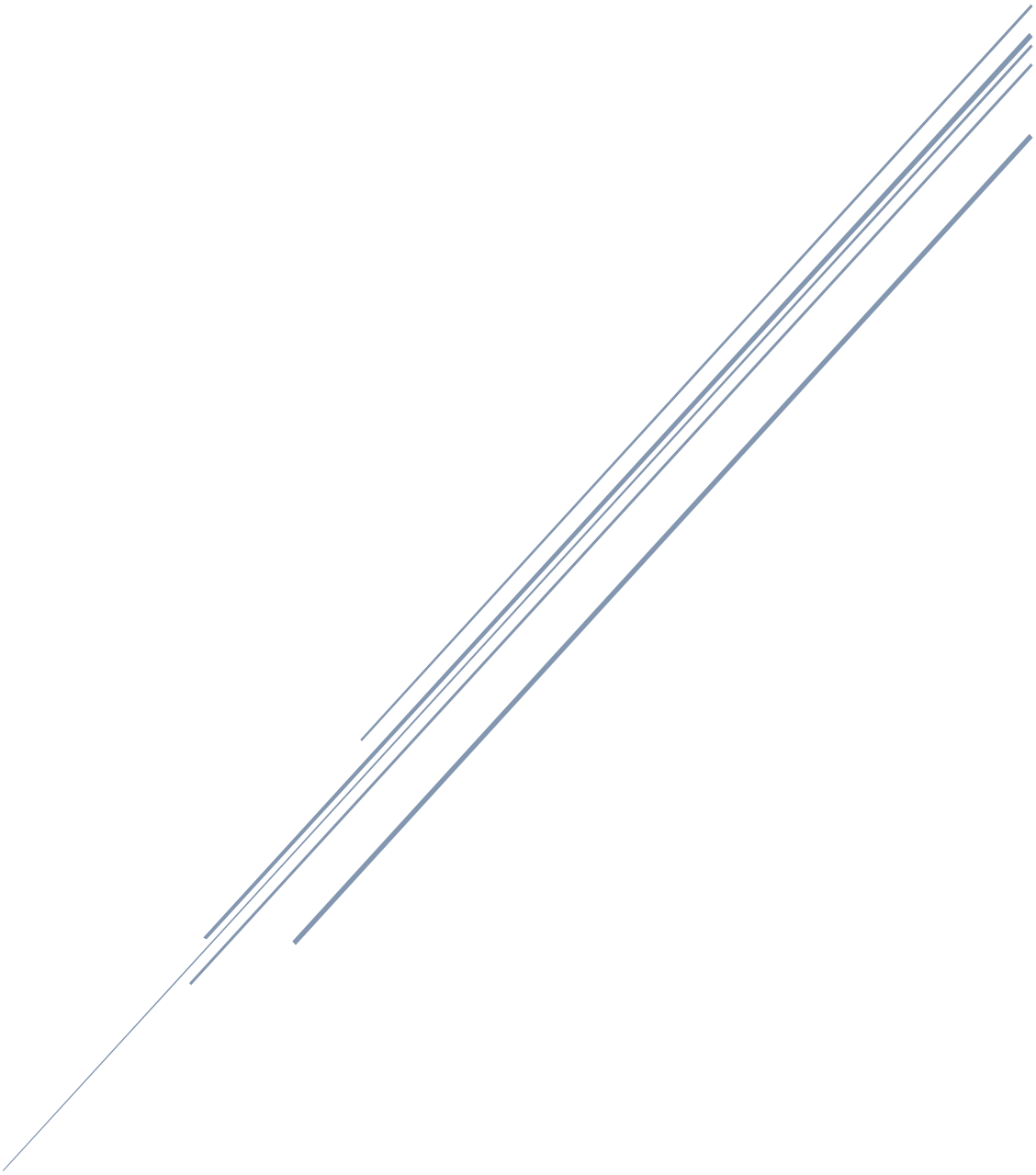
PORTFOLIO OPTIMIZATION

Assignment 2 – CS971 - Evolutionary Computation for Finance



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Garry James McBride - 20125102041663

Introduction

The following report is to investigate the development of a GA-based solution to optimise the weighting of a given portfolio of assets. Chosen stocks to create an optimal portfolio, a close look at their weekly values from dates roughly a year apart and deciding which stocks to keep or add to the portfolio will make the portfolio stronger. Risk and return are an important aspect of a portfolio, keeping the risk low and the return (profit) high is the main purpose to making money in today's stock marks.

Assets

Technology Boom

With the 'boom' in the technology industry in recent years, and the industry screaming out for programmers, I thought it would be interesting to see how the companies hiring are doing financially. Given that when an individual becomes employed at an organization, they are offered stock options to invest in their new-found employer. An interesting approach will be to see what differently valued companies below and above certain market caps are progressing and if they are indeed worth investing in.

Stocks

A total of 37 stocks were chosen from a diverse selection of current computer software or computer manufacturing companies, using the 'QuantMod' library in R-Studio, used to manage the quantitative financial modelling workflow. The stocks were selected from the New York Stock Exchange (NYSE) and are split by capital market. Chosen from the Mega Cap (over 200 Billion or more), 6 were chosen, along with 13 from the Large Cap (10 Billion), 10 were chosen from the Middle Cap (2 Billion) and finally 8 were chosen from the Small Cap (300 Million).

After running the stocks, DELL, Dropbox and ASE Technology were cut from the portfolio as they failed to provide data. Shortly after finding the means of the weekly returns, the portfolio had a lot of negative stocks that stood out compared to the positive or only slightly negative. Large companies such as: Facebook (FB), Electronic Arts (EA), International Business Machines Corporation (IBM), Nvidia (NVDA), Snap Inc (SNAP) and GoDaddy (GDDY)

were removed. Along with these highly successful companies, only a selected few were removed from the Middle Cap and Smaller, not as many as the larger markets.

Since the technology industry is changing every day, it seems more fitting to use the dates from January 2018 to January 2019 covering the realise of new mobile phones or products sold by these companies, and by the recent advances in military technology and the every growing need for defence, a year is the best date range to judge the stocks prices since we are in an every advancing world.

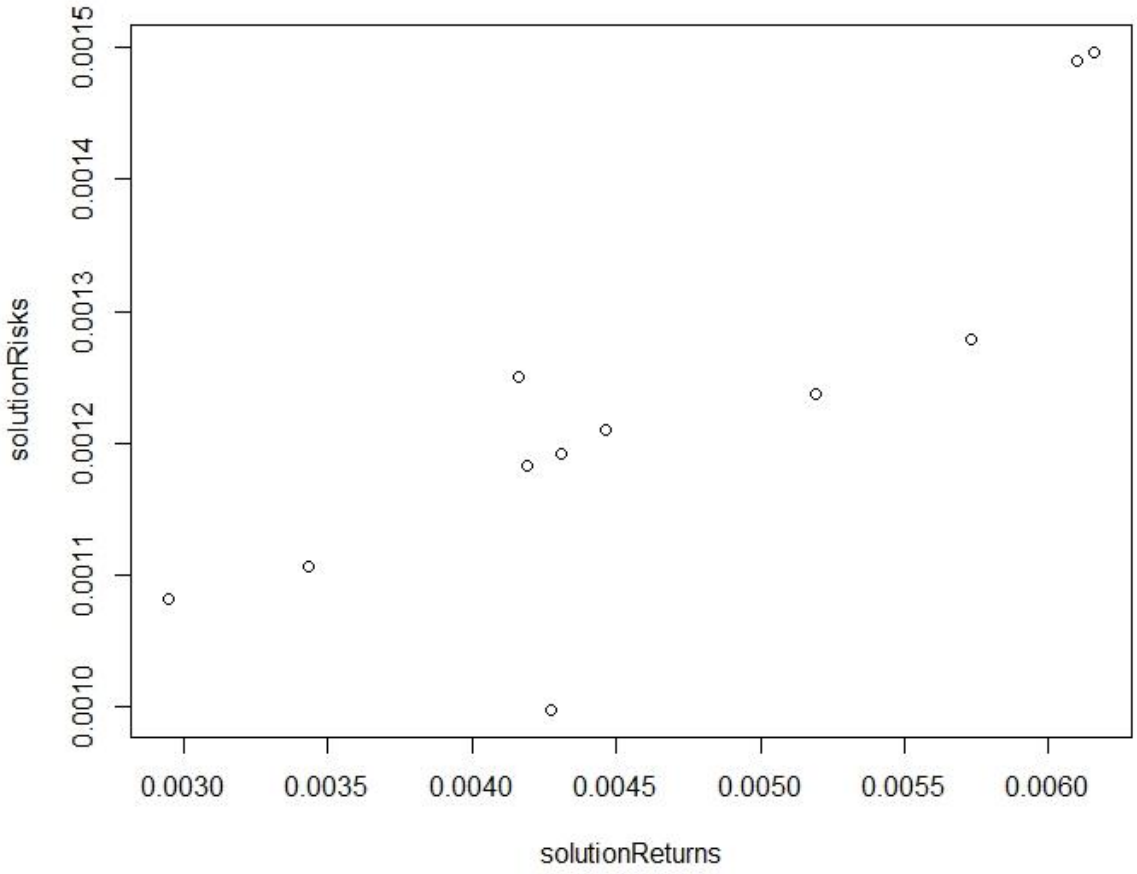

Figure 1 – Solution Risks & Returns

Results

From the run of the algorithm, a risk and return came from the algorithm's best solution, and the risk was considerably lower than the return, show a profit to be made in these selected stocks. Taking away negative stocks, no matter how big the organization is, has

helped this portfolio make a profit with a low risk. A small trend does follow the rise in profit, where the risk does follow, but even though it rises, it is very small in comparison to the growth of the return.

GA Details

Using the 'GA' Package in R-Studio, the fitness function in the package does not support multi-object solution, a combination of risk and return into one function will need to be done, along with thinking carefully about what to maximise or minimise.

The fitness Function is Multi-objective, meaning that there is more than one variable contributing to the fitness value. The Algorithm runs 11 times, using 11 different weights ranging from 0-1, the fitness function multiples the weight of the chromosome from the return, and using the chromosome from the risk to calculate for both.

Weights

Weights are constraint as follows; sum of the total number of assets with the asset 'i' which is = 1, where weight of asset 'i', is between 0-1. Each asset has an expected return value of the following; The mean of asset 'i' is = 1 of the amounts of stocks used. The risk is measured by considering the variance of the portfolio, calculated using the covariance between the returns of two assets. From the calculation it is the selection of both assets i & j, where i is = 1 and j is = 1 out of 7 stocks in total being used, each asset counts as 1 of the selected 7 stocks.

Multi-Objective Optimization & Pareto Front

Multi-objective optimization is where single-objective cant be used because of multiple variables. In a multi-objective problem, considering a car manufacture for example, would consider speed, along with other aspects like price, handling, comfort, fuel etc. A solution now has other things to take into consideration. For instance, a single objective issue would only look for speed, but a multi-objective problem would look for the best speed along with another variable, in this case handling, it tries to find a solution that produces a high ratio with both factors.

If the single-objective issue has a speed of 70, it is best, but when another factor is added, the solution changes, where the handling of the car might be low and choosing the handling factor first will mean the speed of the car will decrease dramatically. Using a pareto front, the variables that are dominated by other can be seen and then excluded from a solution putting forward the more effective solutions for more positive results.

In the case of stocks, we use weight to find our solution as that is the money being invested in the stock. An alternative is to use pareto optimal search. Giving a problem with a range of numbered fitness functions from fitness function 1 to the total number that take to vector of some parameters. Parameters are numbers that are in some way controlled or given in advance, such as money being invested by someone, or being kept the same or constraint within the given solution.

GA Implementation

Using a population of 700, the algorithm as stated above runs 11 times with different weights from 0-11, if the best fitness value stays the same after 50 iterations then the algorithm stops. The solutions the GA's has provided are yet to be scaled to then find out the risk and return for the best possible solutions from different weights.

Results on the evolved solution

Performance & Result Analysis

The portfolio results are both intriguing and confusing, the fact that larger companies who are more known and worth a lot more in both capital and revenue were excluded due to the fact of the poor mean from the weekly returns. Considering the difference in money being invested in these companies, the smaller market companies proved to have better mean values than larger ones, this proved not to have the best return, but it played it key role in securing a low risk factor.

Risk is just as important as return, so by controlling risk and paying attention to it just as much as making a profit from stock, the potential for a larger profit over the course of time by carefully analysing the market instead of using money to basically gamble it away in the hopes of making some money which could potentially prove to be a bad investment if risk is not taken seriously.

Best Solution

The GA that has been designed takes both factors seriously and focuses on them making it reliable and accurate. The best solution is from **run 4** with a risk value of ***0.0012788173*** and a return value of ***0.005732679*** and has a fitness value of;

GA | iter = 130 | Mean = 0.005739244 | Best = 0.006334833

The reason for this being the best solution is its high fitness value in only run 4, where in run 11 a fitness value was smaller, and the return wasn't the highest in the in the graph (see figure 1) but had a very small risk factor compared to two solutions higher in return but the risk in much larger. Profit isn't something that will a happen overnight, and security has to a key factor when using money in a large market where there are many ups and downs. Not chasing the money and being clever when investment money is the best method for success, the algorithm follows that rule and the best solution mirrors it.

Analysis of the evolved portfolios

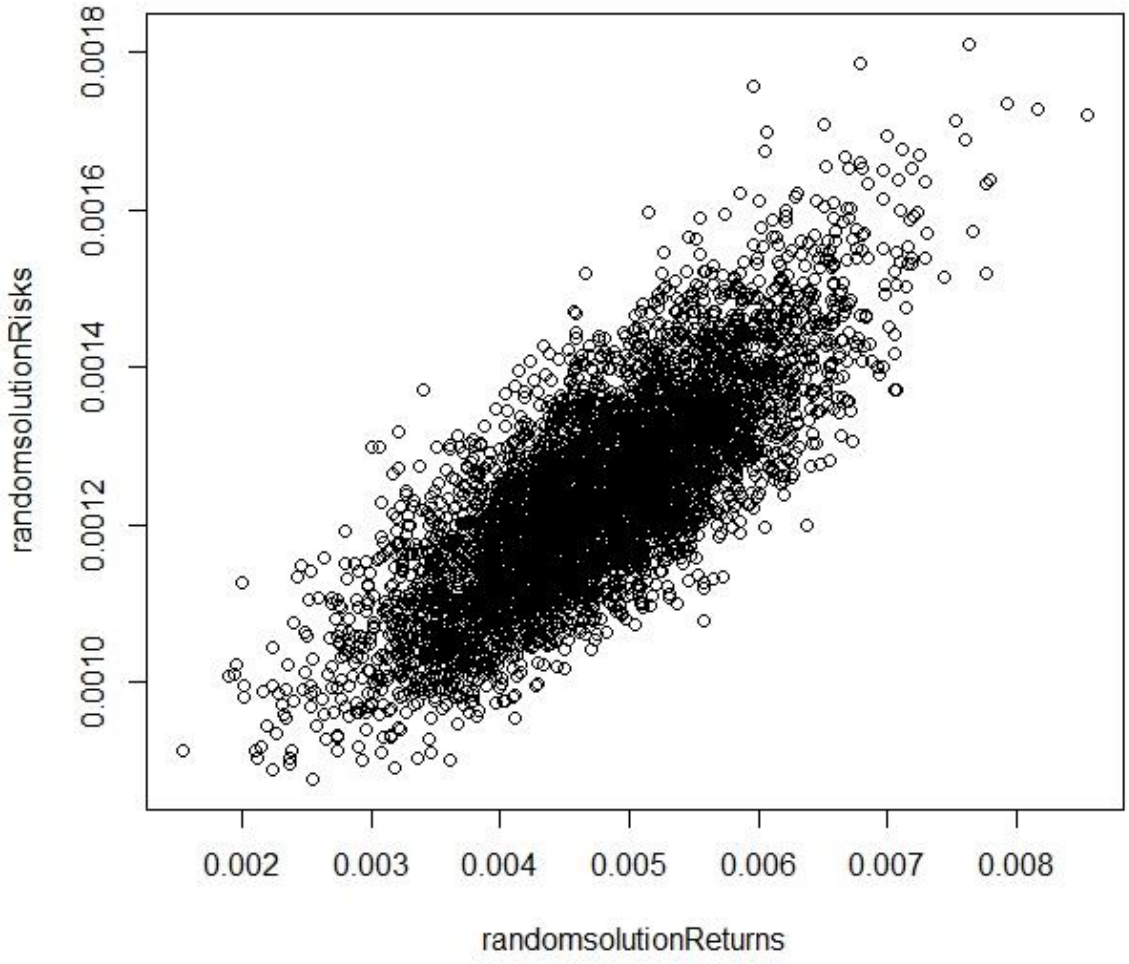

Figure 3 – Random Solution Returns

Comparing the Portfolio to randomly generated portfolios in the range of 5000 chromosomes and compared with the same weights as before, the risk factor has stayed similar, but the Returns has decreased dramatically. Figure 3 shows that randomly generated weighted solutions do not have the same accuracy or reliability towards keeping risk low and return high as the Genetic Algorithm does.

The best solution from the randomly selected weights regarding return is **0.00334585** with a risk value of **0.00455857**. Because of the poor risk values, a high return value isn't selected for a good solution based on the increase in risk, causing the

investment to be pointless in a way to get a high return with more than 3 times the risk, a gamble that wouldn't want to be taken in the market.

Future performance of portfolios

The solutions were tested on data not seen yet from January 2019 – February 2019. If the solutions tested on unseen data proves to be as reliable as the data from the past year, this shows the portfolio can be used again and can be trusted.

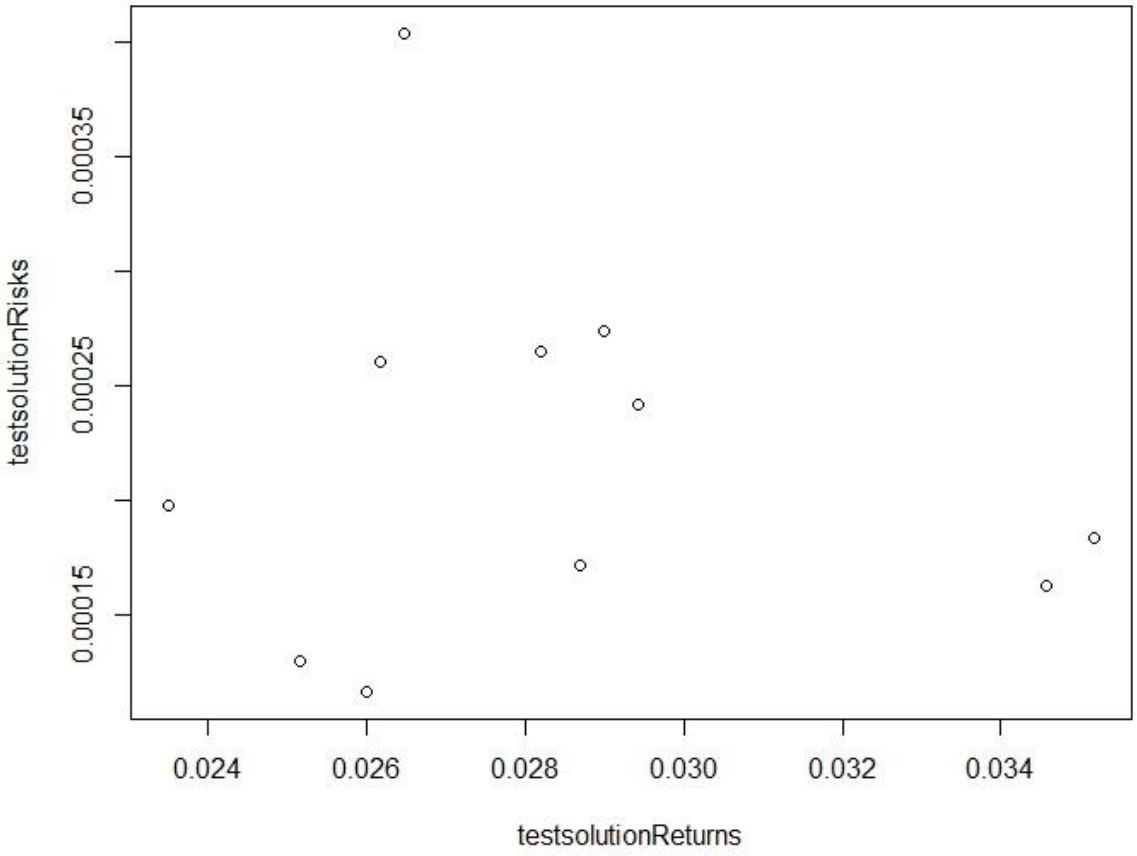

Figure 2 – Test Solution Returns

The results shown in figure 2 show a decrease in returns but also a massive decrease in risk as well. This shows the portfolio that has been built is sticking to the trend of concentrating on risk with an average return.

Giving that this portfolio was designed focusing on risk, from an extra month of unseen data it seems like it performs well, but unfortunately on a smaller scale than before.

Conclusion

After using random search to test its performance against the algorithm, highlighting the reversed results, comparing the solutions to new/unseen data, the Portfolio is successful in terms of focusing on risk whilst also giving a good return. The GA can run quickly and access information or results with speed and accuracy.

Based on the results and the companies that were used and excluded, I think when people are buying stock options from their employers, they need to closely look at how that company are doing in the stock market. Not that someone who is a new employee is going to lose millions, but from the diversity of start ups replacing large company stocks in this assignment because of how risky larger companies are, causes a slight concern or opportunity to learn about stocks you are investing in based on their statistics and not their stature or brand.

Implementing a genetic algorithm to a financial objective has been both interesting and creative.