification of the portfolio. Additionally, many of the approaches use only information contained in the return (price) series. Without additional information or differences in expected returns forecasts, it is hard to identify the "mispriced" securities to include in the portfolio. With lower diversification than the index, it is logical to expect the generation of positive excess returns over the index as a trade-off with the portfolio's beta, the overall risk, or the correlation coefficient with the index. Therefore, it is crucial to analyze carefully the in-sample and out-of-sample performance of the enhanced tracking portfolios to analyze the corresponding risk-return trade-off and the consistency of the tracking strategy.

In this paper, we propose a parametric approach for index tracking and enhanced indexation based on the work of Brandt, Santa-Clara, and Valkanov (2009). We formulate a multi-objective non-linear optimization problem with a small number of decision variables. Our objective function decomposes (approximately) the variance of the tracking error or the portfolio beta into the correlation coefficient of the portfolio and the index and the ratio of their standard deviations. Notice that when the correlation coefficient is close to one and the standard deviations are close to each other, the variance of the tracking error goes to zero and the beta of the portfolio goes to one. Consequently, this specification of the tracking component is more flexible than the ones existing in the literature. For the enhanced component, although other objectives can be proposed, we usually maximize the average excess returns over the index.

As in the portfolio optimization approach of Brandt et al. (2009), we use information inside and outside the return series to build our portfolios. However, due to the time horizon (daily or weekly) of typical index tracking problems, we exclude some of the factors used in Brandt et al. (2009) which explain the cross-section of assets returns. For example, we omit the book-to-market ratio because daily book values are not observable. We consider it of interest to include information on the similarity of the stock's returns with the index returns, under the premise that it is reasonable that stocks behaving similarly to the index have potential to form a part of the tracking portfolio. Also, we include some measures of "momentum" of the stocks to beat the index assuming that the "momentum" will continue in the near future.

In the parametric approach, the portfolio weights are functions of selected characteristics of the stocks. We want to determine how to assign importance to these characteristics depending on the particular trade-off defined in the objective function. By assigning importance levels, it is straightforward to find portfolio strategies and not just portfolio weights. We can then analyze how these strategies change according to the importance given to the tracking or enhanced components of the objective. These features give the investor more information about the portfolio holdings than typical approaches in the literature. Also, the parametric approach is flexible enough to handle cardinality constraints, transactions cost (in various ways), and lower and upper bounds on the portfolio weights.

We implement the parametric approach to build a tracking or enhanced tracking portfolio[1] for the S&P500 index, using as characteristics market capitalization, alpha and beta of the individual stocks. The empirical results show that holding stocks with high market capitalization results in tracking portfolios with high correlation coefficient with the index. Stocks with beta close to one are useful to keep the ratio of standard deviations close to one, while including stocks with high alpha is used to increase the excess returns over the index. The in-sample performance was similar to other models in the literature, and the out-of-sample performance was very robust, especially for the tracking component of the objective. Additionally, the level of turnover was acceptable, and, from examining the maximum and minimum portfolio weights, the tracking portfolios were well-diversified.

The organization of the paper is as follows, Section 2 presents a brief literature review. In Section 3, we describe the typical enhanced tracking model. In Section 4, we develop in detail the parametric approach. In Section 5, we add some refinements to the "plain" parametric model including transaction costs and lower/upper bounds on the portfolio weights. Section 6 describes some characteristics that can be used in the parametric approach. In Section 7, we present the empirical application for the S&P500 index. We conclude in Section 8.

2. Literature review

Since the late 1970s the problem of index tracking has drawn attention from the financial and operations research literature. Now we have many different approaches, in particular to design index tracking funds using partial replication. Next, we mention some of the most common approaches for index tracking. The following is by no means a complete literature survey of index tracking. For further information, the reader can look at the references mentioned in each of the cited documents.

Commonly, the index tracking problem with partial replication is formulated as a mixed-integer programming model, which is challenging to solve to optimality using "traditional" integer programming and optimization techniques. This structure leaves room for the use of a variety of heuristics, metaheuristics and other solution approaches. It is typical in this approach to minimize some function that measures the distance between the index returns (or normalized prices) and those of the tracking portfolio in a specific calibration period. Another common objective in these formulations is to try to construct a tracking portfolio with beta (relative to the benchmark) close to one. Those models contain the assumption that the returns (or prices) will have the same statistical behavior in the next period(s). Complete formulations in this framework include transactions costs, rebalancing policies and other features and constraints. In this line, we refer to Beasley, Meade, and Chang (2003), Gaivoronski, Krylov, and van der Wijst (2005), Canakgoz and Beasley (2008), and the references therein.

Markowitz-type formulations are commonly used in index tracking where the tracking error variance (variance of the portfolio that is long in the tracking portfolio and short in the index)

[1] During our discussion, we frequently use the term tracking portfolio to refer, in general, to the solutions of the optimization problems that will be described in Section 3.