UNI: APK2129

IEOR E4999: INTERNSHIP REPORT

Instructor: Emanuel Derman

Anish Kelkar MSOR '14
Columbia University
apk2129@columbia.edu

About

This document presents a report on my summer internship at *Quantitative Management Associates LLC*[1].The document intends to explain my experience, details of the project I accomplished during my stint at the company, a typical day during this internship, skills and qualifications acquired, relevance to my Columbia program coursework and how the experience shapes my career goals.

Text and layout were written in LATEX, the document preparation system for the TeX typesetting program.

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1 Introduction

1.1 About the company

Quantitative Management Associates (QMA) is a fully owned subsidy of Prudential Investment management division of Prudential Fianancial Inc. It manages 114 billion in equity and asset allocation portfolios for institutional and retail clients, using proprietary models. QMA's long-standing team of investment professionals has skillfully fine-tuned the use of advanced analytics to enhance the investment decision-making process through a disciplined, bottom-up approach. Models incorporate salient insights from academic theory to identify when stocks or asset classes seem mispriced. Rigorous risk controls ensure that non-benchmark risk is focused on areas with the potential to provide sufficient rewards

I was a part of the Core Equity team which encompasses both growth and value stocks, optimized around a broad-based U.S., non-U.S. or global benchmark. Applying the principles of both valuation theory and behavioral finance, it developes proprietary, adaptive investment models to identify opportunities in both U.S. and global markets. The quantitative process results in portfolios that generally provide style-neutral core exposure, broadly diversified across a large number of stocks, with small over or underweights relative to the benchmark.

1.2 Project Overview

I was assigned a project to build a complete analytic solution for equity portfolio managers to analyze, examine various statistical measures and help in client reporting purposes. The application was planned to provide equity portfolio managers enhanced insight and control, enabling them to view multiple reports, analytics and time periods side-by-side to get a clear view of their portfolios. At a glance, understand the basic characteristics of your portfolio including its asset allocation, exposure to different investment styles Plus, easily analyze how well your holdings and expenses are adding up to meet your financial goals, create and evaluate a client portfolio, analyze hypothetical performance, risk statistics, asset allocation.

The intent was to capture historic data and examine historic behaviour of different factors used for stock selection and risk exposures to the portfolio. The Domestic Quant core team didnot have an unified application to capture these characteristics and for client reporting purposes.A simple easy to use user interface encompassing numerous portfolio metrics and historic behaviour was the objective.

2 Project Details

2.1 Overview

The mean-variance analysis of Harry Markowitz provides the basis for portfolio and asset pricing theory. Within those large literatures, factor models have played a significant role. In QMA managers want to examine the factor exposure to a portfolio and which factor is actually driving the alpha. Analyzing Multi factor models to come to a conclusion regarding which factor worked and which did not required statistical analysis and examining historic data. This was the starting point of the project.

Gaining exposure to factors is rather challengingthis is one reason they are seldom applied in institutional portfolios. Ironically, even though risk factors are the basic building blocks of investments, there is no natural way to invest in many of them directly. For instance, much debate revolves around obtaining exposure to GDP growth. Although many studies explore the existence of a link between equity market returns and GDP growth, consensus is lacking. Establishing exposures to some other factors is simpler. Many factors necessitate derivatives and/or long/short positions in order to capture a spread. For instance, exposure to inflation can be constructed using a long nominal Treasuries and short TIPS position.

A few other examples of how to capture specific factor exposures include:

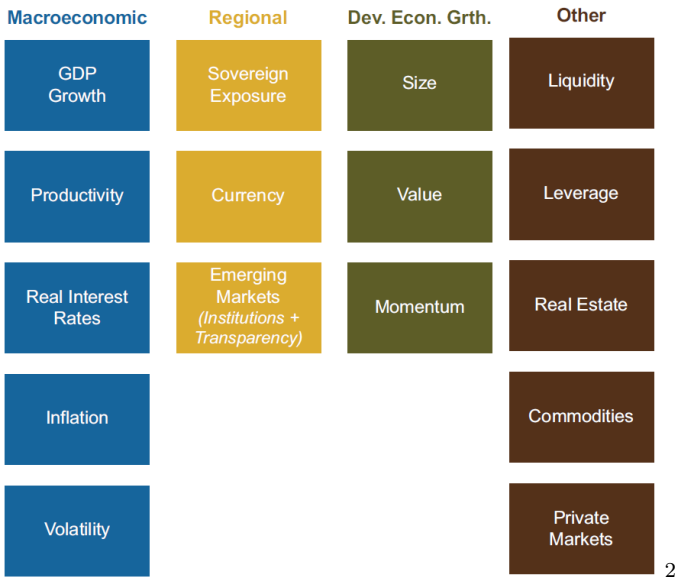


Figure 1: Some Factors for US Equity Markets

I started off by analyzing the huge chunks of data residing in the database. The primary objective was to get familiar with the structure of database and understand the relations between tables. Once I was comfortable with data the first task was to calculate Active Share of all the portfolios . How much active management is being done by your mutual fund manager? A new measure called Active Share may give you the answer.Active Share is calculated by taking the sum of the absolute value of the differences of the weight of each holding in the manager's portfolio versus the weight of each holding in the benchmark index and dividing by two.

$$Active\,Share = \frac{1}{2}\sum_{i=1}^{n} \|P_i - B_i\|$$

Active Share is a measure of the percentage of stock holdings in a manager's portfolio that differ from the benchmark index. The researchers conclude that managers with high Active Share outperform their benchmark indexes and that Active Share significantly predicts fund performance. Active Share is found by analyzing the actual holdings of a manager's portfolio and comparing those holdings to its benchmark index. By measuring active management in this way, investors can get a clearer understanding of what exactly a manager is doing to drive performance, rather than drawing conclusions from observed returns.
Since the publication of "The fundamental law of active management" by Grinold (1989) two decades ago, it has been widely used in the quantitative investment community as a tool to assess a portfolio manager's ability to add value. We consider TC which is the transfer coefficient, defined as the cross-sectional correlation coefficient between risk-adjusted expected residual returns and risk-adjusted active weights to measure how much of the factor is drawn into the portoflio.

$$Transfer\,Coefficient = \rho(P_i, FactorValues_i)$$

Many practitioners are uncomfortable with the use of information ratios as a measure of skill because the assumptions of no limitations on position sizes, zero trading costs and the availability of unlimited short positions are unrealistic for most investment portfolios. Clarke, de Silva and Thorley (2002) tries resolve this issue by introducing a scaling factor into the calculation of the information ratio that they call the transfer coefficient. We can think of the transfer coefficient as a scalar less than one which describes how much of the potential economic value added from our investment strategy actually contributes to actual performance. It points out the extent to which our potential value is lost due to the interference of constraints on position size and portfolio turnover.

$$TC = efficiency\,of\,your\,portfolio\,construction (TC < 1)$$

The **Risk module** hepls to understand all 3 kinds of risks at portoflio level.Unsystematic risk, also known as "specific risk," "diversifiable risk" or "residual risk," is the type of uncertainty that comes with the company or industry you invest in. Unsystematic risk can be reduced through diversification. For example, news that is specific to a

small number of stocks, such as a sudden strike by the employees of a company you have shares in, is considered to be unsystematic risk. Systematic risk, also known as "market risk" or "un-diversifiable risk", is the uncertainty inherent to the entire market or entire market segment. Also referred to as volatility, systematic risk consists of the day-to-day fluctuations in a stock's price. Volatility is a measure of risk because it refers to the behavior, or "temperament," of your investment rather than the reason for this behavior. Because market movement is the reason why people can make money from stocks, volatility is essential for returns, and the more unstable the investment the more chance there is that it will experience a dramatic change in either direction.
Risk Calculations are as follows:

$$Specific\,Risk = \sqrt{\sum_{i=1}^{n}(P_i - B_i)^2\,.\,SpecificRisk_i^2}$$

For calculation of systematic risk, we approached it in a non traditional way. Wehad the exposures and covariances of the factors and we implemented the below formula to get risk values.

$$Systematic\,Risk = \sqrt{\sum_{i=1}^{n}\sum_{j=1}^{n}(Exposure_i \cdot\ Exposure_i \cdot\ Cov(i,j)}$$

The risk model used by QMA is the BARRA risk model and we make use of the BARRA's predicted beta.We fetch predicted beta values for each security and calculate the portoflio predicted beta.

$$Portfolio\,Predicted\,Beta = \sum_{j=1}^{n}(P_i \cdot PredictedBeta_{i)}$$

[3]

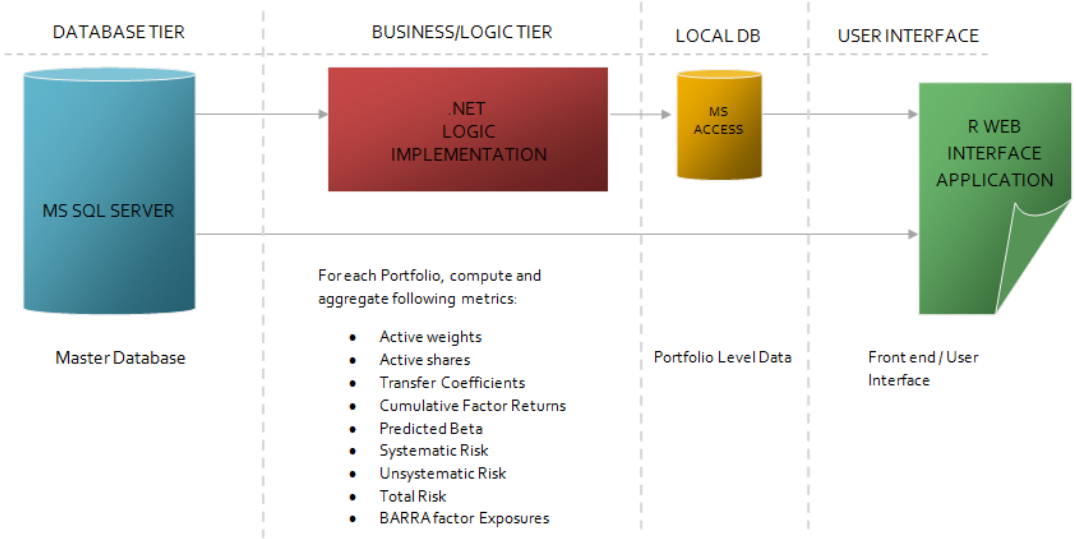
Equity betas can be obtained from the Barra Book. These betas will be levered and either historical or predicted. The historical beta is based on actual trading data for the period examined (often 2 years), while the predicted beta statistically adjusts the historical beta to reflect an expectation that an individual company's beta will revert toward the mean over time.

[3] $P_i : Portfolio\,Weight$
$B_i : Benchmark\,Weight$
$Exposure_i : Risk\,Factor\,Exposures\,to\,Security$
$PredictedBeta_i : BARRA\,Predicted\,Beta\,of\,a\,Security$

The application was titled Domestic Quant Core analytics and aimed to provide following charateristics:

- Draw from our vast database of current and historical data.
- Setup an automatic batch process to perform necessary calculations for all portfolios with daily updated data
- Analyze active performance and transfer coefficient of portfolios.
- Examine the historical cumulative factor return vs security bets of portfolios.
- Examine the systematic, specific and total risk of portfolios.
- Leverage BARRA risk models to understand how various risk factors contributed to your portfolios performance.
- Analyze distribution of securities in any portfolio
- Analyze a security distribution in different portfolios and historical weights in different portfolios.
- Manage exposures to specific tickers
- Understand relative and absolute risk using intuitive, detailed, multi-factor risk models
- Decompose systematic, idiosyncratic and default risk exposures
- Easily change the analysis time frame to 30-60-90 days and visualize long-term performance patterns.
- Report on market exposures and sensitivities and track performance over time.
- Benchmark management: Access indices across the US equity markets
- Easily export any report to XLS or CSV formats

2.2 Application architecture



My manager had given me complete liberty to build up the tool from scratch and i decided to go with a 3 tier architecture.

The database Tier: The Company maintains research database which contains all the latest financial data essential for analysis. Stored Procedures were implemented to fetch necessary data. Such procedures are complied by the SQL engine, resulting in run time faster execution. Metrics such as security portfolio weights, Benchmark weights, active weights where calculated.

The Business Tier: This tier comprises of the most of extensive computations. This middle tier was built in VB.NET and essentially performed the tasks to fetch historic data from repository(database), perform computations and store the results in a local data base (MS ACCESS)

Intermediate Tier: The layer was not was not essential however some considerable amount of data was already present in the local database and i thought to use up as much as i can to improve the robustness of the application.

User Interface: This was the most challenging part of implement because managers expect more than just charts. Dynamic, fully functional and interactive charts were expected by the managers and R was selected as a visualization tool which has evolved enormously over the past years in terms of visualization capabilities.

The 3 Tier architecture gives the freedom to port to any other technology stack, for any future developer to implement. Currently the Technology Stack comprises of MS SQL SERVER, VB.NET, R SHINY

2.3 User Interface (selected screens)

2.3.1 Alpha Dashboard (Portfolio Level Characteristics)

- Summary

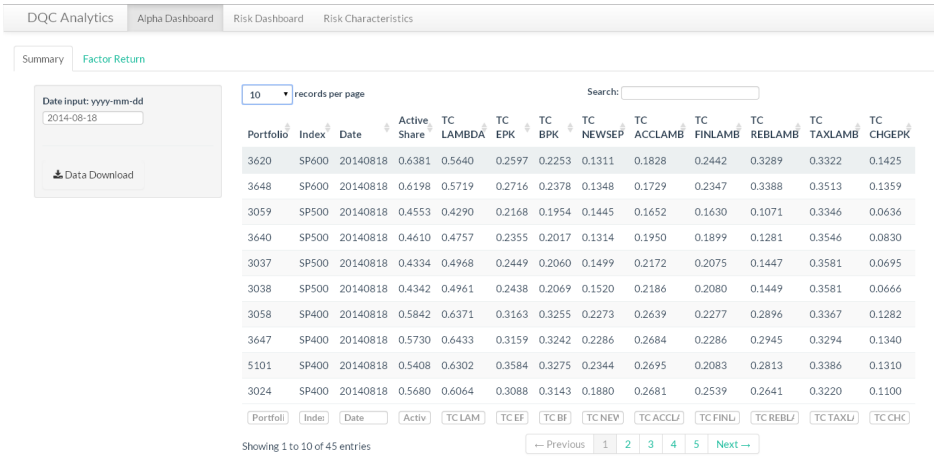


Figure 2: For a given date displays all the portfolios with following metrics: Active Share,Transfer Coefficients (Lambda, epk, bpk, newsep, acclamb, finlamb, relamb, taxlamb, chgepk)

- Factor Returns

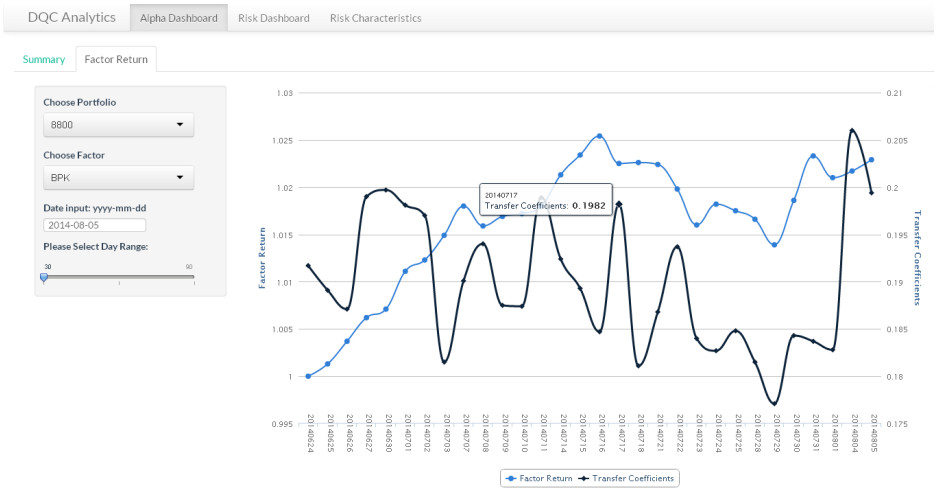


Figure 3: For a single portfolio: Compare Transfer Coefficient of a factor vs. Factor return over a period of 30,60,90 days

2.3.2 Risk Dashboard (Portfolio Level Characteristics)

- Summary

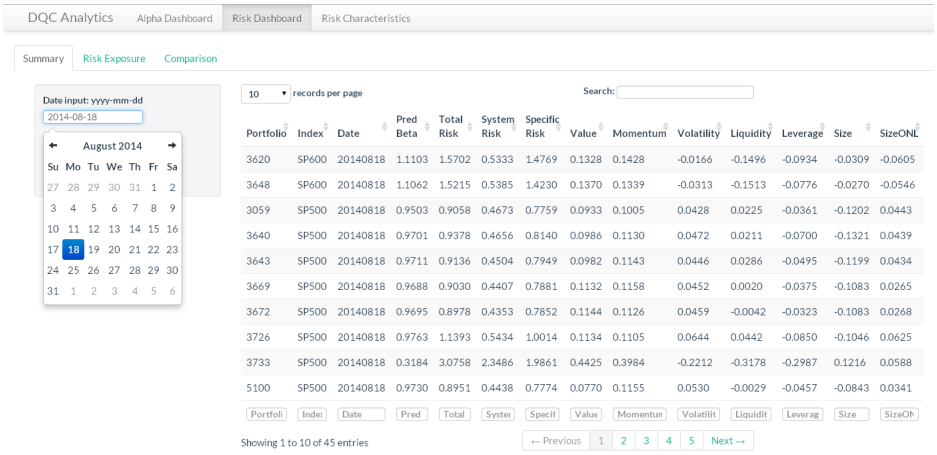


Figure 4: For a given date displays all the portfolios with following metrics: Predicted Beta, Total risk, Systematic risk, Specific risk,Exposure to BARRA risk factors (Value, Momentum, Volatility, Liquidity, Leverage, Size, Sizeonl)

- Risk Exposure Tab

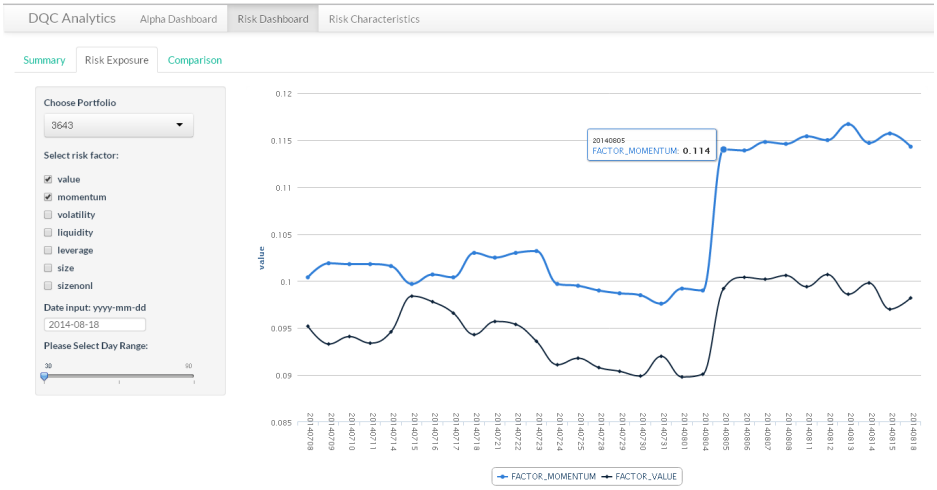


Figure 5: For a single portfolio:Display time series of a Risk Factor exposure over a period of 30,60,90 days,Compare time series of multiple Risk Factors exposure simultaneously over a period of 30,60,90 days

- Comparison Tab

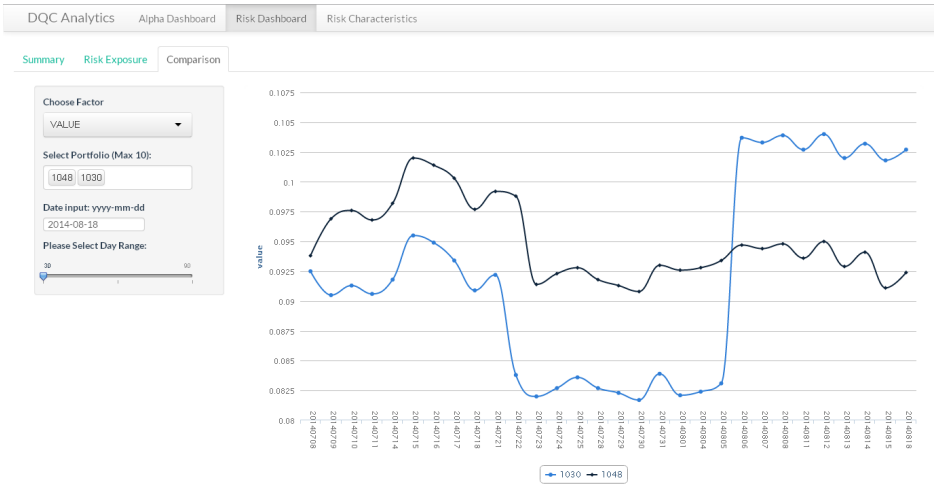


Figure 6: For a single Risk Factor: Compare Factors exposure to different portfolios simultaneously over a period of 30,60,90 days

2.3.3 Risk Characteristics (Security Level Characteristics)

- Portfolio Tab

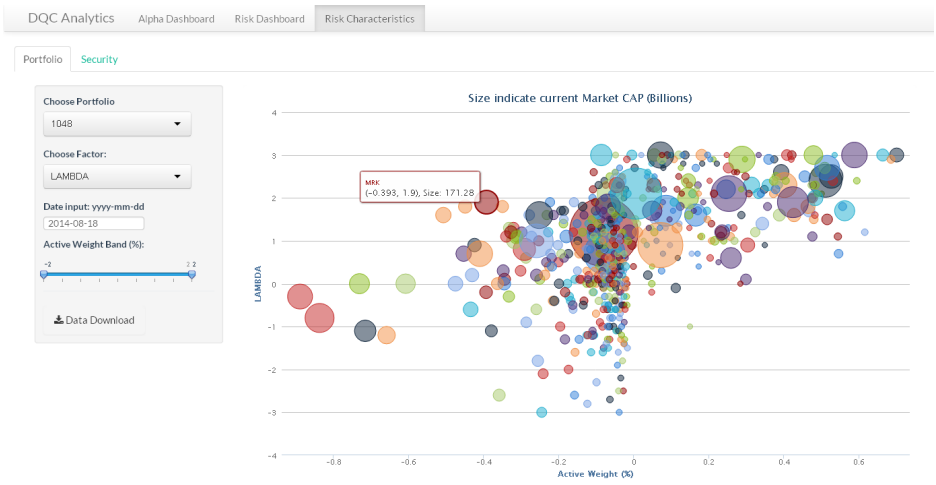


Figure 7: For a single portfolio: Individual security active weights vs. lambda (with Market Cap), Individual security active weights vs. predicted beta (with Market Cap)

- Security Tab

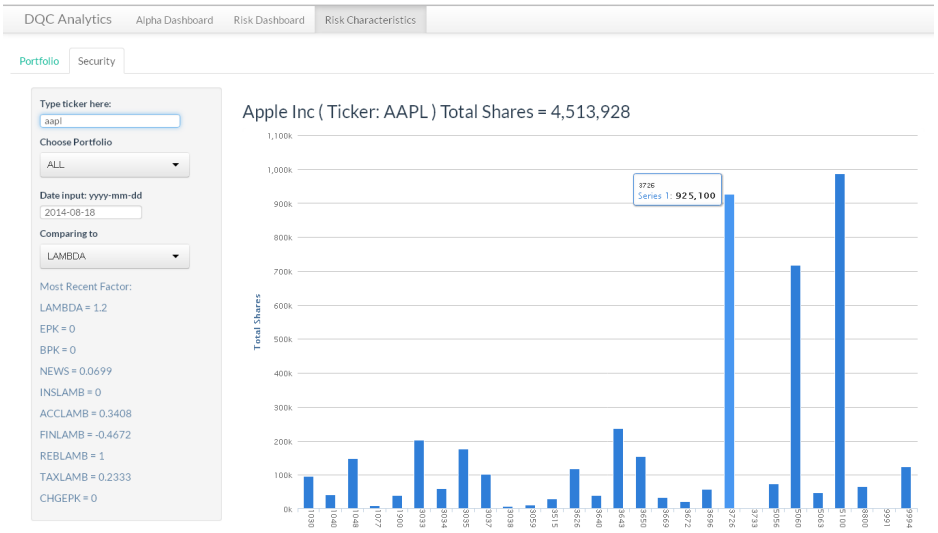


Figure 8: For a single security: Number of shares in Each portfolio

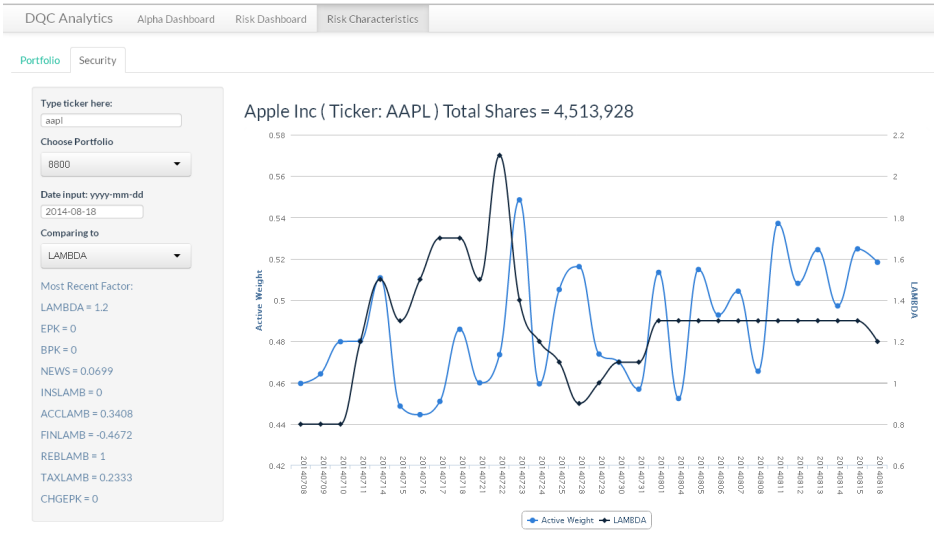


Figure 9: Active Weight time series in a particular portfolio vs. Lambda/Price over a period of 30 days

3 A typical day during this internship

It is difficult to list out a general daily activity routine, however most of my times the following would have been a typical day.

9:00 AM: Morning Meeting. Memebers of teach team (Domestic Core, Value, International) provide the status of their portfolio and discuss the market picture.

10.00 AM: Brief Discussion with my manager to discuss status of my project and activities to-do today

10:15 AM: Start Job to fetch Data from database and store portfolio level information in local database.Once extraction is done, perform integrity check.

12:00 PM: Lunch

1:00 PM: Work on the stored procedures and business logic. Majority of my time was put into designing an efficient robust backend and business layer.

4:00 PM: Get intermediate results and perform data integrity. Verify that calculations are precise and double check with managers numbers which were downloaded from subscribed vendors.

6:00 PM: Update my status to the manager and discuss about any overnight jobs ot be scheduled in order for data to be available the next day.

There were frequent short meetings with the Portfolio Managers to have their feedback on the application and implement their requirements.

4 Skills and qualifications acquired

During my tenure at QMA i acquired immense exposure to the structure of asset management quant shop. Interactions with professional across different business area helped me gain access to a very clear picture of how things work in the asset management industry. It has helped me to be comfortable with a lot of financial jargons that float around and basic market intuitions.

Domain Skills:
Index Funds, Factor analysis, Active weights, Portfolio analytics Portfolio Management, US equity Market, Portfolio Rebalancing, Turnover, Equity research, Data integrity, BARRA risk models, Bloomberg Terminals

Technical Skills:
System Design, Data mining, Data Munging, R Shiny, SQL, VB.NET, ASP.NET

5 Relationship to your coursework at Columbia

My concentration for my graduate program is Financial and Managerial Applications. The coursework over the past 2 semesters dealt with global capital markets, quantitative finance and Data science. The project turned out to be an excellent application of these principles. Practical implementation of CAPM model, factor modeling, Risk Factor exposures, portfolio rebalancing, modeling transaction costs etc. helped me connect the dots i captured during my coursework. With an excellent mentor (VP, Investments) i was able to gain considerable confidence in the asset management space.

6 Contribution to your career plans

I had always been interested in Investment management and that was my primary aim while searching for summer internships. The internship helped to completely understand how a quant investment shop functions. I plan to further enhance my skills in this direction, gain more knowledge about portfolio optimization, quantitative portfolio management, and quantitative research and pursue a career on the buy side. I would love to work for a quantitative hedge fund where their functions constitute the same nature of work and is more dynamic and rigorous. To develop my skills I want to accomplish professional affiliations like CFA examinations long term plan would be to become a portfolio manager or managing my own fund.

7 Conclusion and Future Work

I had a very fulfilling internship experience at QMA. It has led me to be more clear in my career plans. I showcased the application to the entire management and it was very well received my the Portfolio managers from other teams too. They have proposed to extend this application to their team (International portfolios, Value team..) The application can still be optimized; more visualizations could be added, however due time constraints we decided to phase out currently built version 1.0.

I may continue to work for them during as a part time fall intern and take up to projects in researching investing strategies, building my own back testing tool and implement machine learning algorithms to accomplish factor modeling.

8 Bibliography

References

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[3] Kritzman, Mark., *How To Detect Skill In Management Performance*, Journal of Portfolio Management, 1986, v12(2), 16-20.

[4] Viral V. Acharya, Lasse H. Pedersen, Thomas Philippon, and Matthew Richardson, *Measuring Systemic Risk*, May2010

9 Contact

As a contact reference i would like to provide refernce of my manager and a colleague who i was working with for my internship.

Satish Sanapareddy
Investment Vice President at Quantitative Management Associates LLC
satish.sanapareddy@qmassociates.com

Chantal Chaung
Investment Associate at Quantitative Management Associates LLC
tzu-yi.chuang@qmassociates.com

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