# MGT 6090
# Management of Financial Institutions

## Assignment 7
## Smart Beta and Fundamental Investing using R
## Week 7

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# R Assignment 7: Smart Beta, Fundamental Indexing, Factor Investing and Stock Returns

For this assignment we use the monthly returns data from the CRSP dataset msf.csv and COMPUSTAT dataset for the fundamental data. We have calculated the fundament ratios in the previous assignment, and also performed CAPM. We take reference from the previous assingments.

We take care to lag the returns data by one month and the Compustat data by 1 year so that there is no scope for lookahead biases in the portfolio returns.

## 1 Fundamental Ratios

From the COMPUSTAT data, we create the following ratios/factors.

- book value (Book),
- trailing (past) five-year average cash flow (Cash Flow),
- trailing five-year average revenue (Revenue)
- trailing five-year average gross sales (Sales),
- trailing five-year average gross dividends (Dividends)
- trailing five year gross investments (Investment)
- trailing five year profitability, return on assets, (Profitability)
- asset turnover (Asset turnover)
- Altman Z-score (Altman-Z)
- Ohlson score (Ohlson-O)

We will need to create some sort of filters to weed out the microstructure noise and illiquid companies data that might affect our results and observations. We try to perform that filtering by limiting companies that have market cap lower than 10 million USD (in 2021 dollar terms) and price of less than 4 USD (in 2021 dollar terms). We need to deflate this variables and then apply the filter to it.

### 1.1 Methodology for Fundamental Indexing

- We rank the stocks according to the above mention fundamental variables into 5 bins (ranks).
- We then attempt to create 5 portfolio's based on the ranks we obtain, and rebalance the portfolio's each year with newly ranked securities.
- We join the CRSP data to get the portfolio returns. Portfolio returns are calculated by weighted average of the individual stocks returns in the portfolio based on their financial variables.
- We plot each of these portfolio returns along with the Market returns (VWRETD).

- We analyze the portfolio performances by the sharpe ratios, information ratio, volatility, skewness for each ranks.
- The plots and analysis for each protfolio are as follows.

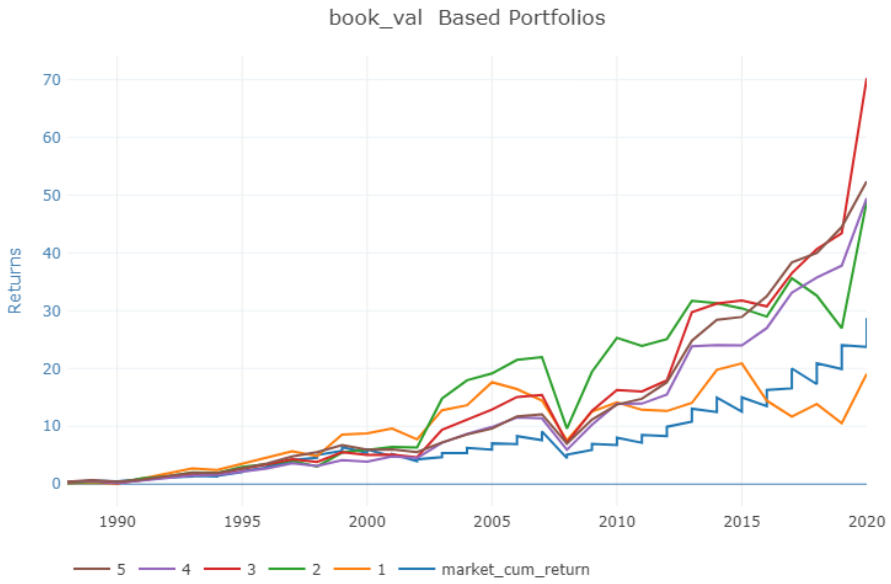


Figure 1: Book Value based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0952 | 0.3163 | 0.3009 | 0.4773 | -0.3144 | 0.2522 | -0.0275 | 0.2522 |
| 2 | 0.1258 | 0.3748 | 0.3357 | 1.0602 | 1.5650 | 0.2731 | 0.0705 | 0.2731 |
| 3 | 0.1380 | 0.5066 | 0.2724 | 0.3554 | 0.7394 | 0.1848 | 0.1639 | 0.1848 |
| 4 | 0.1262 | 0.6006 | 0.2101 | -0.2755 | 0.9148 | 0.1347 | 0.1336 | 0.1347 |
| 5 | 0.1281 | 0.7394 | 0.1732 | -0.6685 | 1.4162 | 0.0715 | 0.2770 | 0.0715 |

Figure 2: Book values based portfolio analysis

Note: I have plotted Recession based graphs in ggplot while for analysis purpose I use plotly, for interest of space, I have only included plotly charts that dont contain recession data.

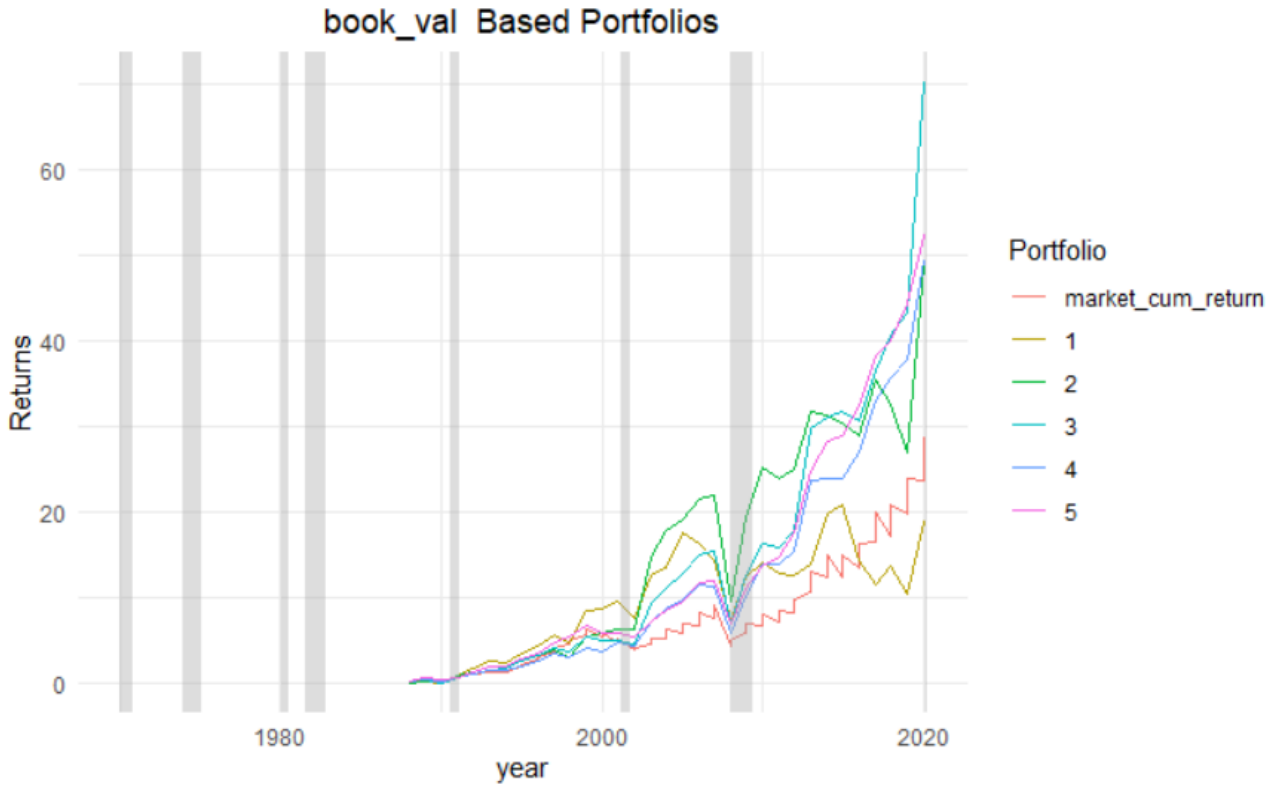


Figure 3: Book values based portfolio analysis with recession periods

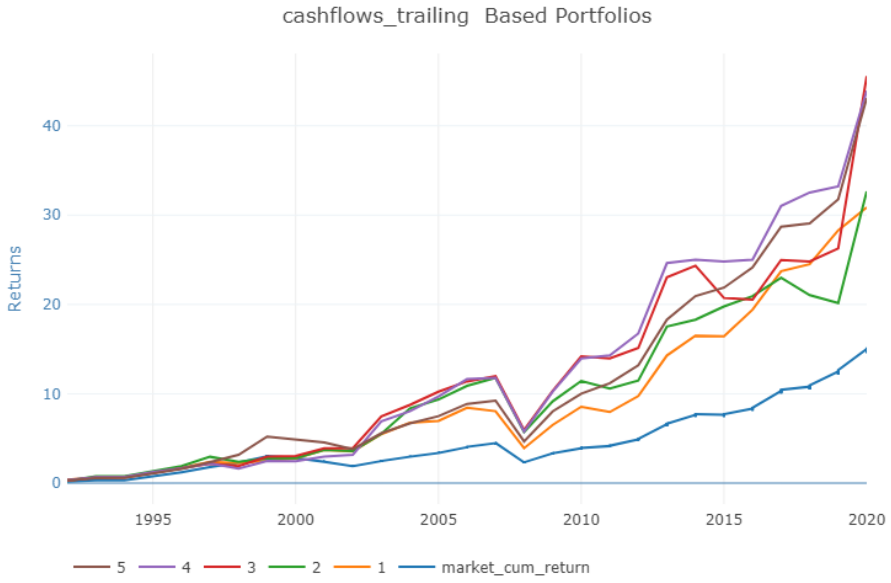


Figure 4: trailing 5 yr Cash flow based based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1268 | 0.6650 | 0.1907 | -0.6922 | 1.9350 | 0.1266 | 0.2086 | 0.1266 |
| 2 | 0.1289 | 0.5593 | 0.2305 | -0.2455 | 0.3636 | 0.1691 | 0.1743 | 0.1691 |
| 3 | 0.1416 | 0.5557 | 0.2548 | 0.3155 | 0.6911 | 0.1853 | 0.2282 | 0.1853 |
| 4 | 0.1402 | 0.5596 | 0.2505 | 0.5022 | 2.0660 | 0.1846 | 0.2151 | 0.1846 |
| 5 | 0.1395 | 0.6941 | 0.2009 | -0.5427 | 1.5791 | 0.0853 | 0.4533 | 0.0853 |

Figure 5: trailing 5 yr Cash flow based based portfolio analysis

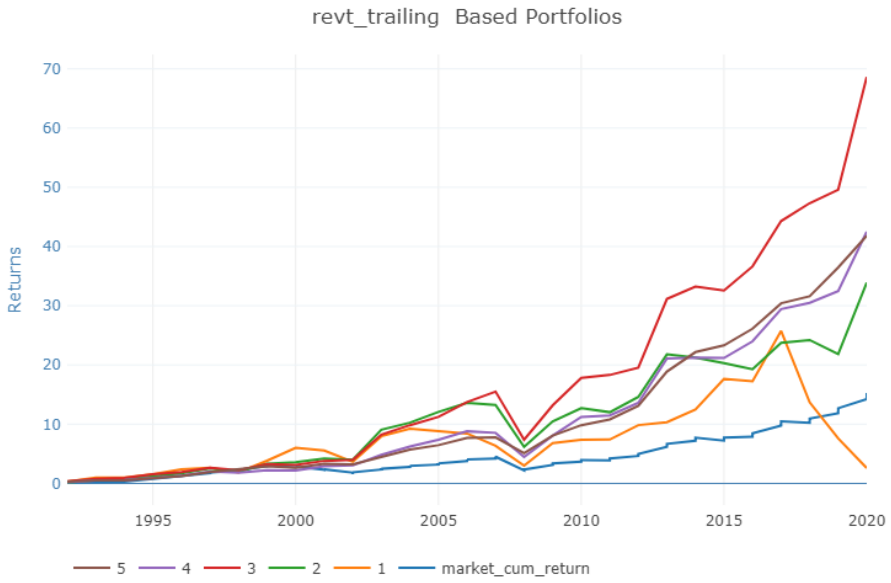


Figure 6: Revenue based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0452 | 0.1164 | 0.3882 | 0.2983 | -0.2961 | 0.3500 | -0.1524 | 0.3500 |
| 2 | 0.1303 | 0.4636 | 0.2811 | 0.6855 | 1.7887 | 0.2140 | 0.1454 | 0.2140 |
| 3 | 0.1575 | 0.6296 | 0.2502 | 0.3142 | 1.8633 | 0.1795 | 0.3185 | 0.1795 |
| 4 | 0.1389 | 0.6867 | 0.2023 | -0.1262 | 1.7062 | 0.1394 | 0.2742 | 0.1394 |
| 5 | 0.1383 | 0.9135 | 0.1514 | -0.4962 | 1.6389 | 0.0855 | 0.4368 | 0.0855 |

Figure 7: Revenue based portfolio analysis

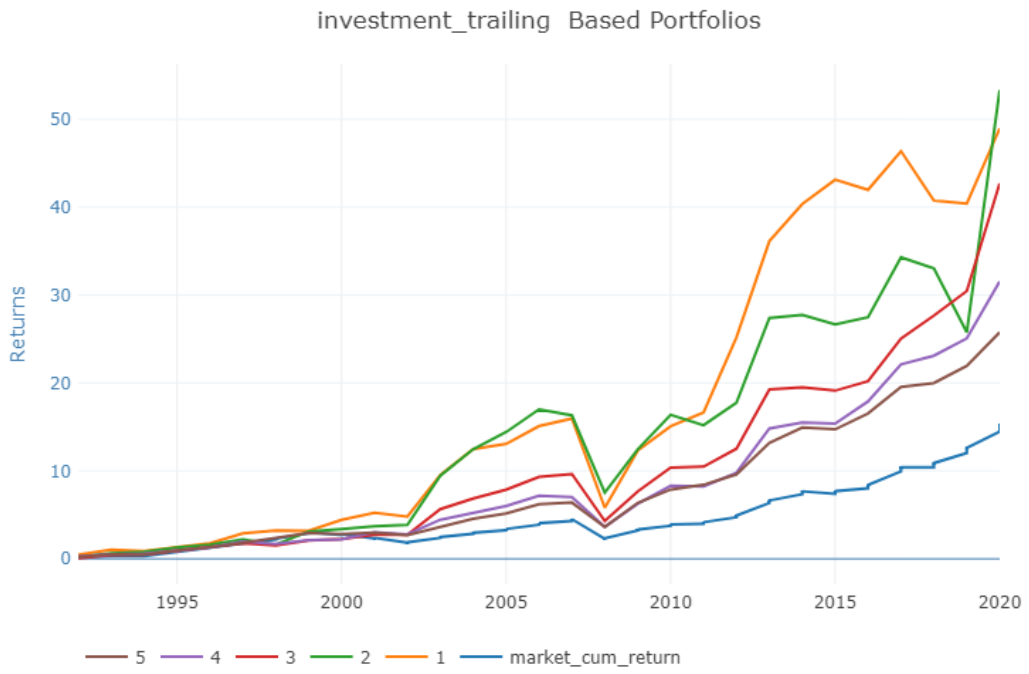


Figure 8: Investments based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1444 | 0.4962 | 0.2910 | 0.3394 | 1.8179 | 0.2247 | 0.2018 | 0.2247 |
| 2 | 0.1477 | 0.4338 | 0.3405 | 0.9949 | 1.6370 | 0.2825 | 0.1721 | 0.2825 |
| 3 | 0.1391 | 0.5932 | 0.2345 | 0.1809 | 2.1495 | 0.1656 | 0.2345 | 0.1656 |
| 4 | 0.1276 | 0.6723 | 0.1898 | -0.3983 | 1.5944 | 0.1249 | 0.2124 | 0.1249 |
| 5 | 0.1200 | 0.7199 | 0.1667 | -0.2653 | 2.8587 | 0.0751 | 0.2568 | 0.0751 |

Figure 9: Investments based portfolio analysis

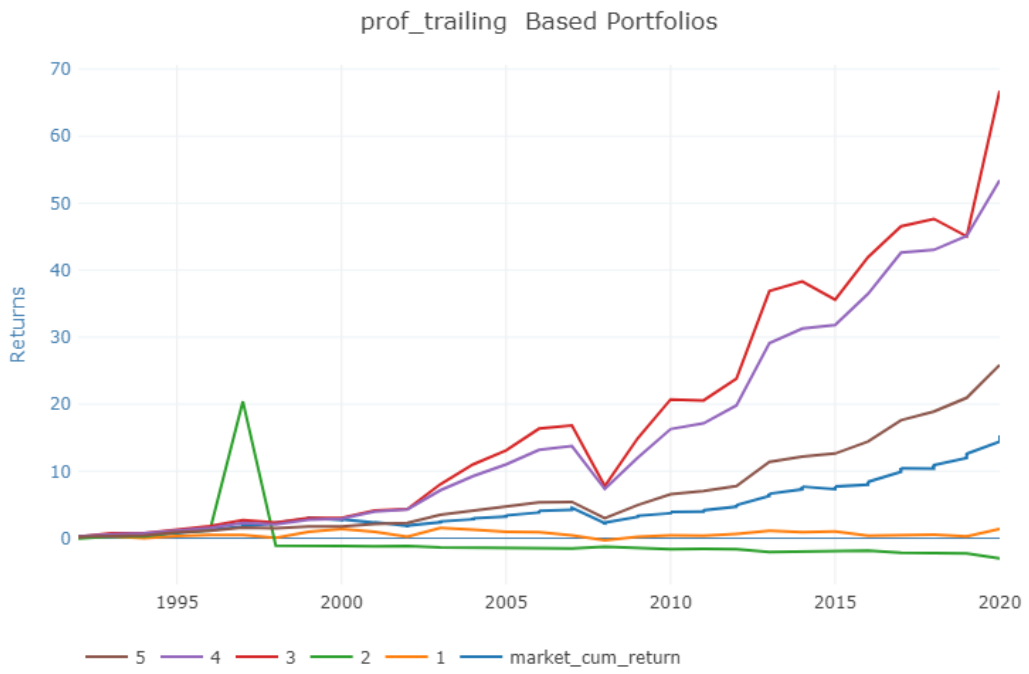


Figure 10: Profitability (RoA) based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0325 | 0.0843 | 0.3858 | 0.9806 | 0.4291 | 0.3240 | -0.2052 | 0.3240 |
| 2 | 0.0806 | 0.1485 | 0.5429 | 0.9477 | 1.0139 | 0.4826 | -0.0384 | 0.4826 |
| 3 | 0.1641 | 0.6429 | 0.2552 | 0.0796 | 1.1130 | 0.1871 | 0.3399 | 0.1871 |
| 4 | 0.1465 | 0.7748 | 0.1891 | -0.5615 | 2.3750 | 0.1361 | 0.3355 | 0.1361 |
| 5 | 0.1212 | 0.7494 | 0.1617 | -0.4403 | 2.3452 | 0.1039 | 0.1967 | 0.1039 |

Figure 11: Profitability (RoA) based portfolio analysis

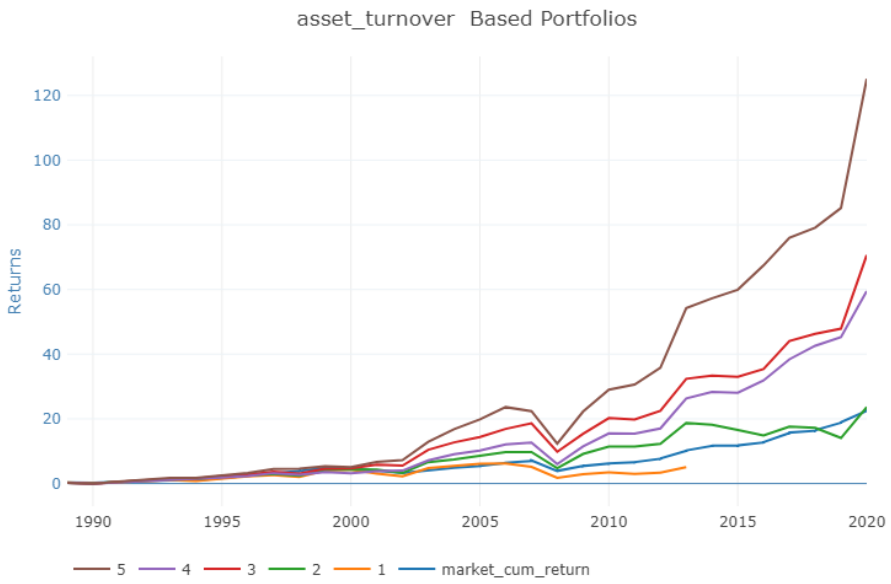


Figure 12: Asset based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0638 | 0.2302 | 0.2773 | 0.0762 | 0.4207 | 0.1814 | -0.2044 | 0.1814 |
| 2 | 0.1045 | 0.3652 | 0.2861 | 0.5808 | 0.1347 | 0.2028 | 0.0028 | 0.2028 |
| 3 | 0.1419 | 0.6091 | 0.2330 | 0.1275 | 1.1534 | 0.1652 | 0.2280 | 0.1652 |
| 4 | 0.1385 | 0.5853 | 0.2367 | 0.1066 | 1.6842 | 0.1610 | 0.2149 | 0.1610 |
| 5 | 0.1648 | 0.6774 | 0.2432 | 0.2053 | 0.7362 | 0.1751 | 0.3475 | 0.1751 |

Figure 13: Asset based portfolio analysis

## 2 Observation for Fundamental Indexing

Before we begin the observation, we highlight our analysis parameters so that we understand the comparative analysis better.

- **Sharpe Ratio**: Sharpe ratio is the excess returns of the portfolio over the risk free rate, divided by the standard deviation of the portfolio returns. Although one portfolio or fund can enjoy higher returns than its peers, it is only a good investment if those higher returns do not come with an excess of additional risk.
- A Sharpe ratio above 0.5 is market-beating performance if achieved over the long run. A ratio of 1 is superb and difficult to achieve over long periods of time. A ratio of 0.2-0.3 is in line with the broader market.
- **Information Ratio**: The information ratio, also known as appraisal ratio, measures the active return of an investment compared to a benchmark index relative to the volatility of the active return.
- **Tracking error**: It is the standard deviation of the daily excess returns of a portfolio against a benchmark in annualized terms.
- **Skewness**: Skewness is the third moment. If the bulk of the data is at the left and the right tail is longer, we say that the distribution is skewed right or positively skewed; if the peak is toward the right and the left tail is longer, we say that the distribution is skewed left or negatively skewed.
- **Kurtosis**: A distribution with kurtosis ¿3 (excess kurtosis ¿0) is called leptokurtic. Compared to a normal distribution, its tails are longer and fatter, and often its central peak is higher and sharper.

Now we conduct analysis of fundamental variables based ranking and weightage.

- Returns for rank 3 book value based pfolio are the highest, but generally annualized returns increase with book value.
- Annualised Std dev and tracking errors reduce as the book value pfolio increase and share ratio increase with increasing book value.
- Recession affects the returns of all portfolios but higher book value stocks are more resistant to recession losses.
- Returns of high cash flow companies are higher while the standard deviations are lower.
- Revenue and Sales based portfolio: information and sharpe ratio rise with sales and revenue data.
- Dividend based portfolio the highest returns are not from the higest dividend giving companies. Since These companies are stable and value based and not in their growth phase. They are the most resilient during recession as well.

- Investment based portfolio have lesser returns with increase in investments. This could be because of higher leverage that a company takes to fund those investments. Also, higher investments are made by stable companies that are usually stable and dont give high returns. Sharpe and information ratios will be better because high investments companies will have low volatility.
- Profitability based portfolio have higher annualized return with high RoA and higher sharpe ratios. Highly profitable firms are generally overvalued in terms of PE ratio's. So during recession times, they are the ones that take the highest beating.
- Highest ranked RoA maybe have firms that use high leverage to generate high roa. So it maybe unhealthy to sustain such high leverage and thus have lower returns. rank 4 and 5 have stable returns.
- Asset turnover based portfolio have higher returns with higher asset turnover. Sharpe and information ratio have risen with rank of the portfolios, and tracking errors are dropping.

# 3 Market Variables

From the CRSP dataset we create the following market variables that can act as crucial factors for estimating portfolio returns.

- Beta from CAPM: (As done in the previous assignment). Higher beta stocks can expect higher returns since investors are taking higher systematic risk in hope of higher returns.
- Annualized volatility: low vol stocks generally tend to outperform the high vol stocks in the longer term.
- Annualized vol with mean Vol = 0
- Idiosyncratic Volatility: It is the stock specific risk. It can be noted that after performing the CAPM the beta is essentially the systematic risk and the error terms from regression is the idiosyncratic risk.
- We create the idiosyncratic volatility by 3 model, the standard CAPM, the 3 factor model, and the 3 factor model with momentum factor.
- Then perform a root mean square on the residuals, and annualize it to get the annualized idiosyncratic volatility.

## 3.1 Methodology for Smart Beta

- We perform regression on the stock returns and market returns to get the beta's and residuals.
- We perform regression on stock returns vs markets return, HML returns, SMB returns to get the beta and residuals for 3 factor models.
- We perform regression on stock returns vs markets return, HML returns, SMB returns to get the beta and residuals for 4 factor models.
- We source the data from ken french library.

- We rank the stocks according to the above mention **market variables** into 5 bins (ranks).
- We then attempt to create 5 portfolio's based on the ranks we obtain, and rebalance the portfolio's each year with newly ranked securities.
- We plot each of these portfolio returns along with the Market returns (VWRETD).
- We analyze the portfolio performances by the sharpe ratios, information ratio, volatility, skewness for each ranks.
- The plots and analysis for each protfolio are as follows.

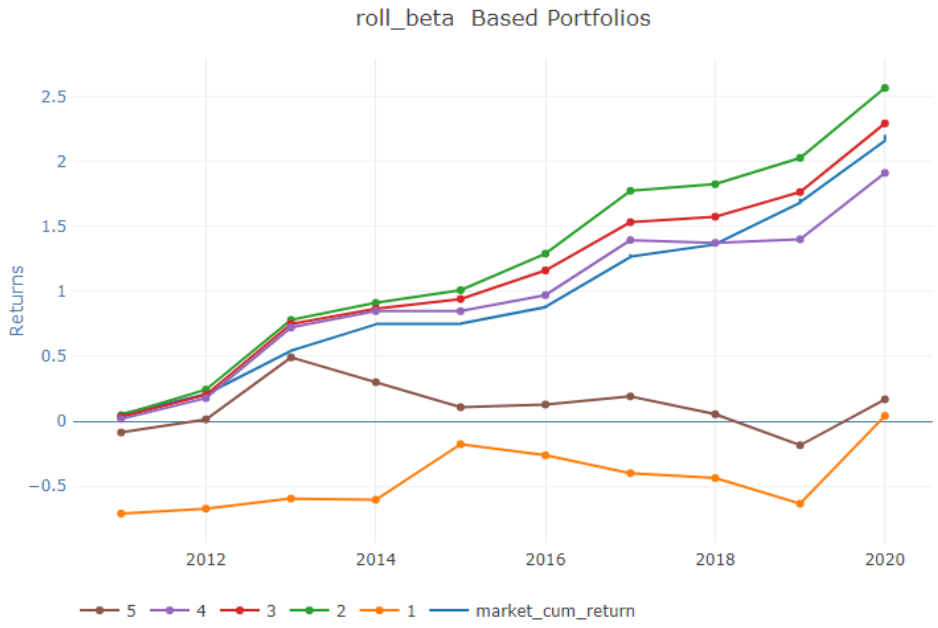


Figure 14: Beta based based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0040 | 0.0053 | 0.7452 | 1.2299 | 0.6315 | 0.7433 | -0.1585 | 0.7433 |
| 2 | 0.1355 | 1.1100 | 0.1221 | 1.3415 | 1.1804 | 0.0646 | 0.1904 | 0.0646 |
| 3 | 0.1265 | 0.9831 | 0.1287 | 1.6288 | 1.9713 | 0.0709 | 0.0426 | 0.0709 |
| 4 | 0.1127 | 0.7672 | 0.1469 | 1.2859 | 0.8388 | 0.0812 | -0.1279 | 0.0812 |
| 5 | 0.0156 | 0.0650 | 0.2403 | 0.9044 | -0.5291 | 0.1902 | -0.5569 | 0.1902 |

Figure 15: Beta based based portfolio analysis

## 4 Observations for Smart beta factors

Let us begin the rank based portfolio analysis

- Beta based portfolio shows us that high beta and low beta portfolio's don't compensate investors linearly for the amount of beta risk that they take. While the Sharpe ratio might be good for rank 2,3,4, the information ratio is low which signifies that investors are not compensated enough for the risk that they take to generate excess returns.

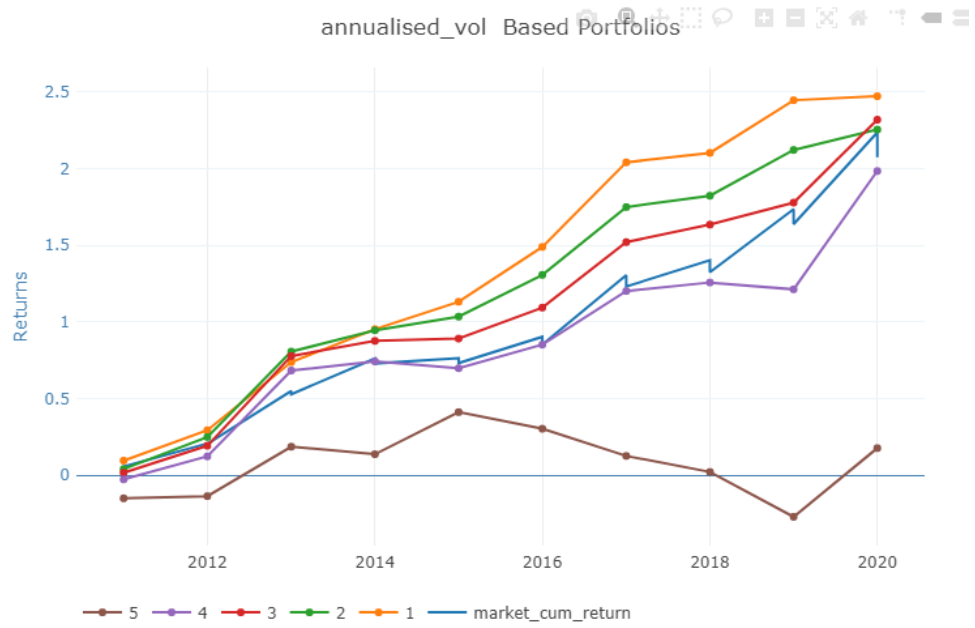


Figure 16: Annualized Volatility based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1325 | 1.3417 | 0.0988 | 0.7049 | 0.0768 | 0.0775 | 0.1026 | 0.0775 |
| 2 | 0.1252 | 0.9843 | 0.1272 | 1.6181 | 1.8040 | 0.0813 | 0.0137 | 0.0813 |
| 3 | 0.1274 | 0.8812 | 0.1446 | 1.5547 | 1.7035 | 0.0823 | 0.0496 | 0.0823 |
| 4 | 0.1155 | 0.6538 | 0.1767 | 1.0715 | -0.0401 | 0.1158 | -0.0580 | 0.1158 |
| 5 | 0.0164 | 0.0590 | 0.2778 | 0.9323 | -0.2420 | 0.2656 | -0.3857 | 0.2656 |

Figure 17: Annualized Volatility based portfolio analysis

- Annualized Vol based Portfolio: High annualised Vol based portfolio have low returns as compared to the market returns. Low vol portfolios have higher returns but still the information ratio's are not so high. These observations are inline with expectations.
- Annualized vol with Ri = 0 have similar observations to annualized volatility based portfolio.
- Idiosyncratic Volatility is the stock specific risk of the security which cannot be explained by any factors. High Idiosyncratic vol have higher volatility in portfolio returns and lower idiosyncratic vol have higher portoflio returns because there is no unsystematic risks. High idio syncratic vol have more potential to drop during recessions.

# 5 SHINY APP for better visualization

I have attempted a Shiny app implementation for the same plots where we can generate interactive plots to better visualize data and compare different rank based portfolio's with each other.

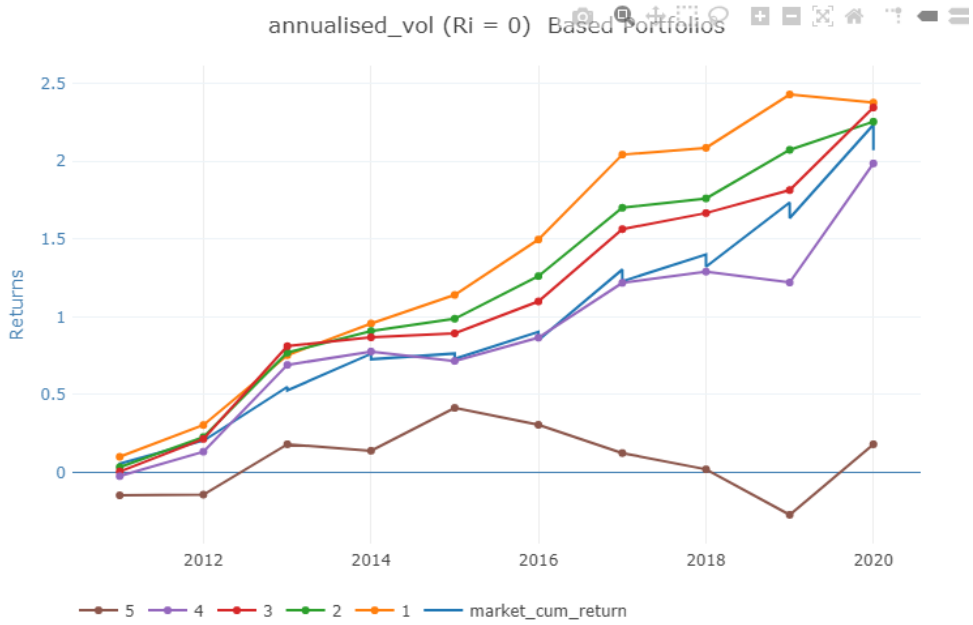


Figure 18: Annualized vol (Ri = 0) based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1294 | 1.2585 | 0.1028 | 0.5421 | 0.0093 | 0.0846 | 0.0575 | 0.0846 |
| 2 | 0.1252 | 0.9996 | 0.1253 | 1.6108 | 1.8559 | 0.0764 | 0.0136 | 0.0764 |
| 3 | 0.1283 | 0.8610 | 0.1490 | 1.3718 | 1.1358 | 0.0876 | 0.0580 | 0.0876 |
| 4 | 0.1156 | 0.6614 | 0.1747 | 1.0175 | -0.1033 | 0.1138 | -0.0608 | 0.1138 |
| 5 | 0.0168 | 0.0600 | 0.2797 | 0.9514 | -0.2084 | 0.2675 | -0.3810 | 0.2675 |

Figure 19: Annualized vol (Ri = 0) based portfolio analysis

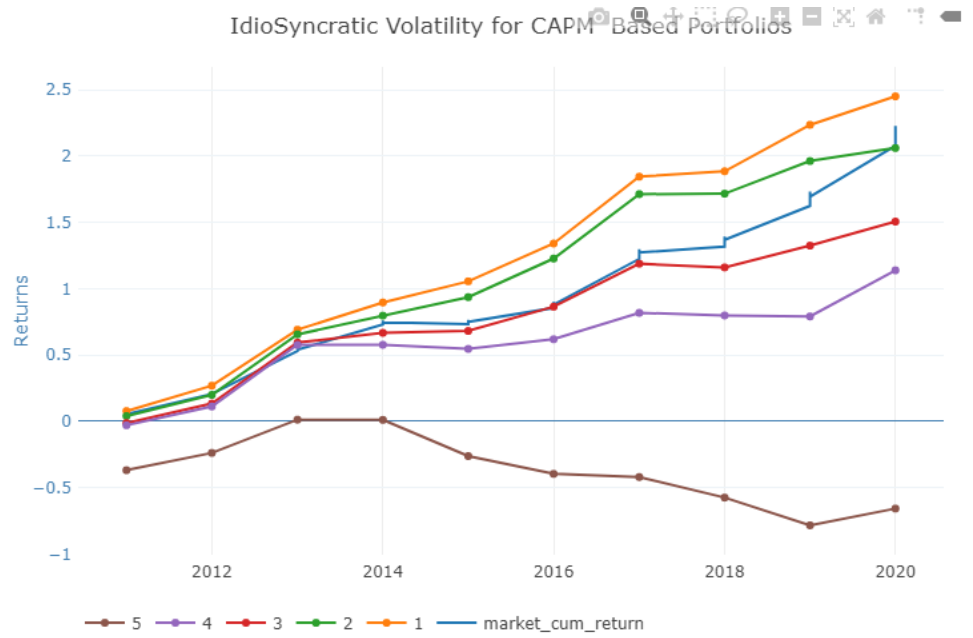


Figure 20: Idiosyncratic Vol (CAPM) based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1318 | 1.4654 | 0.0900 | 0.9530 | 0.4370 | 0.0558 | 0.2308 | 0.0558 |
| 2 | 0.1184 | 1.0662 | 0.1110 | 1.2450 | 0.8734 | 0.0739 | -0.0807 | 0.0739 |
| 3 | 0.0962 | 0.7749 | 0.1242 | 1.4921 | 1.6421 | 0.0682 | -0.4116 | 0.0682 |
| 4 | 0.0790 | 0.5630 | 0.1403 | 1.3799 | 1.0186 | 0.0826 | -0.5336 | 0.0826 |
| 5 | -0.1015 | -0.3013 | 0.3369 | 0.5651 | -0.7087 | 0.2891 | -0.7749 | 0.2891 |

Figure 21: Idiosyncratic Vol (CAPM) based portfolio analysis

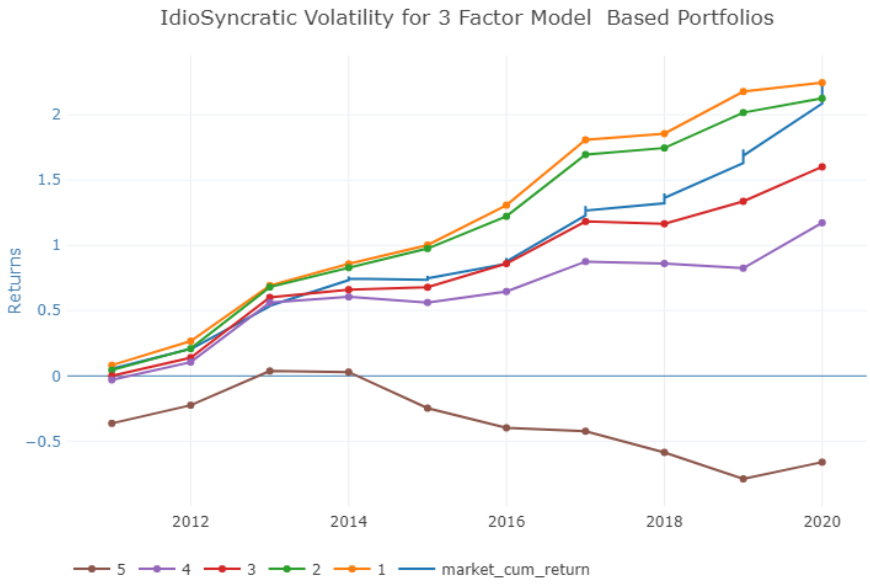


Figure 22: Idiosyncratic Vol (3 factor) based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1250 | 1.3010 | 0.0960 | 0.9024 | 0.2145 | 0.0694 | 0.0817 | 0.0694 |
| 2 | 0.1207 | 1.0976 | 0.1100 | 1.4695 | 1.4093 | 0.0715 | -0.0545 | 0.0715 |
| 3 | 0.1003 | 0.8233 | 0.1219 | 1.5027 | 1.7081 | 0.0637 | -0.3672 | 0.0637 |
| 4 | 0.0807 | 0.5811 | 0.1389 | 1.3084 | 0.9121 | 0.0786 | -0.5430 | 0.0786 |
| 5 | -0.1024 | -0.2972 | 0.3445 | 0.6144 | -0.6897 | 0.2966 | -0.7570 | 0.2966 |

Figure 23: Idiosyncratic Vol (3 factor) based portfolio analysis

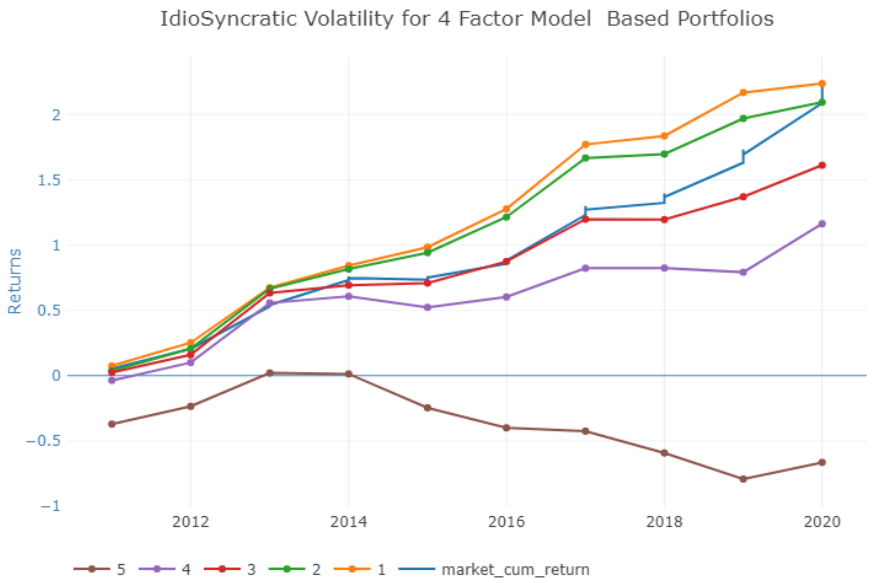


Figure 24: Idiosyncratic Vol (4 factors) based performances for each rank

| | AnnualizedReturn | AnnualizedSharpe(Rf=0%) | AnnualizedStdDev | Skewness | Kurtosis | AnnualisedTrackingError | InformationRatio | TrackingError |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1250 | 1.3010 | 0.0960 | 0.9024 | 0.2145 | 0.0694 | 0.0817 | 0.0694 |
| 2 | 0.1207 | 1.0976 | 0.1100 | 1.4695 | 1.4093 | 0.0715 | -0.0545 | 0.0715 |
| 3 | 0.1003 | 0.8233 | 0.1219 | 1.5027 | 1.7081 | 0.0637 | -0.3672 | 0.0637 |
| 4 | 0.0807 | 0.5811 | 0.1389 | 1.3084 | 0.9121 | 0.0786 | -0.5430 | 0.0786 |
| 5 | -0.1024 | -0.2972 | 0.3445 | 0.6144 | -0.6897 | 0.2966 | -0.7570 | 0.2966 |

Figure 25: Idiosyncratic Vol (4 factors) based portfolio analysis

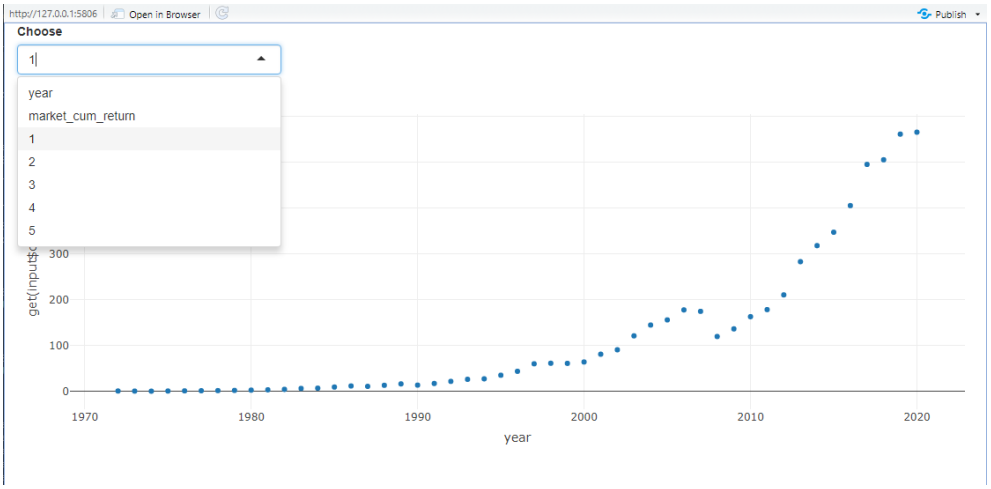


Figure 26: Snapshot of SHINY Implementation

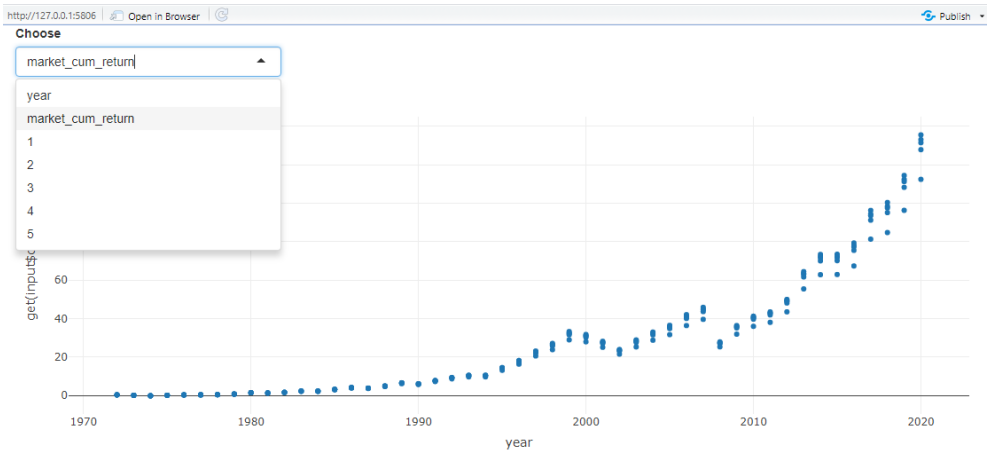


Figure 27: Snapshot of SHINY Implementation