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FE520 Introduction to Python for Financial Applications

beta neutral portfolio optimization

A Python Analysis

**Overview**

Modern Portfolio Theory as proposed by Nobel Laureate Harry Markowitz remains hugely popular today due to its simplicity and performance. The idea developed by Markowitz provides insight to how risk-averse investors can construct portfolios to optimize or maximize returns based on a given level of market risk. This structure emphasizes that risk is an inherent part of a higher reward. Creating optimal portfolios has not been met without challenges. The Capital Asset Pricing Model (CAPM) describes the relationship between the expected return and risk of investing in a security. It shows that the expected return on a security is equal to the risk-free return plus a risk premium which is based on the beta of that security. Here, we are introduced to the term Beta.

**Objective:**

Working as an adviser to a high net worth individual, we are required to produce an optimal investment strategy to minimize market exposure in his/her portfolio. Here, we identify, a beta-neutral or zero-beta portfolio would be ideal in this case. Our investor, with an investment of $1m dollars has a low risk tolerance and is primarily concerned with capital preservation with a set level of returns. With this in mind, we tend to invest in blue chip corporations that are diversified across multiple sectors.

**What is a Beta-Neutral Portfolio?**

A beta neutral portfolio is a portfolio constructed to have zero systemic risk. According to the Capital Asset Pricing Model (CAPM) beta coefficients are a measure of the volatility, or systematic risk of an individual stock in comparison to the unsystematic risk of the entire market. Beta is used to help investors understand whether a stock moves in the same direction as the rest of the market, and how volatile or risky it is compared to the market. The market itself has a beta of 1. For example, a stock whose returns vary less than the market's returns has a beta with an absolute value less than 1.0. A stock with a beta of 2 has returns that change, on average, by twice the magnitude of the overall market. A stock with a beta of 1 moves exactly with the market. Beta can calculated with the below formula;

Where

= Covariance between the return of the portfolio and benchmark

= Variance of the return of the benchmark

Our goal is to create a portfolio where the sum of betas of stocks in our portfolio becomes 1

Where is the beta of each stock,

and refers to the weight allocated to each stock

**Our optimization problem therefore becomes;**

*Minimize minimize the portfolio variance*

*Subject to*

*The expected mean return is at least some target return*

*1=1 Weight sum up to 100% (note, we do allow long and short positions)*

*Beta of portfolio is 0*

**Importing Libraries**

In our portfolio analysis, the following functions are used;

**ffn - Financial Functions for Python -** ffn is a library that contains many useful functions for those who work in **quantitative finance**. It stands on the shoulders of giants (Pandas, Numpy, Scipy, etc.) and provides a vast array of utilities, from performance measurement and evaluation to graphing and common data transformations.

**empyrical:** Used for common financial risk and performance**-** We used it to Calculate Beta Value

**pypfopt:** PyPortfolioOpt is a library that implements portfolio optimization methods, including classical efficient frontier techniques as well as recent developments in the field like shrinkage and CVaR optimization, along with some novel experimental features.

**Method:**

**Selecting Stocks:**

We are fixed with a challenge to select stocks for our portfolio. First, we look at a basket comprising of stocks to pick from. In this case, we choose stocks in the Dow Jones 30. The Dow Jones Industrial Average has consists of most commonly followed equity indices and includes 30 large companies included in the stock exchanges.

***Include function to download prices of each stock for given time fram***

We select beta of each stock

***Include function to calculate beta of each stock***

From our calculations, and ranking stocks quantitatively, on characteristics such as value, momentum, liquidity and opinion. We make our decision on the 5 stocks for our portfolio.

* Industrials & HealthCare tend to outperform the market in downtimes. Top component in Dow Industrials & HealthCare is “CAT” and “PFE” respectively
* Diversify in Technology stocks as well. Technology has performed well in recent years. Choose “MSFT”(positive beta value), and “IBM” (negative beta value).
* Finally, pick a stock in retail. “WMT” being a giant retail stock

So we complete our five choices in the following stocks:

“PFE” - Pfizer Inc

“MSFT” – Microsoft Corp

“CAT” - Caterpillar Inc

“IBM” - International Business Machines Corp

“WMT” – Walmart Inc

Our Analysis Begins:

We get prices of each stock for the past two years “2016-11-01” to “2018-11-01” and plot prices against the SPY (our benchmark, representing the market).

***Insert code to calculate prices and graph for 5 stocks***

After studying past returns and performance of these assets, we gain insight into the distribution of prices over established timeframe. The expected return will be the center of the distribution. Here, we plot a histogram for the distribution of expected returns and report some important performance matrix.

***Insert code for histogram returns and stats***

***Run complete function***

**Back testing and Comparing our Results**

Here, we compare our portfolio performance for the 12 months of investment with that of the S&P 500 (our benchmark). We get the following returns for each.

|  |  |  |
| --- | --- | --- |
| Date | S&P 500 Returns | Beta-Neutral Portfolio |
| Dec 31 2018 | -9.18% | 2.32% |
| Jan 31 2019 | 7.87% | -4.68% |
| Feb 28 2019 | 2.97% | -3.5% |
| Mar 31 2019 | 1.79% | 4.4% |
| Apr 30 2019 | 3.93% | 3.5% |
| May 31 2019 | -6.58% | 6.6% |
| Jun 30 2019 | 6.89% | -0.3% |
| July 31 2019 | 1.31% | 5.14% |
| Aug 31 2019 | -1.81% | 2.74% |
| Sept 30 2019 | 1.72% | 2.12% |
| Oct 31 2019 | 2.04% | -0.8% |
| Nov 30 2019 | 3.40% | 2.8% |

Our return is shown in the graph below;

A close up of a map

Description automatically generated

Conclusions

**Limitations of our Model**

We found the following limitations/challenges

* In real life, a market-neutral portfolio is not self-funded as brokers who lend shares for short selling require collateral. If the spread keeps widening after the long/short portfolio was set up, an investor may receive a margin call from the broker. In our model, we do not assume this risk as we assumed unlimited patience and resources for living through periods of negative returns.
* Reality is much more complicated than theory. Hedge fund managers use other tools e.g verticals and put strategies to hedge trade portfolios.
* Voiding/deleting any of the stock in not possible in our model, e.g if a company goes bankrupt.
* In our model, we ignore transaction costs.

**Conclusion**

Our beta-neutral portfolio provided a return of $203,313.03 which is about 20% of our initial investment. Not only was this profitable, but in comparing with the market, there was almost a negative correlation with the returns of the S&P. This is great in downtimes but could pose questions during a bullish trend when prices of an industry's stocks or the overall rise in broad market indices go higher. Would our portfolio behave similarly or differently? Only time would tell.

Thank You!!

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