Information Management and Business Review (ISSN 2220-3796)
Vol. 11, No. 2, pp. 35-41, June 2019

Excel Based Financial Modeling for Making Portfolio Management Decisions

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Abstract: The Excel based financial model proposed in this paper provides a very simple but powerful method for portfolio selection. Apart from a simple and powerful tool for making portfolio management decisions, the paper also proposes an easy to use technique for calculating portfolio standard deviation without using correlation coefficients. The model uses "Excel Solver Add-In" to create an optimum portfolio by maximizing the Sharpe ratio. Benefits of Sharpe style optimization are demonstrated using data on monthly returns from 1999 to 2010 covering 30 stocks.

Keywords: *Portfolio optimization, Sharpe ratio, portfolio standard deviation, financial model.*

1. Introduction

Investors, fund managers and financial analysts buy securities from capital markets and stock markets in order to create an investment portfolio. Securities which they buy can be either debt type instrument such as bonds issued by government entities (example Central Bank of Oman development bonds) and private companies, or equity type instruments – primarily shares sold in stock markets such as the Muscat Securities Market (MSM). Debt instruments such as bonds earn a fixed annual interest, but the price at which they are traded in the markets may vary according to a variety of factors, and therefore capital gains and losses are possible. Since the extent of price fluctuation is less, bonds (and debt instruments) can be classified as low risk securities. On the other hand, the prices of shares can vary a lot depending on expectations regarding firm performance, industry performance and general economic environment. Compared to debt instruments, risk of equity instruments is higher. Risk related to capital market securities such as shares and bonds is measured using standard deviation of historical returns. The higher the standard deviation higher is the risk in including a particular security in the portfolio of assets held by an investor or an institution.

Modern portfolio theory says that portfolio risk is not the sum total of the risk of each individual security included in the portfolio. Markowitz in his seminal study shows that when two securities with negative correlation are included in a two asset portfolio, the risk of the portfolio is less the than the sum of the individual risks, because returns on these two assets tend to move in the opposite direction over time and therefore loss due to one security is set of by gain in the other security. Modern portfolio theory therefore proposes that while poorly correlated. The principle of diversification, one the main tenets of modern portfolio theory, shows that diversification is useful only when the securities included in the portfolio have low positive or preferably negative correlations. Diversification yields no benefits when securities included in the portfolio have perfect positive correlation. Further past empirical research shows that as the number securities included in the portfolio keep increasing the standard deviation of the portfolio keeps on declining, but the benefits of diversification disappear (or are greatly reduced) when the number of stocks in the portfolio goes beyond thirty.

Estimation Problems and Excel Based Solution: "The number of correlation estimates can be significant – for example, for a portfolio of 100 securities, the number is 4,950" (Reilly & Brown, 2006, pp. 239). Combining all these correlations using the portfolio variance formula given in Table 1 can be tedious, time consuming and can result in estimation risk. An innovative approach to estimating portfolio standard deviation (and portfolio variance) is suggested in this paper, and, is one of the two important contributions this paper. This paper suggests a Microsoft Excel based financial model which can be used for estimating portfolio standard deviation. The model is very powerful to the extent it can be easily extended to include any number of securities in the portfolio. The Excel based model was tested with 30 securities, to calculate portfolio standard deviation and to create an optimum portfolio by minimizing the Sharpe ratio – that is the ratio of portfolio excess returns divided by portfolio standard deviation. The final result of the portfolio selection process is to arrive at weights to be attached to each security. The weights show the percentage of

funds to be invested in each security. If the weight arrived in the portfolio selection process is zero, this implies that the security should be dropped from the portfolio. The equations which are used in calculating the return and risk of a portfolio of securities are shown in Table 1 given below.

Table 1

- Expected return:

$$\mathrm{E}(R_p) = \sum_i w_i \mathrm{E}(R_i)$$

where R_p is the return on the portfolio, R_i is the return on asset *i* and w_i is the weighting of component asset i (that is, the proportion of asset "i" in the portfolio).

- Portfolio return variance:

$$\sigma_p^2 = \sum_i w_i^2 \sigma_i^2 + \sum_i \sum_{j \neq i} w_i w_j \sigma_i \sigma_j \rho_{ij},$$

where ρ_{ij} is the correlation coefficient between the returns on assets *i* and *j*. Alternatively the expression can be written as:

$$\sigma_p^2 = \sum_i \sum_j w_i w_j \sigma_i \sigma_j \rho_{ij},$$

where $\rho_{ij} = 1$ for *i=j*.

- Portfolio return volatility (standard deviation):

$$\sigma_p = \sqrt{\sigma_p^2}$$

For a **two asset** portfolio:

- Portfolio return: $\mathrm{E}(R_p) = w_A \mathrm{E}(R_A) + w_B \mathrm{E}(R_B) = w_A \mathrm{E}(R_A) + (1 - w_A) \mathrm{E}(R_B).$
- Portfolio variance: $\sigma_p^2 = w_A^2 \sigma_A^2 + w_B^2 \sigma_B^2 + 2 w_A w_B \sigma_A \sigma_B \rho_{AB}$

For a **three asset** portfolio:

- Portfolio return: $\mathrm{E}(R_p) = w_A \mathrm{E}(R_A) + w_B \mathrm{E}(R_B) + w_C \mathrm{E}(R_C)$
- Portfolio variance: $\sigma_p^2 = w_A^2 \sigma_A^2 + w_B^2 \sigma_B^2 + w_C^2 \sigma_C^2 + 2 w_A w_B \sigma_A \sigma_B \rho_{AB} + 2 w_A w_C \sigma_A \sigma_C \rho_{AC} + 2 w_B w_C \sigma_B \sigma_C \rho_{BC}$

Source: https://en.wikipedia.org/wiki/Modern_portfolio_theory

As shown in the above table calculating the portfolio return is fairly straight forward as it is just the weighted average of the returns on each individual security included in the portfolio. This formula can be easily estimated even if the portfolio has a large number of securities. However, portfolio standard deviation is not

just the weighted average of the standard deviations of individual securities, nor is the portfolio variance a simple weighted average of variances of individual securities. To calculate portfolio standard deviation or portfolio variance it is necessary to include the pairwise correlations of all securities included in the portfolio. As shown in Table 1 for a two asset portfolio only one pairwise correlation (viz., correlation between security A and security B) is required. However, for a three asset portfolio consisting of three securities (A, B and C) three correlation coefficients are required, and for a four asset portfolio the number of correlations required are 6 and so on. The number of correlations required keeps increasing exponentially posing an estimation problem.

Table 2: Estimating Portfolio Standard Deviation without using Correlation Coefficients

	B	C	D	E	F	G	H	I	J
2		Returns							
3	**Date**	**Market Index**	**AA**	**BB**	**CC**	**Risk-free rate**			**Portfolio Weights**
4	1/12/2000	-3.1%	-6.3%	2.5%	18.7%	7.9%			
5	1/12/2001	30.5%	31.9%	14.5%	24.7%	6.6%		AA	59.6%
6	1/12/2002	7.6%	4.6%	16.9%	19.9%	4.2%		BB	0.0%
7	1/12/2003	10.1%	6.1%	-15.9%	-9.1%	3.5%		CC	40.4%
8	1/12/2004	1.3%	20.1%	6.5%	0.3%	3.5%			100.0%
9	1/12/2005	37.6%	28.7%	39.8%	69.2%	7.1%			
10	1/12/2006	23.0%	38.3%	11.6%	17.8%	5.1%		constraint	100.0%
11	1/12/2007	33.4%	30.3%	45.9%	5.5%	5.6%			
12	1/12/2008	28.6%	-9.8%	14.1%	12.8%	5.2%			
13	1/12/2009	21.0%	26.9%	-27.4%	22.3%	4.5%			
14									
15	**Date**	Portfolio Returns	Portfolio Excess Returns						
16	1/12/2000	3.8%	-4.1%						
17	1/12/2001	29.0%	22.3%						
18	1/12/2002	10.8%	6.6%						
19	1/12/2003	0.0%	-3.5%						
20	1/12/2004	12.1%	8.6%						
21	1/12/2005	45.0%	38.0%						
22	1/12/2006	30.0%	24.9%						
23	1/12/2007	20.3%	14.7%						
24	1/12/2008	-0.6%	-5.9%						
25	1/12/2009	25.0%	20.5%						
26	Portfolio Return	17.54%	12.21%		Sharpe Return to Risk Ratio	**0.86**			
27	Standard Deviation of the Portfolio	14.17%							

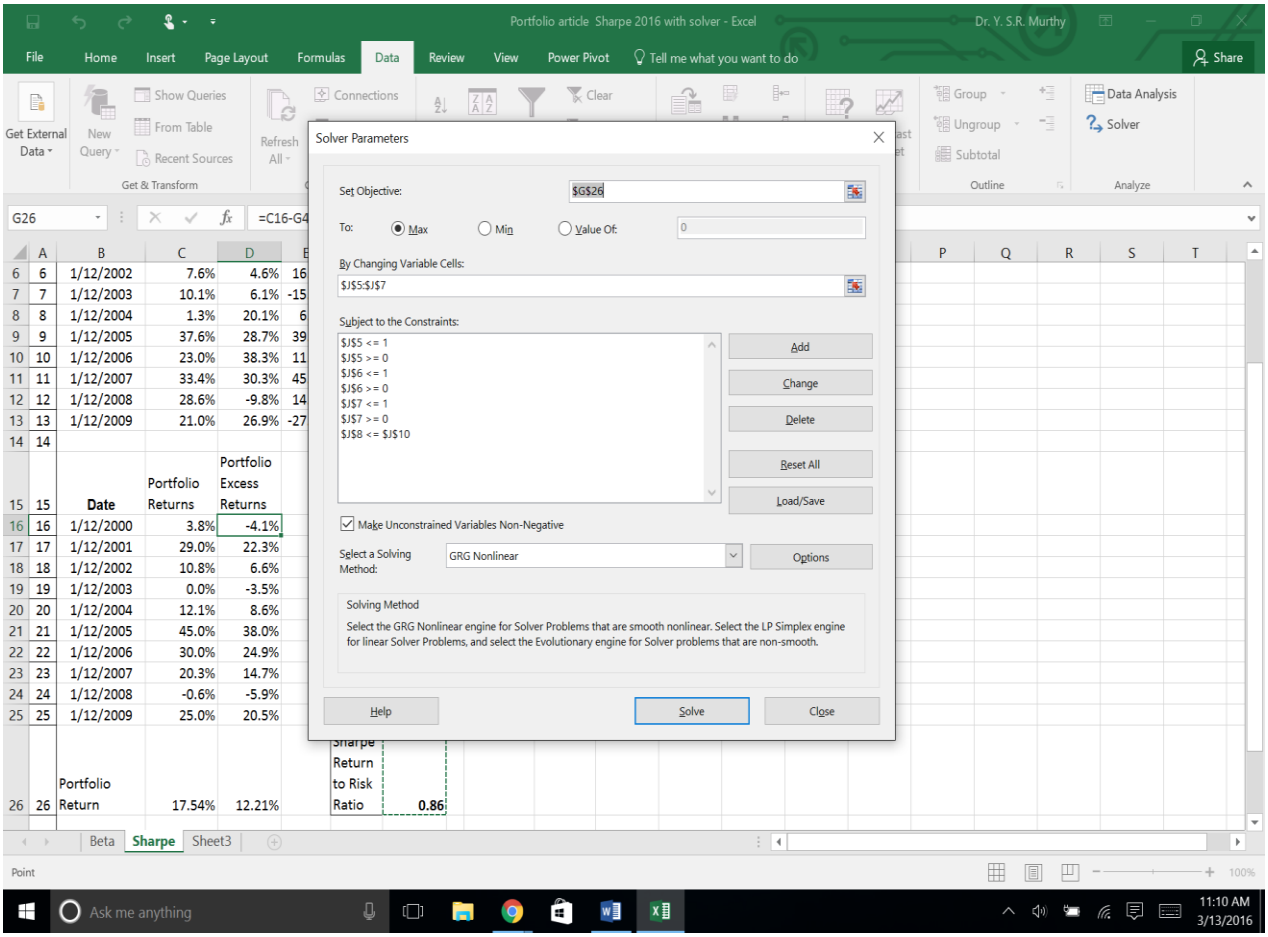
2. Estimating Portfolio Standard Deviation without Correlation Coefficients

As mentioned earlier estimating portfolio standard deviation is fraught with difficulties when there are large numbers of securities in the portfolio. In this section a simple method of estimating portfolio return is presented. The first step of the estimation is to calculate the portfolio return for each period. As shown in Table 2 above, the portfolio returns for each year from year 2000 to year 2009 has been calculated (cells C16 to C25). The formula used for estimating portfolio return for each year is the weighted average of the returns of individual securities (specifically with reference to Excel sheet in Table 2 the formula is "=$J$5*D4+$J$6*E4+$J$7*F4"). The second step is to calculate portfolio returns for the whole period (year 2000 to year 2009) by taking the average of each year portfolio returns (specifically with reference to the Excel sheet in Table2 the formula used is "=AVERAGE (C16:C25)"). The next step is calculating portfolio standard deviation, which can be done by calculating standard deviation of portfolio returns of each year (specifically with reference to the Excel sheet in Table 2 the formula used is "=STDEV.P(C16:C25)"). Portfolio standard deviation obtained through this method is exactly the same as the portfolio standard deviation calculated by using the pairwise correlation coefficients. However, as demonstrated, the method presented in this paper is very simple compared to the pairwise correlation method.

Optimal Portfolio Selection using Sharpe Ratio: In the financial model presented in this paper the optimal portfolio is created using the method of maximizing the Sharpe Ratio. In his original paper Sharpe (1994) says that "properly used, it can improve investment management". Sharpe Ratio = [(Portfolio Return – Risk Free Rate)/ Portfolio Standard Deviation]. To calculate the Sharpe ratio, we first need to estimate portfolio excess returns (Beninga, 2006). Portfolio excess return is portfolio return minus risk free rate (specifically with reference to the Excel sheet presented in Table 2 the formula is "=AVERAGE(D16:D25)", where each of the cells D16 to D25 have been calculated subtracting risk free rate from the portfolio return of the specific year "=C16-G4"). Sharpe ratio is calculated by dividing portfolio excess returns by portfolio standard deviation. Sharpe ratio shows excess returns obtained by the portfolio manager per unit of risk taken, where risk is measured using portfolio standard deviation. Sharpe ratio is a well-accepted measure of performance of portfolio managers and fund managers (Reilly & Brown, 2006).

In this paper portfolio selection is done my maximizing the portfolio Sharpe ratio. In this paper the process of portfolio optimization was done using the "Excel Solver Add-In". The solver allows for maximizing the Sharpe ratio subject to a series of constraints. The key constraints used in this paper, as well as the method used in implementing solver are shown in Table 3 given below. Two types of constraints were used. One set of constraints ensure that the weight of each security in the portfolio remains between 0 and 1, implying that the amount invested in a particular security is more than zero but less than total amount of funds available for investment. The other constraint ensures that the sum of weights is less than 100%. The final optimized portfolio is shown in Table 2. It shows that in the final portfolio only two out of the three securities are included. Stock BB has a zero weight. The solver solution also indicates that 59.6% of the available funds should be invested in stock AA, and 40.4% in stock CC. The financial model can be easily extended to include more number of securities. As mentioned earlier the Excel model was tested with a portfolio of 30 securities.

Table 3



3. Test Results

In this section the results of testing the excel model with a portfolio of 30 securities are presented. For the purpose of constructing the optimized portfolio, the thirty stocks comprising the Dow Jones Industrial Average were included in the original equity portfolio. Estimation was done using monthly returns from January 1999 to December 2010. One stock (Kraft Foods) had to drop due to non-availability of data from 1999. The objective of the optimization process was to create a portfolio which maximizes the Sharpe Ratio subject to a 15% constraint on the weight of each stock included in the optimized portfolio. Nine stocks out of the thirty were selected by the Solver software during the optimization. Table 4 shows the benefits of the optimization process in terms of improvement in annualized returns and reduction in risk (measured by standard deviation). Table 5 given below reports the original equally weighted portfolio and the optimized equity portfolio.

Table 4: Beneficial effects of Sharpe Optimization

	Annualized Returns%	Sharpe Ratio	Monthly Standard Deviation%
Equally Weighted Portfolio	8.025	0.0927	4.83
Optimized Equity portfolio	12.33	0.176	4.57

Table 5: Original versus Optimized Portfolio

Original Equity Portfolio		**Optimizing Equity Portfolio**	
Sharpe Ratio	0.0927	Sharpe Ratio	0.176
Stocks drawn from Dow Jones Industrial Average	**Weight**	**Stocks selected during optimization process**	**Weight**
CHEVRON	3.45%	CHEVRON	15%
PROCTER	3.45%	PROCTER	15%
3M	3.45%	3M	14%
CATERPILLAR	3.45%	CATERPILLAR	13%
UNITED TECH	3.45%	UNITED TECH	12%
EXXON MOBIL	3.45%	EXXON MOBIL	10%
Mc DONALD	3.45%	Mc DONALD	9%
HP	3.45%	HP	6%
TRAVELLERS	3.45%	TRAVELLERS	5%
JOHNSON	3.45%		
VERIZON	3.45%		
DISNEY	3.45%		
ALCOA	3.45%		
AMEX	3.45%		
ATT	3.45%		
BANK AMER	3.45%		
BOEING	3.45%		
CISCO	3.45%		
COKE	3.45%		
DUPONT	3.45%		
GEN ELEC	3.45%		
HOME DEPOT	3.45%		
IBM	3.45%		
INTEL	3.45%		
JPMORGAN	3.45%		
MERCK	3.45%		
MICROSOFT	3.45%		
PFIZER	3.45%		
WALMART	3.45%		

4. Summary and Conclusion

The Excel based financial model proposed in this paper gives a very simple but powerful method for portfolio selection. Apart from being a simple and powerful tool for making portfolio management decisions, the paper proposes an easy to use technique for calculating portfolio standard deviation without using correlation coefficients. Further revisions to the model so as to include borrowing and lending and short selling in portfolio management are possible.

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