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BACHELOR'S THESIS

OPTIMAL SOFTWARE PROJECT PORTFOLIO

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1   INTRODUCTION

1.1   Software Projects and Products

Nowadays modern big software companies can have hundreds and even thousands of simultaneous projects. These projects can be linear or nonlinear in order and can have complex dependencies. One software product can also be a composition of several projects. The companies are also facing serious short term profit goals from their shareholders and need to continuously decide where to invest their money and often limited resources - typically personnel. In order to fulfil shareholder expectations companies must make the best financial results from their available options. These options are the projects at hand and in the near future. A company then faces a dilemma - how should a company set up (allocate personnel) a portfolio of projects so that:

1.   Financial risks are minimized
2.   Financial rewards are maximized

Similar question has been discussed by Harry Markowitz in his world famous article "Portfolio Selection" in 1952 in Journal of Finance (Markowitz, 1952). Markowitz has pondered the question from finance security perspective and the idea could be extended for project portfolios also. The ideas introduced in Markowitz's article have come to form the foundations of what is now popularly referred to as Modern Portfolio Theory (MPT) (Fabozzi et al., 2002).

1.2   Portfolio Selection by Markowitz

In 1952 Harry Markowitz presented his expected returns – variance of returns (E-V) rule. The E-V rule states that the investor would want to select one of those portfolios which give rise to the minimum V (variance) for a given E (expected return) or more and maximum E for a given V or less. The methods available at that time to find out the best possible scenarios were quite limited. Technology has developed quite remarkably in over 50 years and currently

there are no problems finding the best solution for Markowitz's problem. Markowitz presented two possible uses for the E-V rule. It could be used for theoretical analyses or it could be used in the actual selection of portfolios. This thesis builds on the actual selection of portfolios. (Markowitz, 1952)

1.3   Motivation and Goals

If an optimal software project setup could be found, it would mean that the firm would maximize its shareholder value (cash flows) and/or minimize risks (variance) in financial sense. The model would be highly useful in guiding the decision making concerning the current project and future investments. Signalling optimal decision making could also increase the price of a publicly listed company's stock. Given the challenges (1.1 Software Projects) and the proposed framework (1.2   Portfolio Selection) to build on, the goals of this thesis are:

1. To evaluate the suitability of Markowitz's model for software project portfolio selection
2. To propose enhancements to the Markowitz's model or completely new model if the Markowitz's model proves to be inadequate

In financial world the allocation problem is how to allocate available assets in to different securities. This thesis adapts this problem to software projects – how to allocate personnel in to given projects (and products) with optimal benefits. This work is done for Aditro (Aditro, 2008).

1.4   Aditro

Aditro is a company which operates mainly in the Nordic (e.g. Finland, Sweden, Norway and Denmark) area in a four different Business Areas (BA). These BAs are:

- Human Resources
- Financials
- Logistics
- Customer Services

Currently Aditro has roughly 6000 persons partly operating in 200 projects, which cover customer, internal and strategic projects. In Finland Aditro is mostly known as a payroll outsourcing company (Human Resources BA). Other well known products/services are: financial management software (Financials BA), delivery of different products e.g. CDON.com compact discs (Logistics BA), different telephone customer service duties and telemarketing (Customer Services BA). Aditro's headquarter is located in Sundbyberg, Sweden.

1.5 Limitations

This thesis focuses only to the financial perspectives and defines a monetary risk as variance. I.e. the more a given financial investment target has variance the more risky it is. Also this thesis does not take into account any other risks which usually are seen in the modern software project plan's risk management section. Furthermore only three and four software projects will be considered. It should also be noted that hiring new personnel and subcontracting are left outside of the scope of this work.

One project is assumed to deliver one software product. This relieves the calculations and discussion concerning whether some projects should be totally cancelled. Therefore both project and product mean the same thing in this thesis. Besides, timetable for the projects is assumed to be the same meaning that starting date and ending date of the projects is exactly the same. Projects start in the beginning of the year and end in the end of the year.

1.6 Organization of the Thesis

Following this introductory chapter is chapter 2 which presents the theoretical background and framework. Chapter 3 presents the actual model built on using the theoretical framework

set up in chapter 2. The ends of chapters 2 and 3 also include "Putting It All Together" subchapters that will summarise the things that have been learnt in those and/or previous chapters. The model will be discussed in chapter 4 which also presents an enhanced model to overcome the shortcomings of the first model. Chapter 4 also presents ideas which rose from this work for future investigation and study. Finally, chapter 5 ties up the work with conclusions.

2 THEORETICAL BACKGROUND

This chapter provides a short theoretical background and used software components in order for the reader to understand the rest of this thesis. First, the Markowitz's E-V idea will be introduced followed by the Microsoft Excel Solver presentation.

2.1 Harry Markowitz's Portfolio Selection

Unless otherwise stated this chapter 2.1 is solely based on Markowitz's work (Markowitz, 1952). In 1952 Harry Markowitz presented his expected returns – variance of returns (E-V) rule. The E-V rule states that the investor would want to select one of those portfolios which give rise to the minimum V (variance) for a given E (expected return) or more and maximum E for a given V or less. In order to understand Markowitz's work the following elementary concepts and results of mathematical statistics are needed.

Let Y be a random variable. Random variable is a variable whose value cannot be predicted until it is observed. Let's assume that Y can take a finite number of values y_1, y_2,…, y_n. Let the probability that $Y = y_1$ be p_1 and $Y = y_2$ be p_2 and so on. The expected value of Y is then defined to be

$$E = p_1 y_1 + p_2 y_2 + ... + p_n y_n \qquad (1)$$

The variance of Y is defined to be

$$V = p_1 (y_1 - E)^2 + p_2 (y_2 - E)^2 + ... + p_n (y_n - E)^2 \qquad (2)$$

V is the average squared deviation of Y from its expected value. Now suppose that we have number of random variables: R_1,...,R_n. If R is a weighted (a_i) sum (linear combination) of the R_i

$$R = a_1 R_1 + a_2 R_2 + ... + a_n R_n \qquad (3)$$

then R is also a random variable. The expected value of a weighted sum is the weighted sum of the expected values. I.e. $E(R) = a_1E(R_1) + a_2E(R_2) + \ldots + a_nE(R_n)$. The variance of the weighted sum is not so straightforward. To express it, covariance must be defined. The covariance of R_1 and R_2 is

$$\sigma_{12} = E((R_1 - E(R_1))(R_2 - E(R_2))) \tag{4}$$

i.e., the expected value of [(the deviation of R_1 from its mean) times (the deviation of R_2 from its mean)]. In general the covariance between R_i and R_j is

$$\sigma_{ij} = E((R_i - E(R_i))(R_j - E(R_j))) \tag{5}$$

σ_{ij} may also be expressed in terms of familiar correlation coefficient (ρ_{ij}). The covariance between R_i and R_j is equal to [(their correlation) times (the standard deviation of R_i) times (the standard deviation of R_j)]

$$\sigma_{ij} = \rho_{ij}\sigma_i\sigma_j \tag{6}$$

The variance of a weighted sum is

$$V(R) = \sum_{i=1}^{N}\sum_{j=1}^{N} a_i a_j \sigma_{ij} \tag{7}$$

Let R_i be the return on the ith security. Let μ_i be the expected value of R_i; σ_{ij} be the covariance between R_i and R_j. Let X_i be the percentage of the investor's assets which are allocated to the ith security. The yield (R) on the portfolio as a whole is

$$R = \sum R_i X_i \tag{8}$$

The R_i (and consequently R) are considered to be random variables. The X_i are not random variables, but are fixed by the investor. Since the X_i are percentages we have $\Sigma X_i = 1$ and furthermore short sales are excluded so $X_i \geq 0$.

The return (R) on the portfolio as a whole is a weighted sum of random variables (where the investor can choose the weights). From earlier discussion of such weighted sums it can be seen that the expected return E from the portfolio as a whole is

$$E = \sum_{i=1}^{N} X_i \mu_i \qquad (9)$$

and the variance is

$$V = \sum_{i=1}^{N} \sum_{j=1}^{N} \sigma_{ij} X_i X_j \qquad (10)$$

For a fixed probability beliefs (μ_i, σ_{ij}) the investor has a choice of various combinations of E and V depending on his choice of portfolio $X_1, \ldots, X_n$. Suppose that the set of all attainable (E,V) combinations were as in Figure 1.
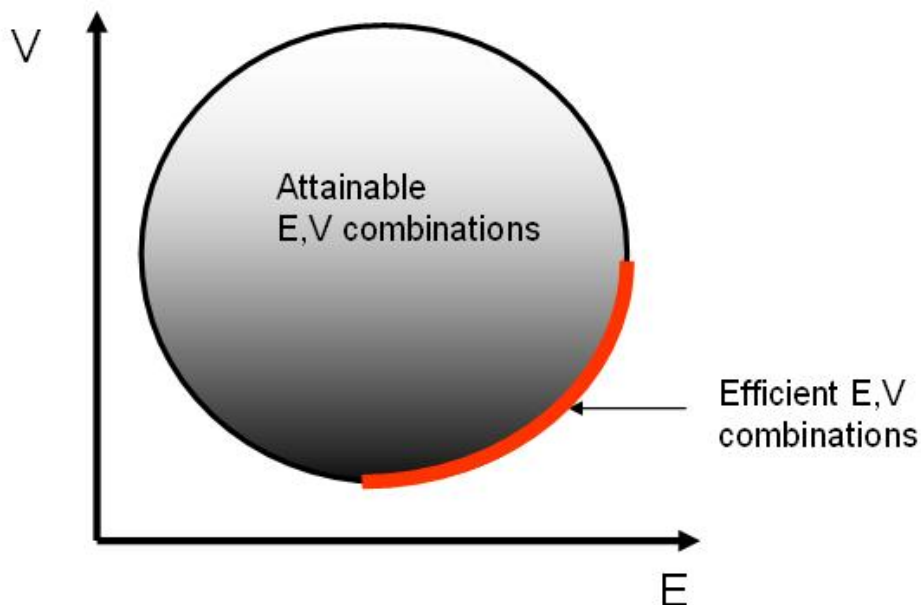
Figure 1. Attainable E,V combinations

The E-V rule states that the investor would (or should) want to select one of those portfolios which give rise to the (E,V) combinations indicated as efficient in the Figure 1; i.e. those with minimum V for given E or more and maximum E for given V or less.

In 1952 Markowitz didn't have easy possibilities to solve the optimal weights for the portfolios when several securities were used. Today the operation is trivial due to powerful calculation capabilities of a personal computer. This thesis uses Microsoft's Excel with optional Solver Add-In.

2.2   Microsoft Excel Solver

Microsoft Excel's Solver is an optional Add-In for the Microsoft Excel 2003 (see Appendix 1 for installation support). Add-In can be thought of as an additional module that enhances computer's or programs capabilities. Solver is used to:

1. To maximize a given function
2. To minimize a given function
3. To find a value of a given function

by changing the predefined values which effect the function. The solver can be guided by adding additional restrictions to it. An easy example is to find out values of X which brings the value of LOG(X) function to 0,2 with logarithm base 10 (see Figure 2). The solver ends up in to a value of 1,584896 which brings the logarithm function to a value of 0,200001. The actual value given with 10 decimals is 0,2000007693 however the accuracy with five decimals is quite enough for our practices.
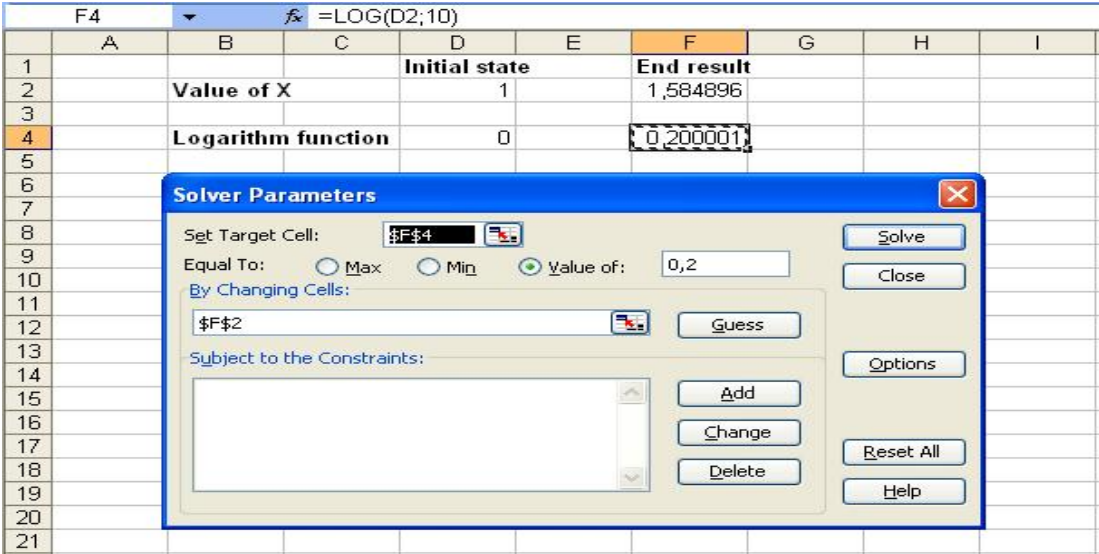
Figure 2. Microsoft Excel solver example

In this work the solver is used either to maximize a given function or to minimize a given function.

2.3 Putting It All Together

Now we have all the needed mechanisms in place to start finding the optimal software projects:

1. We have the mathematical framework in place - E-V rule and its equations
2. We have the solver in place which can be used to find the correct weights which either minimize the variance for a given expected return or maximize the expected return for a given variance

All that is needed is to find out data and build up the model for the solver.

3 OPTIMAL SOFTWARE PROJECT PORTFOLIO

This chapter is organised as follows, first we will describe the data used in this thesis. Second the Markowitz model will be build up that will minimize the variance of a software project portfolio. Finally the actual data will be used in the Markowitz's model.

3.1 Data

In order for us to find out the optimal portfolio only one number from the actual products is needed for the Markowitz's model - Earnings Before Interest and Taxes (EBIT) of a project/product. This thesis uses the numbers retrieved from Aditro's financial department. The following data in Figure 3 is used.

	B	C	D	E	F	G	I	J	K	M	N	O	P
1													
2			PROFITS				COSTS			EBIT	EBIT %		
3			Net sales total	License	Maintenance	Consulting	Costs total	Personnel	Other costs				
4	PRODUCT A												
5		2002	718,75	200,75	301	217	803,01375	803,0138	0	-84,2638	-11,72 %		
6		2003	692,5	152,25	336,25	204	803,01375	803,0138	0	-110,514	-15,96 %		
7		2004	653,25	106,25	366,5	180,5	486,675	486,675	0	166,575	25,50 %		
8		2005	713,75	164,5	382,25	167	486,675	486,675	0	227,075	31,81 %		
9		2006	801,5	184,25	388,5	228,75	448,11953	448,1195	0	353,3805	44,09 %		
10		2007	748,25	87,5	407,25	253,5	437,95343	437,9534	0	310,2966	41,47 %	Std. Dev.	23,84 %
11	2008F		763,5	115,25	420,25	228	437,95343	437,9534	0	325,5466	42,64 %		
12	2009F		743	103	428,75	211,25	437,95343	437,9534	0	305,0466	41,06 %		
13	2010F		722,75	96,25	439	187,5	437,95343	437,9534	0	284,7966	39,40 %	Std. Dev. F	1,32 %
14												Total Std. Dev.	22,27 %
15												Average EBIT %	26,48 %
16	PRODUCT B												
17		2002	1231,75	510,25	522	199,5	940,905	940,905	0	290,845	23,61 %		
18		2003	1162,25	394,75	546,75	220,75	940,905	940,905	0	221,345	19,04 %		
19		2004	1170	442,25	488,5	239,25	754,34625	754,3463	0	415,6538	35,53 %		
20		2005	1091,5	334,25	546	211,25	811,125	811,125	0	280,375	25,69 %		
21		2006	1146	345	576	225	1122,3266	1122,327	0	23,67338	2,07 %		
22		2007	1153	363,75	601,5	187,75	922,7358	922,7358	0	230,2642	19,97 %	Std. Dev.	9,71 %
23	2008F		1301,25	336,5	783,5	181,25	922,7358	922,7358	0	378,5142	29,09 %		
24	2009F		1351,25	336,5	833,5	181,25	922,7358	922,7358	0	428,5142	31,71 %		
25	2010F		1355,25	314	869,5	171,75	922,7358	922,7358	0	432,5142	31,91 %	Std. Dev. F	1,29 %
26												Total Std. Dev.	9,46 %
27												Average EBIT %	24,29 %
28	PRODUCT C												
29		2002	831	149,5	548,75	132,75	519,12	519,12	0	311,88	37,53 %		
30		2003	840	185,25	519,25	135,5	519,12	519,12	0	320,88	38,20 %		
31		2004	840,25	193,75	481,75	164,75	446,11875	446,1188	0	394,1313	46,91 %		
32		2005	790,75	158,25	483,25	149,25	429,89625	429,8963	0	360,8538	45,63 %		
33		2006	713	89	473,75	150,25	369,873	369,873	0	343,127	48,12 %		
34		2007	666,75	88,25	433,75	144,75	704,86763	704,8676	0	-38,1176	-5,72 %	Std. Dev.	21,54 %
35	2008F		694,75	129,75	426,25	138,75	704,86763	704,8676	0	-10,1176	-1,46 %		
36	2009F		697	121,75	447,25	128	704,86763	704,8676	0	-7,86762	-1,13 %		
37	2010F		659,25	87,5	453	118,75	704,86763	704,8676	0	-45,6176	-6,92 %	Std. Dev. F	2,66 %
38												Total Std. Dev.	23,70 %
39												Average EBIT %	22,35 %

Figure 3. Product net sales, EBIT, EBIT %

As depicted in Figure 3 data retrieved is from three products. The products are Product A, Product B and Product C which all are financial management software for three different segments. The data contains the net sales, EBITs and EBIT % of three products. The numbers

are actual figures from the years 2002-2007 and also contain forecasts for the period 2008-2010. Net sales are divided into three components:

1. License – license sales from software license selling
2. Maintenance – yearly maintenance fees
3. Consulting – consulting, training etc.

Standard deviations are calculated from the whole the EBIT % data (including forecasts) using the Excel's STDEVP() –function to get reasonable amount of data. This way the long term expected profits are defined instead of short term future forecasts. Average EBIT is calculated with the Excel's AVERAGE() –function (including forecasts). The standard deviations are: Product A 22,27 %, Product B 9,46 %, Product C 23,70 %. Now all the building blocks are in place for the Markowitz's model.

3.2 Markowitz Model

First we need to find out the correlation coefficients (ρ) to solve the (6). The correlation coefficients are solved by the Excel's CORREL() –function. Figure 4 depicts the correlation coefficient matrix (rows 12-15) after computation. The spreadsheet presentations and formulas in Figure 4-7 are similar to Bodie's presentation (Bodie et al, 2005).

	A	B	C	D	E	F	G	H	I
1									
2				Standard Deviation, Average Return, and Correlation Coefficients					
3				Years 2002-2010F					
4									
5				Std. Dev. (%)			Average Ret. (%)		
6									
7		Product A		22,27			26,48		
8		Product C		23,70			22,35		
9		Product B		9,46			24,29		
10									
11									
12			Product A	Product C	Product B				
13		Product A	1,00	-0,47	0,04				
14		Product C	-0,47	1,00	-0,37				
15		Product B	0,04	-0,37	1,00				

Figure 4. Standard deviations, correlation coefficient matrix and average returns

Now we can setup the covariance matrix by calculating the product of correlation coefficient(s) with the standard deviations (6). Figure 5 presents the covariance matrix outcome.

18		Covariance Matrix		
19				
20				
21		Product A	Product C	Product B
22	Product A	496,1537816	-247,1684693	8,121160364
23	Product C	-247,1684693	561,5146529	-83,13662906
24	Product B	8,121160364	-83,13662906	89,44319721

Figure 5. Covariance matrix

Finally we have all the figures in place to solve the (10). Figure 6 presents the weighted variance matrix.

27		Weighted variance matrix			
28					
29					
30		Results			
31			Product A	Product C	Product B
32		Weights	0,18	0,23	0,59
33		0,18	15,38606043	-9,967396205	0,850784684
34		0,23	-9,967396205	29,44606546	-11,32586846
35		0,59	0,850784684	-11,32586846	31,65478293
36	Sigma	1,00	6,269448912	8,152800794	21,17969916
37	Portfolio variance	35,60194886			

Figure 6. Weighted variance matrix

Figure 6 also includes the weights (rows 33-35, column B, second column) after the solver has found out the minimum variance for the three products. The results indicate that 18 % from the personnel should be allocated to the Product A, 23 % should be allocated to the Product C and the rest 59 % should be allocated to the Product B. The total variance of this portfolio is 35,60194886. The solver was used second time, now with added constraint that variance of the software portfolio should be the one found in the first time, to maximize (expected) return. The expected return does not change indicating that this is indeed the best E-V rule satisfying solution (maximum return with minimum variance). However it should be noted that weighting returns with the solver weights directly does not describe the actual situation very well, when software projects are concerned, as will be discussed later on in Chapter 4.2.

Appendix 2 shows all the formulas and Microsoft Excel functions used when making calculations depicted in Figures 4-6. When reference to "Data" worksheet is found, Figure 3. Product net sales, EBIT, EBIT % is the actual "Data" worksheet used.

3.3   Putting It All Together

After setting up the mathematical framework (Chapter 2) to build on and gathering the data (Chapter 3), a model suggested by Markowitz has been built. The built model corresponds to the mathematical framework. In 1952 the possibilities to solve these kinds of worksheet operations were quite limited and now the solver solves the weights for three products in less than a second. Next, the benefits and shortcomings of the model, when applied to a software project portfolio, will be discussed.

4   DISCUSSION

This chapter is divided as follows, first the model and its data is discussed, second the benefits and shortcomings of the Markowitz model are illustrated. Third an enhanced model will be presented and discussed. Finally ideas for further study will be introduced.

4.1   Model and Data

First it should be noted that when calculating the Markowitz model the whole data available is used including forecasts. The biggest challenge for the firm's management is to evaluate the future performance of the products. When evaluating future performance there is a tendency to use the same growth multipliers when no better method is available or the alternative method is too costly to implement. This causes the correlation coefficients to approach one. When calculating standard deviations the whole data will be used including the forecasts.

Second the model favors those projects whose standard deviation is lowest and whose return is on an adequate level if compared to the other projects. This is congruent with Markowitz's theory. The only problem when using return percentages is that the model does not take into account the absolute levels of returns (i.e. euros/dollars). This will be discussed in Chapter 4.2.

Third the model proposes that most of the personnel should not be allocated to the most profitable product. This is due to the fact that the most profitable product suffers from a big standard deviation. This result is again in line with the theory when trying to avoid risk. If more radical approach (more risk) would be allowed in a given corporate then the model could be used to:

1. First to maximize the returns
2. Second to minimize the variance

Fourth an interesting observation is done when all the projects are delivering nearly the same kind of software – bookkeeping software, the correlation coefficients are quite different from

one. The correlation coefficients are -0.37, -0.47 and 0.04. The reason might be in different market segments (-0.37 and -0.47 for private segment and 0.04 for public segment). Further discussion is left out of the scope of this thesis.

4.2   Benefits and Shortcomings of the Markowitz's Model

The model predicts how the available personnel should be allocated to the projects in order to reach minimum financial variance. The model is correct in financial sense – it minimizes the variance which this thesis has defined as the monetary risk. However it does not take into account the starting levels of return. I.e. if one product (Product A) makes an EBIT margin of 33 % with net sales of 100 000 € and another product (Product B) makes an EBIT of 20 % with net sales of 1 000 000 € The improved model should take the absolute levels of return into account. By maximizing the actual levels of return, for possible dividend payout, the firm also maximizes its value (Elton et al., 2003). In financial world this is irrelevant because it is assumed that the amount of money invested in a given security earns a corresponding return. In project world this is not the case. By increasing the amount of people in the project/product does not necessary yield a corresponding increase in the EBIT/Net sales and in some cases it could also increase the EBIT in the project from which the personnel is moved from. This leads to the idea of *transaction consequences*.

Transaction consequences is defined as follows:
1. What are the benefits in terms of net sales and EBIT in the product which receives more personnel?
2. What are the new costs in the product which receives more personnel?
3. What are the benefits in terms of net sales (if any) and EBIT in the product which loses personnel?
4. What are the new costs in the product which loses personnel?

The improved model should take the transaction consequences into account.

The Markowitz model can also suggest that all the personnel should be allocated to one project with clearly best monetary results. Again this is correct in financial world but not always attainable in the software product/project level. There are (at least) two main reasons for this:

1. Legal modifications
2. Ongoing agreements

Legal modifications mean that some people must be reserved to make modifications to the software that are due to changes in legislation. Also some people must be reserved to satisfy possible liabilities of the already made contracts with the customers (ongoing agreements). This way it is highly likely that not all the personnel can be moved from the product away. The improved model should consider minimum personnel limitation.

Another enhancement that the model requires is forward looking. The current Markowitz model is so called static since it disregards future. The model should be enhanced to include future weights also for the coming years. This is relevant in software project portfolio since products are in different phases of their lifecycle. E.g. a product that will be closed down in two years will receive a minimal or no personnel at all in the last phases of its life cycle. This will in turn increase its EBIT margin and should guide the personnel allocations to new or alternative projects/products. Thus the personnel allocation i.e. weights should be forecasted by the model for couple of coming years.

Finally, the Markowitz's model considers variance as a bad thing. Let's consider the following: let's assume that a product makes an excellent result at some year due to e.g. new currency (euro). The variance of the product rises and causes less weight for the product due to E-V rule. Actually variance is only bad if it's below the expected return. Indeed positive variance (variance over the expected return) is wanted and should even be pursued. This was one the findings of Markowitz but he discarded the idea due to substantial problems in calculations (Sharpe, 1964). This idea has later been recognized as the Post-Modern Portfolio Theory (PMPT).

Currently we have five enhancements to the Markowitz's model when applying it to the software projects:

1. Absolute levels of return
2. Transaction consequences
3. Minimum personnel allocation

4. Future years should be taken into account
5. Not all variance is bad (PMPT)

Post-Modern Portfolio Theory itself is a whole new topic and is left for further study. It should be noted that it seems to be possible to incorporate all the enhancements to Markowitz's model. However when losing the minimum variance restriction the model will be more or less cash flow based spreadsheet calculation and could no longer be called Markowitz's model. Next the improved model built to overcome the challenges listed above will be discussed.

4.3 Transaction Consequences Model

Based on the enhancements listed in Chapter 4.2, the following model was built. Figure 7 presents one project – Product A. The model uses year 2007 as the base year using actual financial figures. The years 2008 and 2009 are forecasted years.

	A	B	C	D	E	F	G	H
1								
2						INPUTS		
3								
4								
5				Baseline				
6			Year	2007		2008F		2009F
7		Product A						
8			FTE	9,5		9,5		9,5
9			Costs/FTE	81,1125		81,1125		81,1125
10								
11			License sales	87,5		87,5		87,5
12			Sales	1		1		1
13			Maintenance sales (fixed)	407,25		420,25		428,75
14			Consulting sales	253,5		253,5		253,5
15			Customer services + development	8,5		8,5		8,5
16								
17			License sales + (Sales increase)	75		75		
18			License sales - (Sales decrease)	75		75		
19								
20			Consulting sales + (Consulting increase)	60		60		
21			Consulting sales - (Consulting decrease)	60		50		
22								
23			FTE Increase(+)/Decrease(-) Sales			0		0
24			FTE Increase(+)/Decrease(-) Consulting			0		0
25								
26		Profit and loss						
27			Netsales	748,25		761,25		769,75
28			Increase by new sales			0		0
29			Decrease by reduced sales			0		0
30								
31			Increase by new cust. serv. + dev.			0		0
32			Decrease by reduced cust. Serv. + dev.			0		0
33			Costs	770,5688		770,56875		770,56875
34			Increase by new			0		0
35			Decrease by moving			0		0
36			EBIT	-22,3188		-9,31875		-0,81875

Figure 7. Transaction consequences model

The number of employees working with the product is given in the Full Time Employee (FTE). It is followed by a rough cost (in thousands euros) per FTE. "License sales" means the yearly sales from software licenses. The line below it is the number of salesmen. Followed by it is the yearly maintenance fee received from the sold licenses. "Consulting sales" is the consulting on top of licenses sold and training. It also includes possible special features required by customers. Below "Consulting sales" is the number of people participating to the consulting sales i.e. customer services and development. The red cells indicate the actual transaction consequences. For example in the column 2007 "License sales +" means the increase in license sales 2008 if one sales person is added. "License sales -" is the result for 2008 when decreasing sales by one person. The same interpretation is used in "Consulting sales +/-". FTE increase/decrease is the yearly increase in personnel. In the bottom part of the Figure 7 is a rough profit and loss statement concerning a given product. Profit and loss statements for the years 2008 and 2009 use the benefits (transaction consequences) from personnel re-allocation. The last line is the actual EBIT that a product is making. The green cells indicate the results of the solver i.e. personnel allocations for the given year. It should also be noted that changes in personnel are expected to deliver results in the following year. Figure 7 depicts the situation before the solver is used i.e. starting situation. Appendix 3 shows all the formulas. Table 1 on summarises the baseline situation with three actual products and one hypothetical product (Product X) that will be ready in the beginning of 2008. The rows depict the number of FTEs in a given product.

PROJECT	2007	2008	2009
Product A	1 Sales 8,5 Consulting	1 Sales 8,5 Consulting	1 Sales 8,5 Consulting
Product C	1 Sales 9 Consulting	1 Sales 9 Consulting	1 Sales 9 Consulting
Product B	1 Sales 13,3 Consulting	1 Sales 13,3 Consulting	1 Sales 13,3 Consulting
Product X	1 Sales 4 Consulting	1 Sales 4 Consulting	1 Sales 4 Consulting
Total EBIT (2008-2009)	-53,83 (t€)		

Table 1. Project portfolio baseline situation, total EBIT and allocated personnel

The model includes also the following restrictions as depicted in Figure 8 for the years 2008 and 2009.

143		Total Cashflow			-91,665	37,835
144		Sales FTE Total			4	4
145		Consulting FTE Total			34,80	34,80
146	Minimum personnel	MIN Sales Product A			0,50	0,50
147		MIN Cons. + dev. Product A			1,00	1,00
148		MIN Sales Product C			0,50	0,50
149		MIN Cons. + dev. Product C			1,00	1,00
150		MIN Sales Product B			0,50	0,50
151		MIN Cons. + dev. Product B			1,00	1,00
152		MIN Sales New product				2,00
153		MIN Cons. + dev. New product				1,50
154	Maximum transfer	Max increase Product A Sales			2,00	2,00
155		Max increase Product A Consulting + Dev.			2,00	2,00
156		Max increase Product C Sales			2,00	2,00
157		Max increase Product C Consulting + Dev.			2,00	2,00
158		Max increase Product B Sales			2,00	2,00
159		Max increase Product B Consulting + Dev.			2,00	2,00
160		Max increase New product Sales				2,00
161		Max increase New product Consulting + Dev.				2,00

Figure 8. Transaction consequences model restrictions

The restrictions include the total amount of personnel working in the projects divided to sales and consulting ("Sales FTE Total" and "Consulting FTE Total"). The minimum amount of people needed for a product is given in the following lines. Also the maximum possible transfer to this project is limited. This is due to the fact that it is not reasonable to assume that putting all the personnel for one project would increase net sales in a linear fashion. Based on these limitations the solver now includes nearly 40 restrictions. Given the assumptions from the net sales increases (Figure 3. Product net sales, EBIT, EBIT %, forecasted years 2008-2010) the solver finds out the maximum EBIT with the allocations listed in Table 2.

PROJECT	2007	2008	2009
Product A	1 Sales 8,5 Consulting	1 Sales 10,5 Consulting	0,5 Sales 4,5 Consulting
Product C	1 Sales 9 Consulting	1 Sales 8 Consulting	0,5 Sales 10 Consulting
Product B	1 Sales 13,3 Consulting	1 Sales 12,3 Consulting	0,5 Sales 14,3 Consulting
Product X	1 Sales 4 Consulting	1 Sales 4 Consulting	2,5 Sales 6 Consulting
Total EBIT (2008-2009)	31,17 (t€)		

Table 2. Project portfolio after the solver

4.4 Transaction Consequences Model - Discussion

The promise of the model seems to be quite modest – the EBIT has increased from -53,83 (thousands of €) to 31,17 (thousands of €). However it should be noted that the estimates from net sales increases are very conservative. The increase in the euros that a company would receive is 85 000 € in two years. Regardless it should be noted that the results depend highly from the actual forecasts that are needed to evaluate sales and consulting increases/decreases when transferring people.

Care should be taken when using the model. It is unlikely that personnel can be transferred from product to product easily. However this should be pursued to maximize the benefits a firm receives. Problems in transferring people from project to project can be due to:

1. The products use different technologies
2. The products are different in their complexity
3. The products are in different phases of their life cycle
4. The products are developed in different countries

These issues need to be carefully catered when using transaction consequences and setting the maximum limit for people allocations per project. Transaction costs (part of transaction consequences in this thesis) listed in nearly every text book which considers the *efficient markets* play a key role in the model.

Another observation is that only four projects/products are used and it would be hideous task to apply the model to the whole product/project portfolio. When using only four products the amount of restrictions is nearly 40. When applying this to a project portfolio of 40 projects the number is 400. The maintenance of the model and data collection would require one full time person or dedicated software.

The model uses nearly all the needed enhancements listed in the end of Chapter 4.2, only PMPT is excluded. The forecasts are rough forecasts from the benefits available. In the future these numbers should be collected so that the biggest benefits could be received from the model. However with linear monetary benefits and with 40 projects the benefits could be 0,85

M€ Almost one million euros in two years from plain optimisation is a good result and recommends the model.

Transaction consequences is the biggest finding of this work. The concept itself is not a new thing however the model gives management a tool with which it can justify the personnel allocations and longer term product development plans. The model also clearly sets a demand - a firm should always look for opportunities which bring money to the company short term not forgetting longer term strategic investments. Usually these short term possibilities are discarded. This can be due to (at least) the following reasons:

1. Software development plans (projects) are made for long time periods
2. Resources are fully allocated in projects
3. Short term possibilities are closed in a short time period

The model bluntly puts the fact in to the table: people should be transferred continuously to those projects where the foreseeable benefits are greatest not forgetting the total picture (other projects).

4.5 Further Study

In this thesis two models for optimal software project portfolios have been introduced. First the original Markowitz model and then an enhanced model to better suit the demands and needs of a software project portfolio. It is noteworthy that the work done in this thesis doesn't try to fit the transaction consequences model to the Markowitz's framework. Preliminary thoughts on the matter reveal that it would be quite a task to fit increasing and changing net sales (effecting also EBITs) per person on a yearly basis to the Markowitz model. Another alternative would be to evaluate the suitability of Markowitz's and Dijk's work - Single-Period Mean-Variance Analysis in a Changing World (Markowitz and Dijk, 2003) to find optimal software portfolios. The topic is left for further study.

Work done by Markowitz after the original 1952 paper considers also the semi variance (PMPT):

"Analyses based on S tend to produce better portfolios than those based on V. Variance considers extremely high and extremely low returns equally undesirable. An analysis based on V seeks to eliminate both extremes. An analysis based on SE, on the other hand, concentrates on reducing losses." (Markowitz, 1991)

Rom and Ferguson (Rom and Ferguson, 1994) have suggested that the time has come when Post-Modern Portfolio Theory (PMPT) comes of age. The PMPT idea has also been suggested by William Sharpe based on Markowitz's work (Sharpe, 1964). An interesting topic for further research would be to investigate the suitability of PMPT against the software project portfolios. The permanence of PMPT is also backed up by Fabozzi, Gupta and Markowitz himself who issued a paper in 2002 (Fabozzi et al., 2002) where they argue that:

"…it seems safe to predict that MPT will occupy a permanent place in the theory and practice of finance."

To grasp the benefits that the transaction consequences model built in chapter 4 suggests the actual transaction consequences should be measured. I.e. data should be collected from the actual benefits from introducing one sales person more. This data, over the years, should be analysed perhaps using regression analysis methods. Similar approach when considering consulting should be done. This method should also take into account the actual life cycle of the product. This is due to the fact that in earlier phases in the life cycle introducing more personnel would probably yield more benefits than in later phases.

5   CONCLUSIONS

Software companies all around the world phase continuous pressure from their shareholders to reach ever growing financial targets. The possibilities are usually quite limited and the management must exert to reach these goals. Best efforts must usually be done with the given personnel. Optimal personnel allocation is a must.

In 1952 Markowitz suggested one solution to a financial security allocation, with the E-V rule. This thesis builds on this idea and extends it to concern software project portfolios. The goals of this Bachelor's Thesis were:

1. To evaluate the suitability of Markowitz's model for software project portfolio selection
2. To propose enhancements to the Markowitz's model or completely new model if the Markowitz's model proves to be inadequate

The Markowitz's model is not directly 100 % applicable in finding the optimal software project portfolio. This is due to:

1. Absolute levels of return
2. Transaction consequences
3. Minimum personnel allocation
4. Future years should be taken into account
5. Not all variance is bad (Post-Modern Portfolio Theory)

Based on these findings, another model, so called *transaction consequences* model, was built to overcome these limitations (excluding the Post-Modern Portfolio Theory which is left for further study). Transaction consequences model builds on the idea of the financial advantages and disadvantages when allocating people in to different projects. The model shows modest promise with 85 000 € benefit from optimizing the personnel between four projects in two years. However, enforcing the model to full project portfolio seems to be worthwhile. The model requires some attention when selecting the parameters but forces the management to realize the facts: people should be transferred continuously to those projects where the

foreseeable benefits are greatest not forgetting the total picture (other projects). Static or status quo situations must not be accepted for long periods of time. It remains to be seen will the necessary data be collected to evaluate and enhance model's actual performance.

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APPENDICES

Appendix 1: Microsoft Excel Help "Load the Solver Add-in"
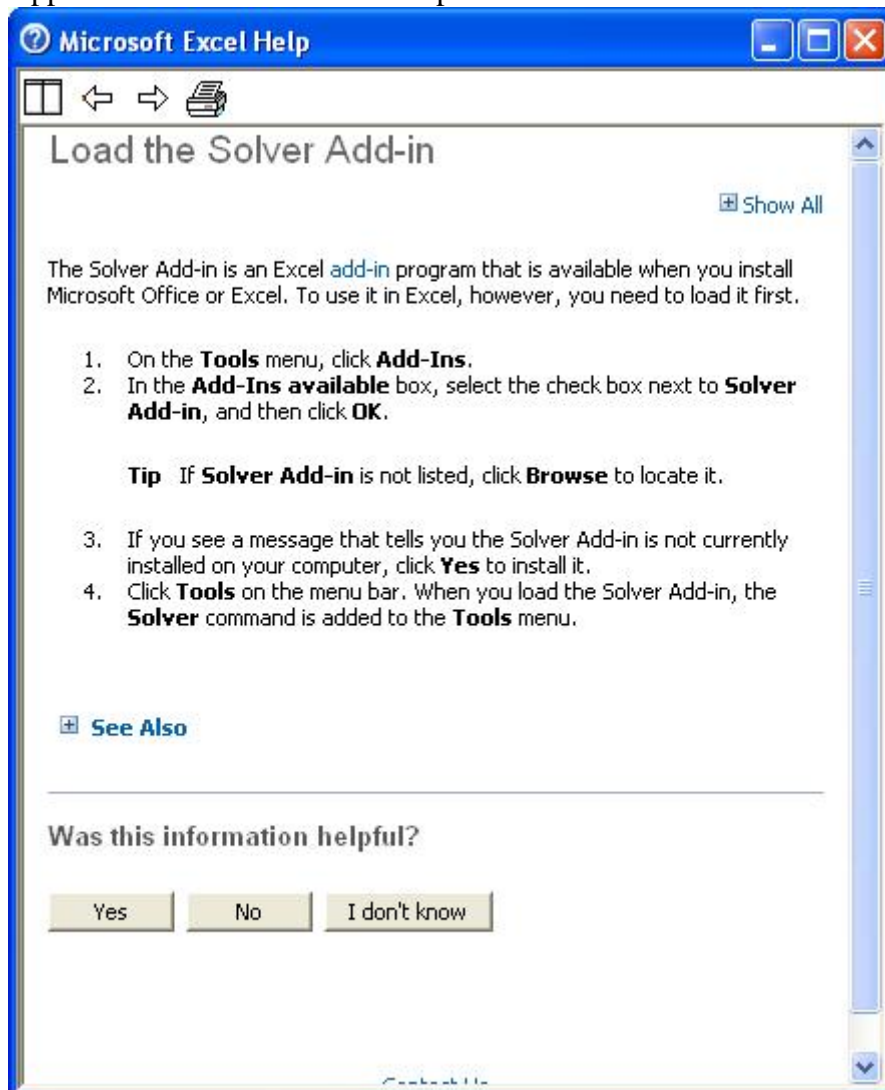
Appendix 2: Markowitz Model Microsoft Excel Formulas

	B	C	D	E	F	G
1						
2			**Standard Deviation, Average Return, a**			
3			**Years 2002-2010F**			
4						
5			Std. Dev. (%)			Average Ret. (%)
6						
7	Wintime		=Data!P14*100			=Data!P15*100
8	Intime		=Data!P38*100			=Data!P39*100
9	Tikon		=Data!P26*100			=Data!P27*100
10						
11						
12		Wintime	Intime	Tikon		
13	Wintime	1	=CORREL(Data!N5:N13;Data!N29:N37)	=CORREL(Data!N5:N13;Data!N17:N25)		
14	Intime	=D13	1	=CORREL(Data!N29:N37;Data!N17:N25)		
15	Tikon	=E13	=E14	1		
16						
17						

	A	B	C	D	E
18			**Covariance Matrix**		
19					
20					
21			Wintime	Intime	Tikon
22		Wintime	=D7*D7*C13	=D7*D8*D13	=D7*D9*E13
23		Intime	=D22	=D8*D8*D14	=D8*D9*E14
24		Tikon	=E22	=E23	=D9*D9*E15
25					
26					
27			**Weighted variance matrix**		
28					
29					
30		Results			
31			Wintime	Intime	Tikon
32		Weights	=B33	=B34	=B35
33		0,176098460220928	=B33*C32*C22	=B33*D32*D22	=B33*E32*E22
34		0,228998729446734	=B34*C32*C23	=B34*D32*D23	=B34*E32*E23
35		0,594902810332338	=B35*C32*C24	=B35*D32*D24	=B35*E32*E24
36	Sigma	=SUM(B33:B35)	=SUM(C33:C35)	=SUM(D33:D35)	=SUM(E33:E35)
37	Portfolio variance	=SUM(C36:E36)			
38	Portfolio SD	=SQRT(B37)			
39	Portfolio mean	=B33*G7+B34*G8+B35*G9			
40	Expected return start	=C32*G7+D32*G8+E32*G9			
41	Expected return solver	=C32*G7+D32*G8+E32*G9			

Appendix 3: Transaction Consequences Formulas

	B	C	D	E	F	G	H
5			Baseline				
6		Year	2007		2008F		2009F
7	Product A						
8		FTE	=D12+D15		=F12+F15		=H12+H15
9		Costs/FTE	81,1125		81,1125		81,1125
10							
11		License sales	=Data!E10		=D11+F28+F29		=F11+H28+H29
12		Sales	=Data!E46		1		1
13		Maintenance sales (fixed)	=Data!F10		=Data!F11		=Data!F12
14		Consulting sales	=Data!G10		=D14+F31+F32		=F14+H31+H32
15		Customer services + development	=SUM(Data!E42:E45)		8,5		8,5
16							
17		License sales + (Sales increase)	75		75		
18		License sales - (Sales decrease)	75		75		
19							
20		Consulting sales + (Consulting increase)	60		60		
21		Consulting sales - (Consulting decrease)	60		50		
22							
23		FTE Increase(+)/Decrease(-) Sales			=F12-D12		=H12-F12
24		FTE Increase(+)/Decrease(-) Consulting			=F15-D15		=H15-F15
25							
26	Profit and loss						
27		Netsales	=D11+D13+D14		=F11+F13+F14		=H11+H13+H14
28		Increase by new sales			=IF(F23>0;(F12-D12)*D17;0)		=IF(H23>0;(H12-F12)*F17;0)
29		Decrease by reduced sales			=IF(F23<0;F23*D18;0)		=IF(H23<0;H23*F18;0)
30							
31		Increase by new cust. serv. + dev.			=IF(F24>0;(F15-D15)*D20;0)		=IF(H24>0;(H15-F15)*F20;0)
32		Decrease by reduced cust. Serv. + de			=IF(F24<0;F24*D21;0)		=IF(H24<0;H24*F21;0)
33		Costs	=D8*D9		=F8*F9		=H8*H9
34		Increase by new			=IF(F8-D8>0;(F8-D8)*D9;0)		=IF(H8-F8>0;(H8-F8)*F9;0)
35		Decrease by moving			=IF(F8-D8<0;(F8-D8)*F9;0)		=IF(H8-F8<0;(H8-F8)*H9;0)
36		EBIT	=D27-D33		=F27-F33		=H27-H33