Optimising a product portfolio of an IT-company

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1. Introduction

In an economic crisis it is crucial for success to have a balanced and profitable product portfolio. Companies tend to neglect the balance in their portfolio as they are adrift in growth, competition, production and delivery. From the domain of IT-portfoliomanagement (see Kersten & Evans, 2003, Kersten & Verhoef, 2003 and Verhoef, 2002) initiatives have been taken to apply quantitative techniques from portfolio theory to the IT-domain. Also the use of these techniques to "common" product portfolio's of companies has been tested. Central starting point in all these experiments is Markowitz's modern portfolio theory (MPT). The assumptions underlying this theory, which might be obstacles for a correct application, are studied and solutions are found. The results are promising but also the results in the slipstream: portfolio management techniques contribute to the transparency and decision making in the extensive IT-domain. A obvious example of the need for such an approach in IT is the Clinger-Cohen Act which has been accepted in the Senate of the United States of America.

In this article we present results of the application of Markowitz's modern portfolio theory on a product portfolio of an IT-company. Starting with a short introduction, the portfolio problem of the IT-company is described. The constraints on the problem are described and the optimal results are presented. These results give the executive board insight in which direction to adjust the portfolio. This article ends with a discussion on the assumptions underlying the application of MPT on such a practical case. The results of this application yield perspective for the use on other portfolios as assumptions and conditions are more often met and data on the products are available.

2. Markowitz's Modern Portfolio Theory

The modern portfolio theory is constructed initially by Harry Markowitz [19..]. It is based on sophisticated investment decision approach that permits an investor to classify, estimate, and control both the kind and amount of expected risk and return. One of the essential parts of the modern portfolio theory is the quantification of the risk/return ratio. The fundamental goal of Modern Portfolio theory is to optimally allocate investments between different assets.

Modern Portfolio Theory is associated with mean variance return/risk analysis. A mean variance model minimises the portfolio risk for a given level of expected return. The volatility of an investment/asset is measured by the standard deviation of its return. Markowitz identifies the standard deviation of the portfolio return as the portfolio risk.

The mean-variance model has some underlying assumptions. First of all, the model is based on a single period model of investment. This means that the investor allocates its wealth among different assets in the beginning and harvests the returns at the end. Three measures are necessary for using the mean-variance model. The standard deviation of the return of each asset i (denoted by σ_i), the expected return over a given time of period per asset and the correlation between each pair of assets are required. The variance or the standard deviation of an assets return over a given time of period is a standalone risk, also called the undiversified risk. The general idea is to minimise the portfolio's standard deviation of returns for a given level of expected portfolio return, considering the correlation of each pair of individual asset. The portfolio risk, standard deviation of portfolio returns, is denoted by σ_p, and is derived by

$$\sigma_p = \sqrt{\left(\sum_{i=1}^{N} X_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{\substack{j=1 \\ j \neq i}}^{N} X_i X_j \sigma_{ij} \right)}$$

X_i represents the position of asset i in the portfolio.

$$\sum_{i=1}^{n} X_i = n$$

where n is the number of assets in the portfolio

$$\sigma_{ij} = \rho_{ij} \sigma_i \sigma_j$$

ρ_{ij} is the correlation between asset i and j.

Modern portfolio theory assumes that for a specified expected portfolio return, a rational investor would choose the portfolio with the smallest possible risk and visa versa. A portfolio is said to be *efficient* if there is no portfolio having the same standard deviation with a greater expected return and there is no portfolio having the same return with a lesser standard deviation. The *efficient frontier* is the collection of all these efficient portfolios. An example of the efficient frontier is displayed in figure 1.

The graph in figure 1 is an example of an efficient frontier with the following four different portfolio positions:

- Current portfolio: This is the point where the current portfolio is situated. The mean return and volatility is well below the efficient frontier.
- Max return: This point on the efficient frontier is the portfolio with the same volatility as the current portfolio. By optimal changing of positions in the portfolio an efficient portfolio with the same volatility and maximal return is given by this point on the efficient frontier.
- Min Risk: This point on the efficient frontier is the portfolio with the same mean return, but with the minimal volatility
- Max return/risk ratio (Sharpe): This ratio is a measurement for portfolio performance calculated as the mean return divided by the volatility of those returns. The higher the ratio the better the performance ratio. In general, its importance is more a theoretical one.

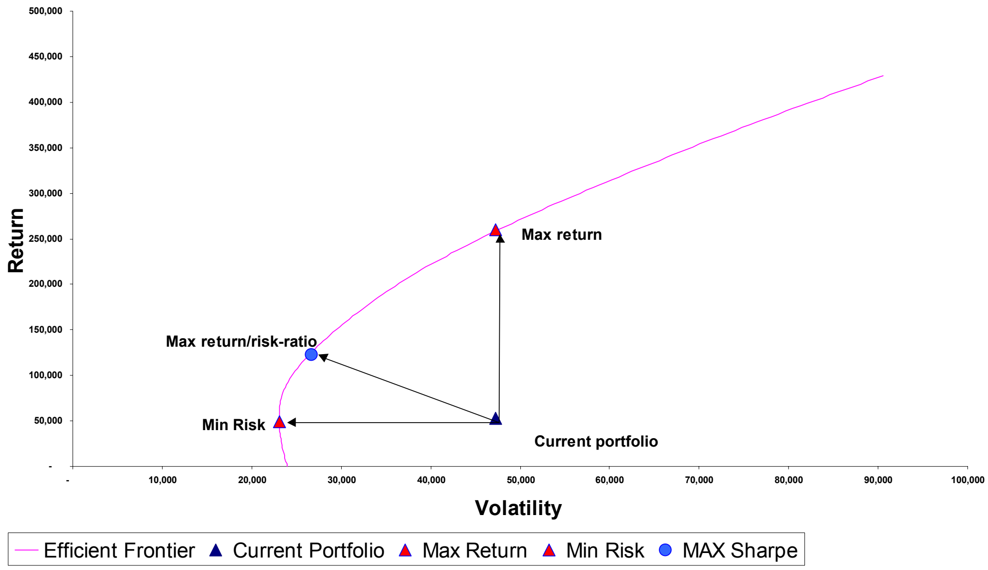

Figure 1. Example of an efficient frontier and optimal position of the portfolio.

Each portfolio on the efficient frontier offers the minimum possible risk for a given level of return. The general idea is to move the current portfolio in the direction of the efficient frontier. It's clear that for any given amount of return, you would like to choose a portfolio that gives you the least amount of risk. You want a portfolio that lies on the efficient frontier.

The following mean variance model is an example of a quadratic programming problem, which determines the efficient portfolio for a given level of expected portfolio return μ_p.

$$\text{Min} \sqrt{\left(\sum_{i=1}^{N} X_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{\substack{j=1 \\ j \neq i}}^{N} X_i X_j \sigma_{ij} \right)}$$

Subject to

$$\sum_{i=1}^{N} X_i = N \qquad (1)$$

$$\sum_{i=1}^{N} X_i \mu_i = \mu_p \qquad (2)$$

$$X_i \geq 0, \qquad for \quad i = 1,..,N \qquad (3)$$

Where μ_i is defined as the expected return of asset i, and μ_p is the expected/desired return on the portfolio. The efficient frontier can be calculated by solving this problem for a number of portfolio returns.

Some additional restrictions could be applied to his model. An investor could constrain some asset’s size with an upper- and lower bound. These constraints could be found necessary by the investor. Market specific information could make an investor to decide to limit some asset’s size.

To construct an optimal portfolio with the mean-variance model, you should have information about the mean and the variance of this return. One could derive these figures from the past or expected future. Correlation between investments X_i is also absolutely needed, so risk can be spread over a few facilities.

3. Product portfolio of an IT-company

LogicaCMG is an IT-company which operates on a global level. Within LogicaCMG several business units operate with their own profit/loss responsibility. Amongst them is a business unit, which offers products and services in the domain of payroll and salary systems. The company is profitable in a high competitive market. In this market often opportunities arise which might yield to good results. Because of the many opportunities and the current portfolio of eighteen IT-products, the management decided to use a portfolio approach. In preparing for this the expected return and volatility of each of these products is determined.[1] Due to confidentiality, the names of the products are replaced by P_1, …P_{18}. Table 1 presents the monthly returns (in Euro's) of each of product P_i.

Month	*P_1*	*P_2*	*P_3*	*P_4*	*P_5*	*P_6*	*P_7*	*P_8*	*P_9*
June	607,713	58,171	-6,861	-389	15,817	-72,520	21,604	33,714	13,255
July	710,581	69,573	-19,517	1,981	7,138	-63,656	5,986	61,343	10,292
August	435,793	62,288	-55,090	2,172	13,901	27,233	7,695	32,036	11,017
September	679,975	54,513	-30,337	481	11,480	-88,458	3,814	42,665	10,944
October	648,977	70,463	-10,772	2,144	10,019	-48,416	5,036	82,719	-14,832
November	732,679	64,867	4,553	2,081	9,294	73,063	4,785	34,817	13,634
December	1,143,622	80,822	-36,590	2,797	6,568	12,320	5,218	60,328	9,014
January	1,464,130	105,256	-24,251	575	7,412	-97,742	3,759	112,673	16,107
February	788,003	521,164	-27,537	2,215	12,807	-131,872	5,529	45,581	-513
March	702,673	56,760	-40,464	1,565	8,063	-36,699	4,537	43,906	-7,443
April	622,925	89,826	23,718	1,655	8,385	-127,196	4,780	52,787	-12,229
May	681,775	41,189	-69,999	2,991	12,308	-117,495	3,802	61,696	-9,294
June	675,692	58,566	-42,964	3,296	14,775	-172,369	6,614	59,636	-31,341
July	721,799	79,681	-45,885	2,980	10,122	-137,974	8,423	53,788	-13,641
August	628,581	52,164	-6,718	2,468	9,720	-122,108	22,567	75,008	-17,612
September	548,692	52,796	-21,851	2,611	8,958	-227,136	9,089	91,758	2,354
Mean return	737,101	94,881	-25,660	1,976	10,423	-83,189	7,702	59,028	-1,268

Month	*P_{10}*	*P_{11}*	*P_{12}*	*P_{13}*	*P_{14}*	*P_{15}*	*P_{16}.*	*P_{17}*	*P_{18}*
June	-4,948	-22,845	-250,511	-26,460	-14,882	46,478	42,794	-68,274	-1,230
July	15,512	-28,632	-234,581	-35,780	-15,505	-15,328	71,246	-180,321	-26,404
August	3,954	-54,380	-223,717	-44,905	-21,983	38,002	24,939	-100,343	-3,274
September	3,798	-20,013	-185,654	-45,552	-15,305	-15,313	22,360	-142,448	101,822
October	4,050	-9,590	-222,239	-34,614	-19,313	24,733	48,562	-83,501	99,160
November	2,403	-8,338	-243,626	-44,895	-14,650	18,715	52,755	-80,559	79,891
December	2,163	-11,123	-172,501	-18,532	-54,727	-2,207	53,724	-31,769	-2,992
January	941	-11,742	-174,585	-24,395	-2,438	11,801	62,565	-79,668	41,194
February	1,757	-10,565	-178,679	-33,278	0	-17,780	27,125	-136,524	78,232
March	1,647	-23,299	-174,697	-40,319	0	-2,232	3,725	-115,973	38,705
April	769	-15,735	-410,180	-54,270	0	-14,552	22,852	-166,904	115,148

[1] Note that one of the assumptions underlining MPT might be an obstacle: tradability of products. However, the sense-of-urgency is that high that outsourcing and selling of products in the portfolio in a real option.

May	511	-16,655	-221,442	-51,349	0	14,213	28,113	-111,285	-285
June	537	-2,682	-150,413	-8,492	0	-10,705	27,955	-99,626	-14,191
July	21	-10,182	-185,309	-9,928	0	-13,684	13,444	-122,341	-19,196
August	503	-6,052	-147,301	127	0	-6,506	13,875	-96,620	37,369
September	1,807	2,891	-94,017	7,688	0	-28,011	48,463	-83,028	19,887
Mean return	2,214	-15,559	-204,341	-29,060	-9,925	1,727	35,281	-106,199	33,990

Table 1. Monthly return (in Euros) of product P_i in the portfolio

The mean return for every product per month has been calculated. We consider this mean return known as the expected monthly return per product. The sum of these expected returns represents the expected monthly portfolio return. From the data the expected return, volatility and correlation is calculated. The results are presented in table 2. The volatility is expressed in the standard deviation of the return. Also the correlations between the return of the products can be calculated.

Month	*Volatility*	*Expected Return per month*
P_1	235,088	737,101
P_2	111,161	94,881
P_3	22,699	-25,660
P_4	978	1,976
P_5	2,728	10,423
P_6	74,376	-83,189
P_7	5,655	7,702
P_8	21,621	59,028
P_9	13,737	-1,268
P_{10}	3,992	2,214
P_{11}	12,710	-15,559
P_{12}	66,346	-204,341
P_{13}	18,127	-29,060
P_{14}	14,124	-9,925
P_{15}	20,910	1,727
P_{16}	18,743	35,281
P_{17}	36,534	-106,199
P_{18}	45,930	33,990
total	**349,680**	**509,123**

Table 2. Volatility and mean return per month for P_i

4. Optimisation

First we calculate the efficient frontier by calculating the efficient set for every desired return μ_p. In figure 2 the current position is displayed to give a general view of the distance to the efficient frontier. Then we calculate the positions of each product - in which each product is considered to have the same weight in the portfolio - for the following three directions of optimisation.

1. Minimise the risk, for a given level of return
2. Maximise the return for a given level of risk

3. Minimise the risk and maximise the return by maximising the risk/return-ratio.

The results are summarised in table 3 and figure 2.

Portfolio	*Original*	*Min Risk, same return*	*Max Return, same risk*	*Max risk/return-ratio*
Return	509,123	509,123	1,334,007	122,902
Volatility	349,680	86,524	349,680	9,886

Table 3. Current situation of the portfolio and the different optimal positions

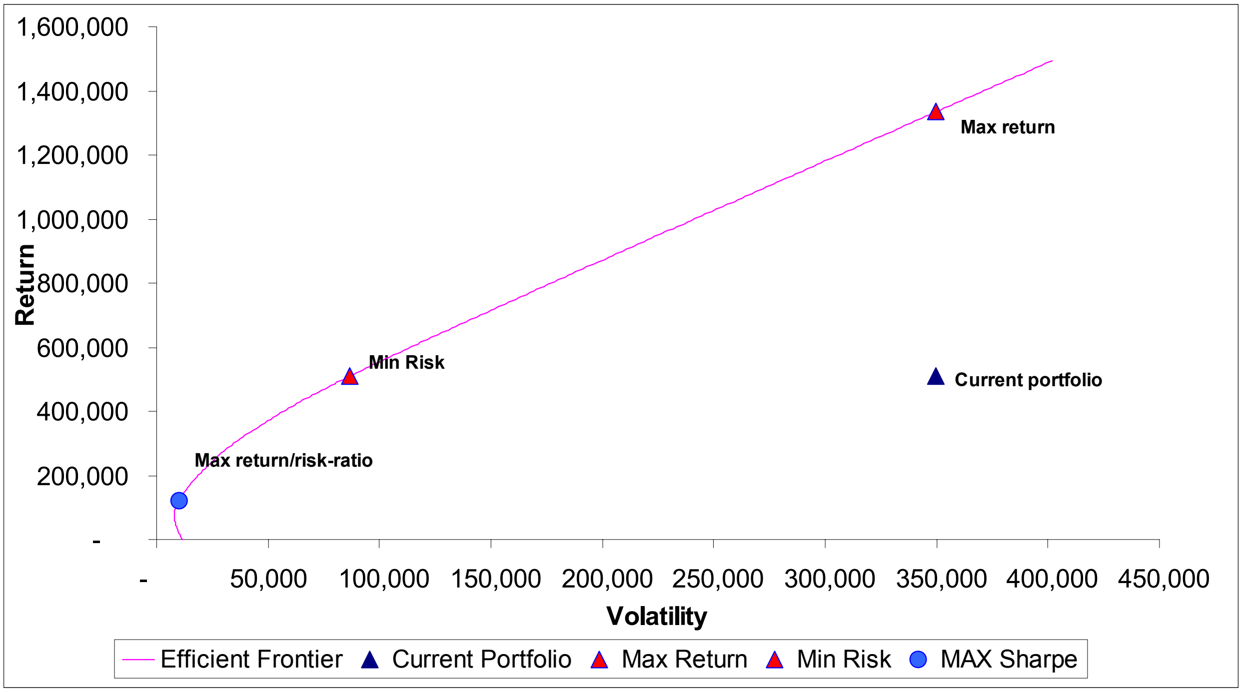

Figure 2. Efficient frontier and current position of the portfolio

It is clear that when one wants to keep the same level of risk, the return can be optimised to 1,3 million Euro per month, thus being an increase of 260%. Or, when maintaining the same level of return, the risk can be reduced to about 25 percent of the original risk.

Although perhaps exact optimal positions cannot be reached, the results provide the management with directions in which to improve their portfolio.

The entire optimisation and construction of the efficient frontier has been done in Excel. This application has a solver that is useful for small-scaled programming problems. To construct the efficient frontier a small macro has been written. The macro is built in such a way that for every level of return, the minimum risk is determined by solving the optimisation problem.

An additional analysis can be performed on the portfolio. The management of the company was asked to specify constraints for the products in the portfolio. They decided that no product should exceed 2 times its current size in the portfolio and that each product should be considered to be removed from the portfolio.

5. Weighted portfolio

The previous analyses were assuming that each product was equally weighted in the portfolio. That's fine if the products need the same amount or number of resources. In this paragraph we will demonstrate how we can optimise a IT-product portfolio considering that every product has a different weight.

LogicaCMG calculated the resources needed for each product. Table 4 summarises the result.

	Product costs	*Resulting Weights*
		X_i
P_1	7,503,120	26.45%
P_2	1,596,064	5.63%
P_3	1,195,111	4.21%
P_4	94,859	0.33%
P_5	133,546	0.47%
P_6	4,585,611	16.17%
P_7	10,574	0.04%
P_8	1,387,211	4.89%
P_9	276,407	0.97%
P_{10}	92,675	0.33%
P_{11}	148,427	0.52%
P_{12}	2,530,931	8.92%
P_{13}	318,581	1.12%
P_{14}	673,474	2.37%
P_{15}	1,418,486	5.00%
P_{16}.	419,015	1.48%
P_{17}	3,854,142	13.59%
P_{18}	2,125,953	7.50%
Total	28,364,187	100.00%

Table 4. Product costs and resulting weights of the products

The portfolio optimisation is adjusted to the following equation, where every position X_i is constrained with an upper bound. X_i is constrained to a shift of $\pm 100\%$ (management constraints on the individual products).

Minimize $$\sqrt{\left(\sum_{i=1}^{N}\sum_{j=1}^{N} X_i X_j \sigma_{ij}\right)}$$

Subject to $$\sum_{i=1}^{N} X_i = 1 \qquad (1)$$

$$\sum_{i=1}^{N} X_i \mu_i = \mu_p \qquad (2)$$

$$0 \le X_i \le 2 * X_i^{Old} \quad for\ \ i = 1,..,N \qquad (3)$$

The problem is solved for the three different optimisation directions. The results are summarised in table 5.

Portfolio	*Original*	*Min Risk, same return*	*Max Return, same risk*	*Max risk/return-ratio*
Return	509.123	509.123	1.023.053	1.789.036
Volatility	349.664	252.076	349.665	528.320

Table 5. Current portfolio, optimal portfolios and efficient frontier

With the restrictions on the change of positions, the calculated optimal portfolios are still out performing the original portfolio.

Tables 6 and 7 show the positions of the products after solving the problem with the three optimisation directions. Figure 3 gives the graph.

	Original Portfolio		*Min Risk*		*Max Return*		*Max return/risk-ratio*	
	X_i	Expected Return	X_i	Expected Return	X_i	Expected Return	X_i	Expected Return
P_1	*0.26*	737,101	*0.15*	426,978	*0.29*	814,309	*0.52*	1,452,873
P_2	*0.06*	94,881	*0.03*	46,651	*0.03*	52,801	*0.03*	51,330
P_3	*0.04*	-25,660	*0.02*	-9,925	*0.02*	-13,846	*0.00*	0
P_4	*0.00*	1,976	*0.01*	3,953	*0.01*	3,953	*0.01*	3,953
P_5	*0.00*	10,423	*0.01*	20,846	*0.01*	20,846	*0.01*	20,846
P_6	*0.16*	-83,189	*0.14*	-72,781	*0.17*	-87,906	*0.00*	0
P_7	*0.00*	7,702	*0.00*	15,405	*0.00*	15,405	*0.00*	15,405
P_8	*0.05*	59,028	*0.10*	118,057	*0.10*	118,057	*0.10*	118,057
P_9	*0.01*	-1,268	*0.00*	0	*0.00*	0	*0.00*	0
P_{10}	*0.00*	2,214	*0.01*	4,428	*0.01*	4,428	*0.01*	4,428
P_{11}	*0.01*	-15,559	*0.00*	0	*0.00*	0	*0.00*	0
P_{12}	*0.09*	-204,341	*0.00*	0	*0.00*	0	*0.00*	0
P_{13}	*0.01*	-29,060	*0.00*	0	*0.00*	0	*0.00*	0
P_{14}	*0.02*	-9,925	*0.05*	-19,850	*0.05*	-19,850	*0.05*	-19,850
P_{15}	*0.05*	1,727	*0.10*	3,453	*0.10*	3,453	*0.10*	3,453
P_{16}.	*0.01*	35,281	*0.03*	70,562	*0.03*	70,562	*0.03*	70,562
P_{17}	*0.14*	-106,199	*0.21*	-166,634	*0.03*	-27,138	*0.00*	0
P_{18}	*0.07*	33,990	*0.15*	67,980	*0.15*	67,980	*0.15*	67,980
Total	*1*	509,123	*1*	509,123	*1*	1,023,053	*1*	1,789,036

Table 6. Current portfolio and three optimal positions.

	Original portfolio weights	*Min Risk portfolio weights*	*Change in %*	*Max return portfolio weights i*	*Change in %*	*Max return/risk-ratio portfolio weights*	*Change in %*
	X_i	X_i		X_i		X_i	
P_1	*0.26*	*0.15*	-42%	*0.29*	10%	*0.52*	97%
P_2	*0.06*	*0.03*	-51%	*0.03*	-44%	*0.03*	-46%
P_3	*0.04*	*0.02*	-61%	*0.02*	-46%	*0.00*	-100%
P_4	*0.00*	*0.01*	100%	*0.01*	100%	*0.01*	100%
P_5	*0.00*	*0.01*	100%	*0.01*	100%	*0.01*	100%
P_6	*0.16*	*0.14*	-13%	*0.17*	6%	*0.00*	-100%
P_7	*0.00*	*0.00*	100%	*0.00*	100%	*0.00*	100%
P_8	*0.05*	*0.10*	100%	*0.10*	100%	*0.10*	100%
P_9							

P_{10}	*0.00*	*0.01*	100%	*0.01*	100%	*0.01*	100%
P_{11}	*0.01*	*0.00*	-100%	*0.00*	-100%	*0.00*	-100%
P_{12}	*0.09*	*0.00*	-100%	*0.00*	-100%	*0.00*	-100%
P_{13}	*0.01*	*0.00*	-100%	*0.00*	-100%	*0.00*	-100%
P_{14}	*0.02*	*0.05*	100%	*0.05*	100%	*0.05*	100%
P_{15}	*0.05*	*0.10*	100%	*0.10*	100%	*0.10*	100%
P_{16}.	*0.01*	*0.03*	100%	*0.03*	100%	*0.03*	100%
P_{17}	*0.14*	*0.21*	57%	*0.03*	-74%	*0.00*	-100%
P_{18}	*0.07*	*0.15*	100%	*0.15*	100%	*0.15*	100%
Total	*1*	*1*		*1*		*1*	

Table 7. Change of each product position in the different optimisation portfolios

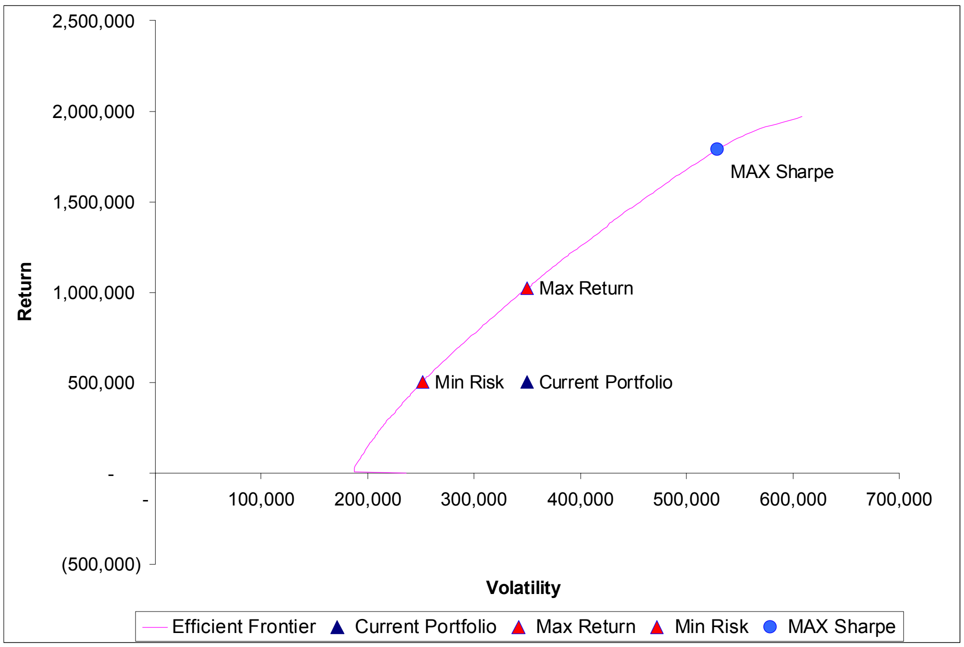

Figure 3: Efficient frontier of the weighted portfolio and current portfolio

6. Assumptions

By calculating the efficient frontier additional restrictions on product positions have been formulated. These constraints can rise from management perspective and from marketing conditions. Among the first category are constraints that reflect the possibility to outsource or sell off certain product lines and the marketing strengths of the company to increase the relative position within the portfolio itself. Also under market conditions some products positions could not so easily be expanded, due to market satiation or heavy competition.

The flexibility of reducing product positions is bound to contracts with customers. Therefore reducing the portfolio or the 'killing' of certain products is not that easy. A solution can be found in outsourcing or selling this part of the portfolio to another company who will take over the contracts.

All these constraints however can be implemented in the calculation of the efficient portfolio. The constrained efficient frontier will then move downwards compared with the unconstrained efficient frontier.

Another question mark could be placed by the calculation of the volatility and the correlation between products. The volatility is in fact the standard deviation of the return. Correct information on these returns is critical in terms of calculating the volatility. Calculation of the volatility and of the correlation is more accurate if the information on the returns available over a longer period.

7. Conclusion

With the mean variance theory constructed by Markowitz, the management of a product portfolio can be improved. The results show a considerable decrease in risk, while maintaining the same return. Even with constraints applied on the portfolio and its products, the optimal portfolios perform far better.

The mean variance theory has proven its worthiness for an IT-product portfolio. By evaluating returns achieved in the past, portfolio selection is possible. However, returns from the past do not guarantee the same results in future. The model cannot foresee any event that could occur in the future. It only diversifies the portfolio by looking at the results of the past.

One of the MPT-assumptions which might be violated are marketconditions. For example, an increase of the proportion of a product in the total portfolio might be hindered because of the presence of competitors and of a limited market. In the case of the LogicaCMG-company: the market for payroll systems for seatransport companies is small, an increase in the portfolio could only be realized by a focussed and sharper competion in the Dutch market for this product or the expansion of the sales and marketing of this product to new markets abroad.

The flexibility of the portfolio is also bound to a certain extent by long term contracts with customers. Therefore reducing the portfolio or the 'killing' of certain products is not that easy. A solution can be found in outsourcing or selling this part of the portfolio to another company who will take over the contracts.

It is clear that the application of MPT to other domains than for which it was originally developed, yields interesting results. It introduces a quantitative approach to new domains, especially product portfolios and IT-portfolios. The application towards loan portfolios has been tried earlier.

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