Diploma Thesis Exposé

Portfolio Optimization with Factor Views

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1. Problem Statement

Can we detect a value premium and / or a momentum premium in the European stock market over the last 29 years? I analyze the equity universe defined by the STOXX 600 index and investigate on the sector level whether Black Litterman (BL) optimized portfolios with factor forecasts can improve portfolio-return characteristics. I.e., forward-looking BL model views are constructed according to the average value and momentum which can be measured in sector portfolios. Additionally, which risk properties would the optimized portfolios have in terms of Sharpe ratio, information ratio and would this strategy deliver a positive Capital Asset Pricing Model (CAPM) Alpha, i.e. would these portfolios deliver risk-adjusted returns in excess of STOXX 600 index?

A factor can be thought of as any characteristic relating one group of securities that is important in explaining their return and risk [1]. The single factor CAPM states that the β is driving all assets' expected returns. This factor is market return in excess of T-Bills, and the higher an asset's exposure to it, the higher the risk premium. The market itself is an example of the most important equity factor. Further examples, among others, include fundamental factors like momentum, value, asset growth and low-volatility. Since factors affect asset returns and asset classes have different exposures to factor risks, would it be possible to integrate this information into portfolio optimization itself? If a particular sector index has higher return momentum than others, why not overweight this sector relative to others and check if this portfolio strategy delivers consistent overperformance relative to the market over time? In other words, is it possible to outperform the European market by just using publicly available information contrary to the efficient market theory developed in the 1970s?

Modern Portfolio Theory (MPT), or mean-variance analysis, is *de facto* the standard when it comes to financial risk management and empirical asset pricing (optimal asset allocation in a portfolio). This portfolio diversification strategy tool is highly appreciated among today's investors, risk managers, and investment institutions. MPT proves to be highly advantageous, because it allows an investor to select a portfolio with maximum return for a given level of risk or with minimal risk for a given level of return. There are, however, some disadvantages to this model. If an investor has some additional information about future returns of particular portfolio constituents, which they usually have, and makes small readjustments in expected returns, most of the portfolio positions and weights change in such a way that they become unreasonable. This is due to this model's extreme sensitivity to the return assumptions made. This model's property makes it usable mostly with past performance data, and hence, inappropriate for this task. Most investors know that past performance is no guarantee of future performance. Working with only historical data may lead to overlooking newer circumstances, since such may not have occurred in the past.

2. Solution

The solution would be building the optimal portfolio with STOXX 600 sector indexes as holdings by using the Black-Litterman model [4] to compute optimal portfolio weights with help of fundamental factors like momentum and value of individual sectors as forward-looking information incorporated into Black-Litterman model views. Momentum is the strategy of buying stocks that have gone up over the past six (or so) months (winners) and shorting stocks with the lowest returns over the same period (losers) [3]. The momentum effect refers to the phenomenon that winner stocks continue to win while losers continue to lose. [3] The value effect refers to the observation that investing in assets with low prices relative to their fundamental value (or low price-to-book ratio) and selling assets with high prices relative to their fundamental value (or high price-to-book ratio) leads to excess returns in the long run. These two factors shall be used as investors' subjective views, or beliefs, about the future for the BL optimal portfolio construction. This portfolio shall then be rebalanced on a four-week basis and back-tested through the history of roughly 20 years of data, ranging from 1999-09-03 to 2019-02-08, and will be benchmarked against STOXX 600 index performance on a yearly basis.

The Black-Litterman Model (BL) takes the Markowitz Model as a basis then goes one step further. This model combines ideas from the CAPM, Markowitz's mean-variance optimization model and Bayesian statistics. BL incorporates the investor's subjective views regarding the future performance of various assets with the market equilibrium returns in order to calculate both the optimal portfolio weights as well as updated expected returns under specific parameters. Additional benefits of this model are the ability to specify confidence on views (i.e., the investor does not have to be 100% certain in his own predictions) and the τ (tau) parameter, which is a measure of the investor's confidence in the prior estimates (i.e. returns implied by the market portfolio). Higher τ values indicate smaller investor confidence in the market-implied returns. Contrary to the Markowitz model, BL output, if properly implemented, is an intuitive, diversified portfolio. This way, portfolio diversification is not only based on assets' past performance but augmented with factor-predicted future returns. All these properties make the BL model suitable for the portfolio optimization using factors as forward-looking information provided as the model views.

3. Expected result

Value has been known for decades now and has produced excess returns above the market for the last fifty years [1][3]. Value stocks, which are stocks that trade at a lower price relative to its fundamentals, outperform growth stocks, which are growing at a faster rate than the overall market, in the long run. There are, however, periods where this strategy has produced large losses, e.g., the financial crisis of 2007-2008 [3]. Momentum, also called “trend” investing, has also been well documented and used for decades now [3].

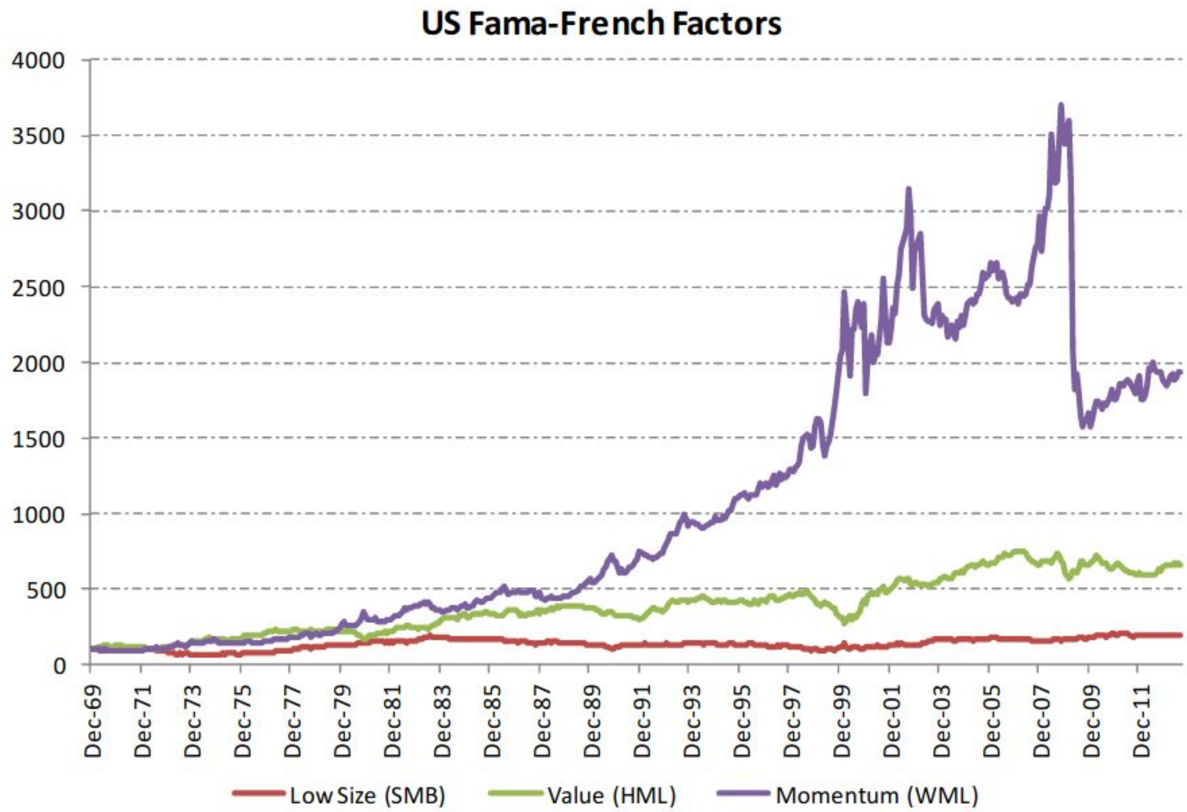


Figure 1: Fama-French Factors cumulative returns for the US equity market [1].

As it can be seen from the figure above, in the US equity market over past few decades, momentum returns have been far superior compared to value returns. The cumulated returns of momentum strategy have produced an order of magnitude larger profits compared to the value factor strategy in the US market [3]. Since the momentum factor is observed in every asset class, it should be well suited as input in the investor’s view of the BL model. In times of financial market instabilities, e.g. recessions, momentum can crash and cause so-called momentum crashes which may result in large losses [3].

Combining the Black-Litterman model with factors like value and momentum as investor views should result in a well diversified portfolio that beats the benchmark, which is STOXX Europe 600 total return over the same period of time. Combining these two methods for portfolio building is promising. However, it is also possible that this approach yields, compared to the benchmark index, no value premium at all -or, even worse, that it underperforms the benchmark.

4. Methodological Approach

The methodological approach consists of the following steps:

- **Data Preparation**

  The data provided consists of a simple total weekly return time-series for 1,544 stocks over 1,571 weeks. The first step would be to build a STOXX 600 value-weighted sector indices, then to calculate the complete return variance-covariance matrix, which is needed for the portfolio optimization process, market **β**, and expected returns**.**

- **Model Implementation and Forecasts Setup**

  Since there is no standard library for portfolio optimization with Black Litterman, an own model implementation in R is required. Furthermore, per sector momentum and value factors need to be calculated and adequately configured so that they can be used as views in the BL framework. The BL models' both strength and weakness lie in the views, and this step is crucial for getting any meaningful portfolios that potentially deliver good performance. For clarity purposes of this approach I will demonstrate the idea with an example.

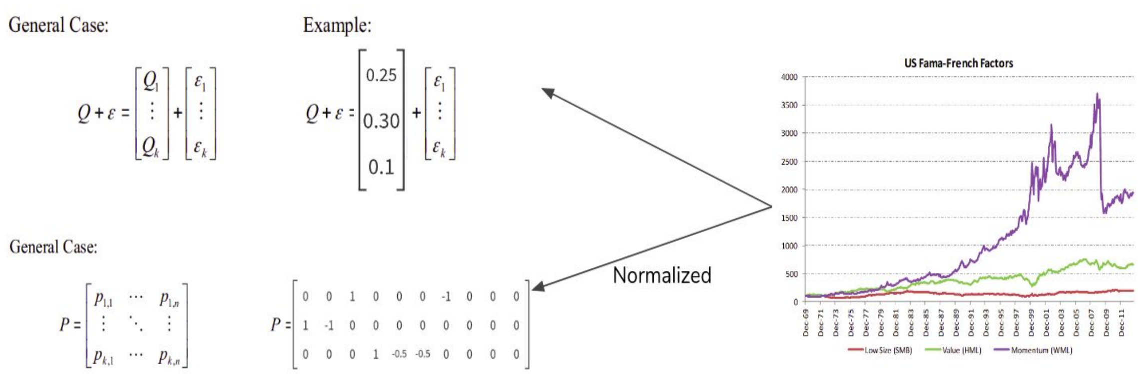
  The three relative views about the future performance are calculated from data using value and momentum factors.

  View 1: The Health Care sector has 25% higher Momentum than the Industrials sector.

  View 2: Basic Materials sector price-to-book (P/B) ratio is 30% lower than Consumer Goods sector.

  View 3: Oil and Gas sector has 10% higher Momentum than Financials and Technology sectors.

  These three factor views are going to be merged with the implied market equilibrium in the BL model. My intendent approach of using factors as BL model views from above is shown below.



Source: A STEP-BY-STEP GUIDE TO THE BLACK-LITTERMAN MODEL, Thomas M. Idzorek.

Figure 2: Factors as views in the Black Litterman model.

- **Backtesting, Result Visualization, and Parameter Calibration**

  To find out if this approach of combining the BL model with the factors as views will deliver any added premia, an ex-post check, i.e., backtesting, needs to be performed. This ex-post check requires to be performed after every parameter change. Backtesting will help to find out which ***τ*** (tau) and ***δ*** (delta) parameters deliver the highest performance. The resulting visualization will provide more intuitive insights into model behavior.

- **Result Analysis**

  Documenting and interpretation of the risk properties and the performance of the optimized portfolios. The market portfolio weight changes after the optimization will be documented and visualized.

5. State of the Art

Currently, there is a vital discussion about the long-term stability of factor returns in equity-portfolio management. There is a branch of literature, most notably the work of the 2013 Nobel Laureate Eugene Fama and his coauthor Kenneth French [9], which consider factor premia as constant and stable over time. A second branch focuses on the time-variation of factor premia and tries to characterize their dynamics [10, 11]. This thesis is intended to contribute to this discussion by combining Black-Litterman portfolio optimization [4, 5, 6] with (dynamic) factor views [7, 8, 9].

The Black-Litterman portfolio optimization model has been extensively covered and used over decades, as well as value and momentum factor investing strategies. However, empirical research of the two-method combination has never been performed on the STOXX 600 sector indexes.

Within this master thesis, the idea of incorporating return forecasts into the portfolio optimization model makes the mean-variance theory inappropriate for the task, which is shown by Black and Litterman [5]. They discuss the disadvantages of modern portfolio theory in detail when trying to incorporate return forecasts of the future. They demonstrate the advantages of the BL model when working with investor views of future returns.

Contrary to the MPT, which uses historical expected returns, the BL model uses market returns that are implied by the market portfolio. Black and Litterman [6] discuss how CAPM equilibrium returns can be used as a starting point for a portfolio optimization process. Furthermore, they indicate how the portfolio weights are tilted according to the investor views, and the benefits of the implied returns when investors have no views at all or have no confidence in their forecasts. They also show how the investors can control the portfolio tilt between the CAPM prior distribution and their subjective forecasts. This investor certainty parameter of their forecasts, or investor uncertainty of the CAPM distribution coefficient, plays a crucial role in the BL portfolio optimization. This paper argues and shows how this new method in portfolio optimization, according to the investor's certainty in their own subjective forecasts, controls the magnitude and tilts the portfolio from the market neutral starting point. The higher the investor view certainty, the stronger the tilt toward the investor forecast. Conversely, the low investor confidence in the CAPM prior keeps the portfolio weights close to those implied by the market. In this paper, I shall derive the implied CAPM prior and use it as a starting point for the portfolio optimization. Additionally, I will be using a broad range of the $\boldsymbol{\tau}$ values in the backtesting process in order to find out which specific value adjusts the neutral weights, according to the investors' views, that deliver the highest premia.

Bender, Briand, Melas, and Subramanian [1] offer an overview of factor investing based on the existence of factors grounded in the academic literature that have earned a premium over extended periods. They argue that factor indexes should not be taken as a replacement for market-cap indexes, but on the contrary, that they rebalance away from the neutral market cap starting point. For this reason, they can be viewed as the result of an active view or decision and the investor has to form their own belief about what explains historical premia and if it is going to persist in the future.

Jagadeesh and Titman [7] and Fama and French [8] discuss momentum and value factors respectively, and document how these two factors have made abnormal returns over long periods. The future return forecasts for the BL model views within this thesis is going to be derived using these two factors. The difference in average returns of the winning (top) and loosing (bottom) portfolios will be used as performance predictors for the next period. This top/bottom portfolio performance difference, as a predictor of future returns, shall be used as (active) views in the BL portfolio optimization model.

Frank J. Fabozzi, Sergio M. Focardi and Petter N. Kolm [12] present how to incorporate trading strategies in the Black-Litterman model. Specifically, they discuss how to incorporate factor models and cross-sectional rankings in this framework. In their example, by using MSCI World data from 1980/1/1 to 2004/4/31 consisting of 23 developed market country indices, they demonstrated how to combine momentum strategy with the market equilibrium in a portfolio optimization framework by using the BL model. By rebalancing the portfolio according to the momentum factor at the end of each month, this approach resulted in significant outperformance over the MSCI World Index in a period of about 25 years.

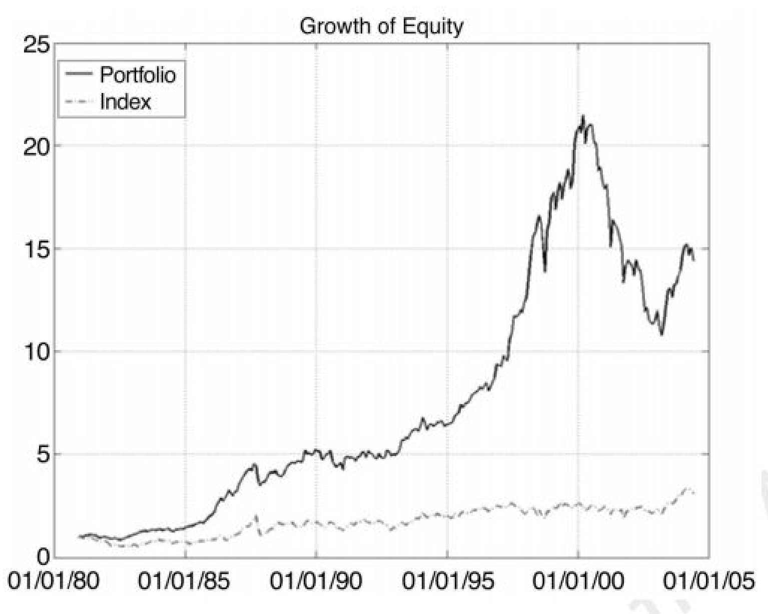


Figure 3: Momentum Optimized Strategy and the MSCI World Index [12].

The key difference of my master thesis to the work of Fabozzi et al. (2006) is that my paper concentrates on the aggregation to 10 European industry portfolios, which is not done by Fabozzi.

6. Relevance to the Curricula of Business Informatics

The portfolio optimization process is a process of selecting an optimal portfolio out of (infinitely) many possible portfolio alternatives. This optimization is subject to given constraints (mainly on portfolio weights and desired portfolio characteristics) and constitutes a sub-branch of convex optimization. Mathematical optimization problems arise in all quantitative disciplines from computer science and engineering to economics and operations research. This thesis contributes to the fields of corporate finance and optimization, which are an integral part of the curriculum of Business Informatics. The optimization and corporate finance section of this thesis is mostly related to the following curriculum courses:

VU Optimization in Business and Economics
VU Advanced Financial Planning and Control
VU Project and Enterprise Financing
VU Model-based Decision Support
VU Machine Learning

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