

REAL R&D OPTIONS
VALUATION:
A PORTFOLIO OF
PROJECTS AT PHILIPS ADL

INTEGRATING DEPENDENCY EFFECTS IN A PORTFOLIO OF PROJECTS

Public version

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MANAGEMENT SUMMARY

This research project has been conducted at Philips Advanced Development Lighting with the following goal:

To develop a practical model, for Philips ADL, that can be used to calculate the value structure of projects in a technology portfolio, in order to improve project assessment.

In order to achieve this goal, the context has been examined which gave the following requirements:

- The model must provide a value structure, quantifying the value of projects and the project interactions
- The portfolio structure must be relatively easy to create
- The outcomes of the model must be easy to understand
- The model must be easily adjustable to every company level

Within Philips ADL a valuation method had been developed for individual project valuation. The method could be applied for individual projects but lacked portfolio valuation. The method could not be used to compare the different projects because the impact of projects on one another was not known.

A search of the real option literature showed a uniqueness of the already used valuation method and a portfolio real option method to fit the Philips ADL situation has not been found. A further development of the valuation method has led to a new portfolio valuation model.

The contribution of all of the scenarios in a portfolio is calculated, if the scenario is only dependent of uncertainties in one factor, the value is appointed to that project. If the scenario contains uncertainties from more than one project, the value is appointed to all the projects that manage uncertainties in that scenario. In the project in which the scenario is managed it is added to the project value, in other it is counted as value impact of the project. The influence not only the risk but also the potential, of all of the uncertainties on the portfolio value is calculated within the model.

An assessment of a portfolio of projects has shown that the situation can be modeled with the developed tool and that it is practical in its use. Besides the project and the portfolio value, the value of relationships can be made visible with the help of this tool. Executing the tool has led to more scenario thinking within the project teams and between the project teams. The developed model could improve project assessment.

PREFACE

In this report I present my thesis for which I have worked as an intern at Philips Advanced Development Lighting in Eindhoven, the Netherlands. This period started on the first of December 2007 and ended at Philips at the end of June 2008. During this period I have suffered the loss of my father. He has always been a great support for me, I am disappointed that he can't experience the day that I present my thesis.

My supervisor at Philips, Ruud Gal, and Supervisor from the University of Twente, Marc Wouters have helped me to keep a focus on my graduation project. I would like to thank them for that. Furthermore I would like to thank them and Berend Roorda for their contribution to, and good ideas for, this project.

Eelco Rondhuis

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CHAPTER 1 VALUATION PROBLEMS IN R&D

Organizations struggle with monitoring the value of their R&D (Research and Development) projects. The motive for starting this research project was the doubt about the valuation of projects in a portfolio at Philips ADL (Advanced Development Lighting). Within Philips ADL the projects are valued on basis of real option techniques which have been validated by a previous graduate student. The total of these values is not regarded as the value of the entire portfolio.

In this chapter, a description is given of the organization in which this research project takes place. This is done by describing where this project takes place within Philips. The structure of the projects and portfolios is explored. Then the valuation process of the projects and portfolios is explained, which leads to a research goal. The accompanying research questions to achieve this goal are stated. At the end of the chapter, the further structure of this thesis is given.

ORGANIZATION

Philips consists of Business Units: Lighting, Consumer Lifestyle and Healthcare. Figure 1-1 displays the organization chart of Philips Lighting. This is a research project for Lighting, ADL (Advanced Development Lighting) which is part of PD (Product Development) Support & Leadership. Furthermore Philips Lighting consists of seven Business Groups (BG), a CFO (Chief Financial Officer) and a CEO (Chief Executive Officer). Each of the business groups has its own function. Groups have to cooperate when approaching the market, e.g. cooperation between BG Lighting Electronics and BG Lamps has to take place: the architecture of a lamp developed at BG Lighting Electronics is needed by BG Lamps to actually bring a product to the market.



FIGURE 1-1 ORGANIZATION CHART PHILIPS LIGHTING

The PD Support & Leadership consists of three groups: GOAL (Global Organization Applications Lighting), Mechanization and Advanced Development Lighting (ADL). GOAL brings technology and marketing together, fitting products even better to the end-user needs. Mechanization facilitates supplies and services around the world. Philips ADL is the development group.



FIGURE 1-2 ORGANIZATION CHART PHILIPS ADVANCED DEVELOPMENT LIGHTING

The organization chart for Philips ADL is displayed in Figure 1-2. Philips ADL has approximately 250 employees. There are four main departments which are divided by function, namely Materials & Processing, Discharge Lamps, Electronics and Systems. Under the department name, is the Business Unit on which the department focuses. The output of Philips ADL can be divided into three sectors: Discharge & Filament, Solid State Lighting and the New Value Drivers. The mission of Philips ADL is diverse. On one side ADL wants to develop the 'Future Stars' for Lighting in high technologies, on the other side it wants to enable and support development in the more generic technologies that enter the lighting market. The strategy supporting this mission is based on entrepreneurship in the projects. Understanding the end-users needs and their business opportunities should create the new concepts for growth in the form of new projects. Key success factors for the projects are: open innovation, knowledge productivity, and speed & reliability.

PROJECTS

In a portfolio, all projects are based on the same *technology*. The *technology* can create dependencies between projects. Within Philips ADL all projects follow a similar path through four milestones. This is from milestone minus three till milestone zero. The goal of the milestones is to prove technical feasibility and commercial fit with a Philips Lighting Business Group. The milestone method is schematically represented in Figure 1-3.

Technology is defined as the usage and the knowledge of tools and techniques/ methods. For Philips ADL the same technology is the usage of the same technique/ method in order to create light.



FIGURE 1-3 MILESTONE SCHEME

The GEIN (GEnerating INnovations) process can enable projects to enter the milestone phase. In this phase ideas are created that could lead to the beginning in the Milestones. Also concrete questions from business groups can lead to the start of a project in the Milestones. The Milestone phase is:

Milestone -3

Milestone minus three is the start; an idea is defined as an assignment, describing the goals of the project in detail. This will also include a plan for what needs to be achieved and how to achieve the set goals at Milestone minus two.

Milestone -2

Milestone minus two is an 'evaluation' milestone: it is passed if the project has developed to the preset criteria. In Milestone minus two, criteria are present which every project has to achieve in order to pass this Milestone, these include: a demonstration of the commercial attractiveness and, the technical feasibility of the project

Milestone -1

Milestone minus one is a 'formulation' milestone; a plan for the next phase have to be formulated. For milestone minus one, the project plan has to be rewritten in more detail. It has to be updated on the technical features of the project, but more importantly, the commercial part of the plan has to be defined more precisely.

Milestone 0

Milestone zero is an evaluation phase, in order to pass, a business case has to be developed to prove the commercial attractiveness of the project. Also, the manufacturing/ industrial platform for the product range must be defined. In the milestone zero the review of the project takes place for Philips ADL. The results are described and the limitations of the product are reviewed. If this Milestone is passed, the responsibility for the project is transferred to one of the BG's.

PORTFOLIO MANAGEMENT

A portfolio is a group projects that have something in common. For Philips ADL, portfolios of projects have the same underlying technology in common. Portfolio management is a dynamic decision making process wherein new projects are evaluated, selected and prioritized (Cooper, Edgett, & Kleinschmidt, 2001, p. 3). For a technology company, like Philips, three general views on portfolio management can be distinguished (Cooper, Edgett, & Kleinschmidt, 2001, p. 4):

1. The *strategic view* a portfolio is aligned with the company's vision and mission.
2. The *financial view* aims to optimally achieve allocation of the financial resources in order to maximize the created shareholder value in the projects.
3. The *technical view* selects the projects in which the technological innovation is the main priority.

In this research, the financial view is taken because the current method of valuing of projects does not incorporate the value implications that the different projects have on one another. Value based management can currently not be applied within Philips ADL because of the absence of information about the value implications of projects within a portfolio.

PROJECT VALUATION

A Project Value is defined as the expectation of future cash flows, i.e. "how much" money can be made from the project, with adjustments for the risks of not achieving the expected future cash flows.

The uncertainties of a project can be split in two areas: "*Coping with market uncertainty greatly complicates the already difficult task of managing technical uncertainty, because resolving the technical uncertainty depends on which market the technology is intended to serve and vice versa. One can not anticipate the best path from the beginning*" (Chesbrough, 2004). In valuation literature these uncertainties are categorized in the *systematic*- and *unsystematic* risks of an investment.

Systematic risks are risks that have links with the economic circumstances, e.g. a decline in the overall demand or high inflation in raw materials.

Unsystematic risks are unique for a company, e.g. solving technological problems or difficulties with the labor force.

Traditionally, a *Net Present Value* (NPV) calculation is used for projects. In this method, future cash flows are discounted to a present value. The discounting is done by a certain pre-set interest rate. As can be seen from the citation, the future cash flows will and cannot be estimated at the present time for New Product Development (NPD). The interest rate used in should incorporate the risks present to the investment. Covering both the systematic as the unsystematic risks in the interest rate makes the assessment of what interest rate to use difficult. All the risks are averaged in order to come to a interest rate, but the validity of the valuation is compromised. **This makes the determination of the project's** interest rate is a serious point of discussion. Still the NPV method is often used for uncertain projects.

Projects that could lead to a major break-through are valued less when an NPV calculation is applied. The reason for this is that the NPV has an '*all or nothing*' investment built into its calculation. This underestimates the value of a breakthrough of a high-risk project. The small innovation projects will be valued higher because of the higher incorporated certainties. Most of the time, the value of a project is used in a ranking method in order to use them with an overall selection process (Archer & Ghasemzadeh, 1999).

The risk of an NPV cannot be identified and stays anonymous in the interest rate. The inflexibility of **the NPV method suggests the outcome is a hard value. The 'all or nothing' number gives a feel of** security that is not present. In the case of a research and development process the value implications that a reduction of the risk, caused by development, has on the value of the project, let alone the value

of the portfolio, cannot be calculated from the NPV method. This makes value based management of a portfolio impossible.

Due to the technological uncertainties of the projects, the exact outcome is difficult to predict. For Philips ADL, their projects in a portfolio are based on the same technology. Uncertainties can therefore be correlated within a portfolio. The calculation of the value of an individual project is therefore difficult, let alone for an entire portfolio.

For research and development projects, the downside of the NPV method is its inflexibility. A more flexible way to calculate the value of projects is the use of a *real options* method. Real option valuation provides flexibility to the valuation of projects by letting the value of the underlying project vary and value the option of doing the next investment with the vary project value as the return for the investment. Currently, Philips ADL makes use of real option techniques to gain insight into the value of individual projects. Projects are valued using an *option table* as provided in Table 1-1.

A Real Option is defined as the valuation of a *real* projects the use of *option* valuation techniques, i.e. the right but not the obligation to buy (or sell) an asset. The theory will be explained in Chapter 3.



TABLE 1-1 EXAMPLE OF AN OPTION TABLE

The method uses *uncertainties* and *scenarios* in order to cover the flexibility of a project.

An Uncertainty is defined as independent *problems that need to be 'solved'* in order to be of contribution to a *scenario*. A uncertainty has a certain chance of being solved, stated in its probability.

A Scenario is defined as a collection of uncertainties which as a group are expected to have a value (the scenario value in Table 1-1).

In Table 1-1, there are four uncertainties, numbered I to IV with their probability stated directly beside the numbers. There are also four scenarios, named A to D. If a uncertainty needs to be solved for a scenario, a '1' is stated at the intersection of the row of the uncertainty and the column of the scenario. This creates the structure of the valuable outcomes of the project, every scenario is a valuable outcome. In order to calculate the option value of the project the following steps are taken:

1. The methods are ranked based on their scenario value, the one with the highest value will be placed in the first column of the scenario, in this case the position of scenario A. The second highest on the second scenario row, in this case scenario B, and so on.
2. The scenario probability is calculated. Scenario A is calculated first, because this scenario has the highest value. This is done with the help of the probabilities that the uncertainties can be solved. Scenario B will only be tried to reach as outcome of the project if scenario A has failed. For the calculation of scenario probability B, it has to be taken into account that scenario A has failed so limited options of getting scenario B as outcome remain. For scenario probability C, it has to be taken into account that A and B failed and for scenario D, the failure of A, B, and C has to be accounted for in the scenario probability calculation.
3. The option value is calculated. The scenario probability times the scenario value is the expected value of that scenario. The expected value of the project is the summation of all the expected scenario values.

This method to value projects has been developed by the Innovation Improvement manager, Ruud Gal. In a previous graduation project at University of Twente in cooperation with Philips ADL, this method has been validated by Willem Chung.

GOAL

The value and the value implications of development projects in a portfolio is management information that is not available within Philips ADL. This is useful information for value based management of the development projects. This leads to the following research goal:

To improve the current project value calculation method to a practical portfolio model, for Philips ADL, so it can be used to calculate the value structure of projects in a technology portfolio, in order to improve project assessment.

A Practical portfolio model is defined as a model that 'easily' (without much effort) can be applied to real life portfolios managed by practitioners within a Research & Development Company.

A Value structure is defined as the construction of a portfolio by its projects and their interactions that create the value for the portfolio.

A Technology portfolio is defined as a collection of all projects sharing their basis in the technology that is applied within the project.

A Project assessment is defined as the judgment of the project based on the added value of the project for the Research & Development Company.

RESEARCH QUESTIONS

In order to achieve the research goal, the following questions need to be answered:

1. What is the scope of a (new) portfolio value calculation model within Philips ADL?
2. What are the requirements & criteria of the new value calculation model?
3. What can be learnt from the theoretical models in valuation literature and real option literature in particular for the Philips ADL context?
4. What model can be specified, regarding the requirements and criteria?
5. Can the newly specified model be applied in practice?

APPROACH TO THE RESEARCH QUESTIONS

In order to tackle the research questions the writer has worked as an intern at Philips ADL. From December 1st till June 30th the writer has worked at Philips Lighting in Eindhoven, the Netherlands. During this time regular meetings with the Innovation Improvement manager occurred in order to discuss the progress of the new model and generate ideas for the direction of the future progress in the development of the model. The Innovation Improvement manager has been a guide through Philips Lighting for the writer. The approach to the individual research questions is explained next.

Q-1 What is the scope of a (new) portfolio value calculation model within Philips ADL?

The scope is the context in which the value structure can be created. This is the process that the new value calculation model needs to cover.

This question is answered by an examination of internal documents of Philips ADL. The internal documents¹ used for this are documents from the intranet site of Philips ADL and the intranet site itself. Besides the examination of Philips internal documents, the cooperation with the Innovation Improvement manager provided knowledge about the execution of the internal documents and additional information. Incidental conversations with project managers confirmed the information that was provided by the documents and meetings with the Innovation Improvement manager.

¹ Milestones.pdf & Projects.pdf from pww.lighting.philips.com/ADL/documents

Q-II *What are the requirements & criteria of the new value calculation model?*

The requirements form the basis for the criteria on which the new value calculation model can be judged.

This question is answered in the process of the tool development. During the development phase, in cooperation with the Innovation Improvement manager, conversations about what was needed got structure and were made practical. In these conversations requirements and criteria for the model were formed.

Q-III *What can be learnt from the theoretical models in valuation literature and real option literature in particular for the Philips ADL context?*

This question is answered by an examination of relevant valuation literature. The theoretical models will be assessed using the requirements and criteria that are set in the previous question.

Q-IV *What model can be specified, regarding the requirements and criteria?*

Combining the knowledge from the theoretical valuation models and the requirements and criteria, a new portfolio value model has to be specified capturing the scope of the Philips ADL situation.

This question is answered by a trial and error process; the development of the model has been done by creating a Microsoft Excel tool which could be used in practice. The development of the tool has been a cooperation of the Innovation Improvement manager and the writer. The development of the tool was discussed in regular meetings and research has been done by the writer in order to provide with additional background information.

Q-V *Can the newly specified model be applied in practice?*

This question is answered by a reviewing a practical test. This test will be conducted on a portfolio of projects at Philips ADL. For the test, inputs have been generated through interviews with project managers. The outcomes of the tool are reviewed by the same project managers and, in addition, two portfolio managers. The tool is applied to a real portfolio in order to test the model and come to possible improvements. This is done with the information available within Philips ADL, before introducing the tool to the business groups of Philips Lighting.

STRUCTURE

The rest of this thesis is constructed based on the questions. This is visualized in Figure 1-5. In Chapter 2, the scope of this project will be set and the requirements will be formulated to which the new value calculation model must comply. In Chapter 3, the theory of real options will be explored in order to gain knowledge for the new model. The new model will be specified in Chapter 4 and tested in Chapter 5. This will lead to conclusions in Chapter 6. In Chapter 7, some recommendations will be given for improving the model/ method and areas for future research will be given.



FIGURE 1-3 CHAPTER DIVISION

CHAPTER 2 CONTEXT

This chapter answers the following two research questions: ‘What is the scope of a (new) portfolio value calculation model within Philips ADL?’ & ‘What are the requirements & criteria of the new value calculation model?’

The scope of the new portfolio calculation model contains two parts. The first part describes the situation that the model needs to capture and what it doesn’t need to or cannot capture, i.e. what process does the new portfolio value calculation model need to capture. The second part addresses the purpose of the model, i.e. what does the new portfolio calculation model need to present for the model users. This answers the first question.

Following, requirements for the new value calculation model will be introduced. The scope determines the boundaries of the requirements. The requirements are made concrete in the criteria that can be set. This provides a basis for the evaluation of the ‘new’ value calculation model. This answers the second question

SCOPE

In order to identify the processes that the new portfolio value calculation model needs to capture, first the projects types need to be distinguished, and what kind of actual connections could be present between the projects in a portfolio. This will be done in *Projects & Portfolios*. Secondly, the value process of the projects is analyzed in order to see where the value is created and if and where the value implications of the projects are placed. This will be done in *Philips ADL Value Process*.

PROJECTS & PORTFOLIOS

The structure of projects at Philips ADL can be seen in Figure 2-1. The projects can be divided roughly into three groups, projects creating: a technology, a function or a system concept. The development of a technology is the start for a portfolio of projects based on this technology. If a technology is developed, there could be three types of projects present in the portfolio, a platform/ technology improvement project, a function creation process project, and a product creation process project.

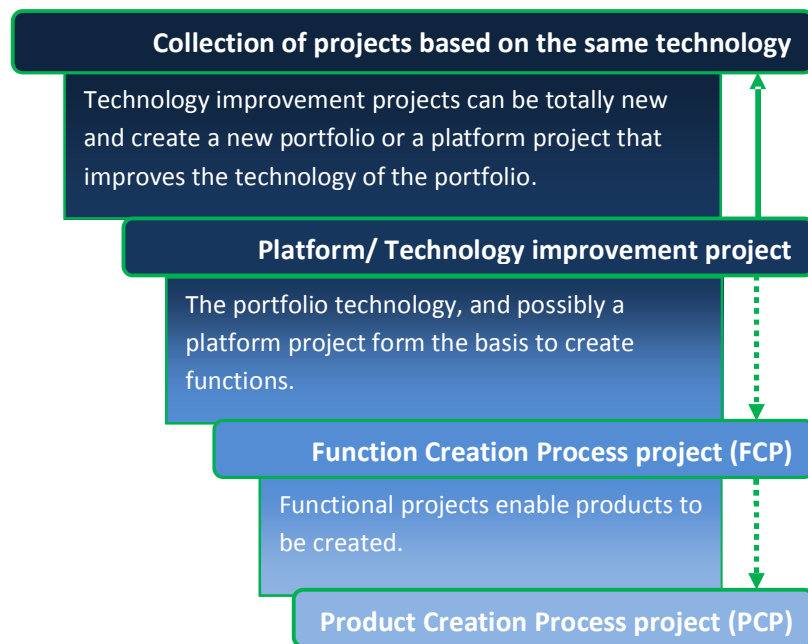


FIGURE 2-1 PROJECT STRUCTURE

Platform/ Technology improvement project

The development of a new generation for a specific technology creates a platform project. This is a technology project. On this platform, new functions and systems can be based. This project renews the technology of the portfolio. This project could also happen outside a technology and so create a new portfolio, the start of a portfolio. In the case of platform projects, all projects that are scheduled later have to benefit from this new generation. For this kind of projects the Milestone phase cannot be completed because technical feasibility and commercial attractiveness can be assigned, but it cannot go to the market.

FCP (Functional Creation Process) project

In order for a technology to come to an application in a product, functions need to be created. This is done in the FCP projects. They investigate the technology, independent of future products in order to apply the technology to create a function concept of a lighting system. For this kind of projects the Milestone phase cannot be completed because only a function does not go to the market.

PCP (Product Creation Process) project

A combination of functions can become a system concept which can be developed further into a product. This is done in PCP projects. The Milestone phase can completely be completed for PCP projects. Combinations of functions are made to fit each other to create an application, the project creates besides the application a complete supply chain to manufacture and supply the product after the Milestone phase.

Example 1: positive dependency

FCP project A develops a new burner for BG Lamps. This burner is new generation and the costs of this burner will be reduced by 50 percent and compared to its predecessor can be used in more applications. PCP project B develops a new spotlight for retail shops. The application is relatively expensive, but will give more light at a lower wattage. The price will be so high that the market probably will not accept it. The new burner from project A can reduce the costs of the product that is developed in B in such a way that the price can substantially be reduced. Then the compelling case can be built to bring project B to the market. Project B is *dependent* of project A. Project B can only succeed if project A succeeds.

Example 2: positive value relationship

Platform project C develops a new generation of a technology. FCP project D develops a new driver, on the basis of the new technology. The development of the second generation in Project C must succeed in order for Project D to have any function and therefore any value. This is a *positive value relationship*. Project D can only succeed if project C succeeds.

Example 3: negative dependency

FCP project E develops a new driver and is based on an existing standard for drivers. FCP project F also develops a new driver but on the basis of a new standard. For future PCP's these two projects compete and only one can be made the new standard function. If the technical uncertainties in project F decrease, then the chance of a success for F increase and the potential value for E decrease. This is a *negative dependency*. From the two projects only one can succeed. The projects cannot be seen separately from each other, while in a technological perspective they differ.

Interaction

Thus, portfolios should consist of three types of projects, FCP's, PCP's and platform projects. In practice, this is not the case. In a project a new function can be created for a new product within the same project. Also, platform projects do often not start as a platform project but as a FCP project and then develops to become a platform. This will not only create dependencies between the 'PCP' projects and 'FCP' and platform projects, but also amongst the PCP projects because they can have an integrated FCP in them.

PHILIPS ADL VALUE PROCESS

FCP and platform projects are enablers for product creation process projects. The FCP and platform projects will not have outcomes that could generate value. These projects will therefore not come any further than milestone minus two. The FCP- and PCP project are in practice often integrated, which could also be the case for platform and FCP projects, so the integrated parts are treated here.

FUNCTIONAL/ PRODUCT CREATION PROCESS PROJECTS

Figure 2-2 represents the cash flows of a 'successful' FCP/PCP project as a function of time. The project goes through different phases. The first phase is the development phase; this is the responsibility of Philips ADL. This phase has a circle around it in the Figure.

Project starts at Milestone minus three, which is the beginning of this cash flow path. At the start of the development phase it is unknown what cash flow path the project will have. The cash flow path can take many shapes, dependent of the developments in the project and the market. The first phase is not an expensive one to start, but it is important to start the projects that have the best cash flow paths in the future. In the case that a PCP and FCP are integrated in one project, the project will have a go to milestone minus two separately for the function as well as for the product. Both should be defined in the same project in order for the function to be used in other PCP projects. This can create the relationship between PCP projects that is important for a good project assessment.



FIGURE 2-2 ILLUSTRATION OF A VALUE PATH FOR A PRODUCT CREATION PROJECT

The second phase, in the Figure right from the vertical line in the middle, starts at milestone zero. This phase starts with the decision whether or not the project is taken to the market, so whether or not the project is adopted by one of the business groups. In order to introduce a project in the market, investments must be made in order to produce and to market the product from the project. This is the go/ no go decision for the project, if seen as an option, this would be the exercise. This exercise decision is taken by the business group that adopts the project. The go/ no go decisions at time zero are taken on the basis of a NPV case. After that the product is implemented in a production line and is available for sales, until that time, no revenues are generated.

In a portfolio of projects which are in the development phase, projects are partly finished. Selecting **the 'most successful' projects is the R&D management challenge.** A successful project for Philips ADL is a project in which the technological/ project uncertainties are resolved and the commercial prospects are positive. The value of a development project is in the gained knowledge and can only be materialized if the project becomes successful. When a project has a positive prospective to be successful, the option on the project can be exercised and investments can be made and bring it to the market. This is a decision that will require a large investment and must be earned back by the sales. An example of the cash flow coming from a successful project is presented in the right part of Figure 2-2.

PLATFORM/ FUNCTIONAL CREATION PROCESS PROJECTS

The FCP projects and the platform projects are projects that create links between the PCP projects. The first level of such a link is the FCP projects and the second level is the platform projects. These projects are important for the value of a portfolio. They cannot create value on their own but they do determine which PCP projects can exist and where value is created. Some FCP projects are integrated with PCP projects. The execution of that project is not only important for its possible cash flow path, like Figure 2-2, but also for the influence it can have on other cash flow paths.

In the value process of FCP and platform projects it is not always clear where the extra value of that platform will be created. FCP's and platforms are the basis of new products but what PCP projects will make use of the platform or FCP might in the beginning of an FCP or platform be unknown. The new portfolio calculation model should capture the value if it is known and if projects are already defined for it. It should in these circumstances be obvious that the project is a platform or FCP project because of all the connections it has with other projects. If the platform or FCP projects uncertainties are resolved, the connections will be lost and the projects can use the knowledge freely. Connections between projects are then not apparent any more.

MANAGEMENT

A process within Philips ADL goes through different milestones. The process through the milestones is not a process that is time driven, it is *content driven*. Therefore managed on the contents while appointing the FTE's (Full Time Equivalent) is a process that is *time driven*. FTE's are appointed to a project for a year. There are no guidelines for determining the number of FTE's appointed to the different decisions. The decision regarding this number is commonly based on a manager's feeling. Time and content do not have decision points at the same time. An overview of the values and the risks of the projects in a portfolio will give more insight in effectively appointing the FTE's. Optimizing this process could be a subject of further research, if the new value calculation model is present. More over this is presented in the recommendations.

MODEL PURPOSE

To explain the purpose of the new portfolio, the question 'what does the new portfolio calculation model need to present for the model users' needs to be answered. To answer this question the users need to be defined, what the model will be used for and what the needs of the users are.

USE/ USERS

The management of Philips ADL has to determine what budget and how many FTE's certain projects receive. These decisions are based on the assessment of the projects, or even portfolios, that are present. For these decisions, the prospects of the projects need to be known and a vision of where the market is heading should be present. These decisions can be based on the financial effects that the projects will have in the future for Philips Lighting. Providing insight in the value structure of the projects within a portfolio will help in making more effective decisions by R&D management. Within the value structure, the structure of the projects is determined by the projects themselves and the value that comes from a market assessment.

The use of the model can be defined as using the value calculation model in order to provide a comprehensible value structure of a portfolio with the purpose of improving investment decision in the portfolio by Philips ADL management.

As could be seen from the use of the model stated above, the user of the model is R&D management of Philips ADL. They will be the main users of the model but an addition must be made. Project management and market experts must be added to the users of the model because they will deliver the information needed for the model and they are participants in the decisions taken by Philips ADL management.

USER NEEDS

In order to make sure that the model can actually be used, and to create a practical model as stated in the goal formulation of Chapter 1, the needs of the users of the model must be taken into consideration in the new portfolio value calculation model.

The user needs are:

- Structure must be easily creatable and maintainable
- A comprehensible method must be made to calculate the value of projects and interactions
- Value structure must be accurate

In order to use the model, it needs to be executed. In the execution a portfolio structure must be made in order to create a value structure for the portfolio. The creation of this structure must be easy and a good overview must be kept over it to become useable for R&D management. A model which application is time consuming will not be practical. The value structure must be updated through time. For the value structure to become usable it will need to be easily creatable and maintainable.

In order for the model to be part of the project assessment it is essential that it is comprehensible for its users. Implications of a model that cannot be understood will not give a good informational background to support decision taking. The execution of decisions will be most effective if the participants know why a decision is taken. A good comprehension of the model will also give a good knowledge about the limitations of the model. It is important to know the limitations to understand exceptions within the model.

Confidence in the model will be based on the accuracy it. The goal of the model is to improve the investment decision for Philips ADL. In order for the decision taking to be reliable, the created model must be as accurate as possible. If this is jeopardized, the decisions that will be taken based on the information that is provided by the model could have serious consequences in delivering the 'right' projects to the business.

MODEL - REQUIREMENTS

'What are the requirements & criteria of the new value calculation model?' is the question that will be answered in this subsection. The requirements that will be set determine what the model must be able to do and what it has to take in consideration. The user needs define the input and output of the model, while the requirements defines what the model should do in order to fulfill the user needs. From these requirements criteria can be set that will make the requirements operational in order to create the right model for Philips ADL.

From the value process and the purpose of the model the following requirements are set:

The model must provide a value structure, quantifying the value of projects and the project interactions

The goal for the model is to create insights in the value structure of a portfolio of projects, to give a good picture of the portfolio which enables the viewer to see the value of the projects in the portfolio and the value of the interactions between the projects in the portfolio. The robustness of the value

structure is must be assessed by a risk assessment for all the individual parts of the structure. Criteria for this requirement:

- An overview of the value dependencies between projects
- A valuation of projects and the relationships between projects
- A portfolio risk assessment for all the individual parts of the structure

The portfolio structure must be relatively easy to create

The new portfolio value calculation model should capture an entire portfolio of projects. In practice, there is no one at Philips ADL that has a full overview of the structure of all the projects in a portfolio and fully aware of all the uncertainties within that projects. It is therefore important the model is fragmented in parts to which expert knowledge is available. Experts on individual projects are available in project management. They have a good overview of the uncertainties per project. Communication between the fragmented parts must then deliver a complete structure to which the model can be built. Criteria for this requirement:

- A non-sequential model for the structure of the valuation must be used
- A good overview of the uncertainties per project in the structure

Outcomes of the model must be easy to understand

From the user needs, the outcomes of the model must be easy to understand and be comprehensible for all the users and participants of the model. In the application of the model this means that the outcomes will have to be explained in figures. Criteria for this requirement:

- **A comprehensible figures must be presented as the outcomes of the model**

The model must be easily adjustable to every company level

In order to make the model useable throughout the entire company, it is important that the outcomes of the model can be adjusted for the different market segments in which the company operates. For the different segments, an analysis can be executed for what the value structure of the portfolio is for that particular segment. The different business groups can then see which part of a portfolio can be interesting for them.

✦ A valuation of the total portfolio in different segments must be present

CONCLUSION

What is the scope of a (new) portfolio value calculation model within Philips ADL?

The scope of the new value calculation model contains two parts, the value process it needs to capture and the purpose of the new model. The value process the model needs to capture is the process in which three kind of projects are present. Platform and Functional Creation Process Projects are the projects which enable Product Creation Process Projects to bring the products to the market. These platform and FCP projects form the links in the portfolio of projects. Assigning the 'right' amount of FTE's to the various projects in a portfolio is the way for management to stimulate its development. Making the right choices in this assigning process is the management task. The purpose of the new portfolio value calculation model is that the use of the model can be defined as using the value calculation model in order to provide a comprehensible value structure of a portfolio with the purpose of improving investment decision in the portfolio by Philips ADL management. The structure must be easily creatable and maintainable, a comprehensible method must be made to calculate the value of projects and interactions, value structure must be accurate are defined as the user needs.

What are the requirements & criteria of the new value calculation model?

The following requirements can be set from the goal and the scope of the project:

- The model must provide a value structure, quantifying the value of projects and the project interactions
- The portfolio structure must be relatively easy to create
- Outcomes of the model must be easy to understand
- The model must be easily adjustable to every company level

These requirements lead to the following criteria:

- An overview of the value dependencies between projects
- A valuation of projects and the relationships between projects
- A portfolio risk assessment for all the individual parts of the structure
- A non-sequential model for the structure of the valuation must be used
- A good overview of the uncertainties per project in the structure
- A comprehensible figures must be presented as the outcomes of the model
- A valuation of the total portfolio in different segments must be present

CHAPTER 3 LITERATURE - REAL OPTIONS

This chapter answers the following research question: *‘What can be learnt from the theoretical models in valuation literature and real option literature in particular for the Philips ADL context?’*

First, in order to get a feel of real options, an introduction will be given of them, i.e. what are real options. Secondly the context of valuation of projects will be explained and the place of a portfolio of Philips ADL will be determined in the context. Real options could be applicable for Philips ADL so thirdly, the different approaches in real options will be described. This will turn out to be three kind of major approaches, namely the classical approach, the tree approach and the qualitative approach. All the approaches turn out not to be usable in the context of Philips ADL. They will be treated because the methods will set the boundaries for the use of real options within the Philips ADL context; also questions about the classical method were asked from within Philips ADL.

REAL OPTIONS - INTRODUCTION

‘Real options’ is a term that was introduced in 1977 by Myers and it refers to the valuation of non-financial investments or ‘real’ investments with the help of option pricing theory. To value the investments, it can be staged. The factors of learning and the flexibility of an investment, can be taken in consideration with this approach (Myers, 1977). The first investment that has to be made is the right but not the obligation to continue with the project. Real options are based on an analogy between projects, plain vanilla options and investment opportunities (Amram & Kulatilaka, 1999). Plain vanilla options are contracts on the basis of financial assets. The holder of the contract has the right but not the obligation to buy or sell the underlying financial asset at a predetermined exercised price within a specified time-frame (Hull, 2003). The project, for a real option, is the financial asset in the plain vanilla option. The option valuation of a project is based on the uncertainty of: future cash flows, investment irreversibility and timing of the project initiation. The irreversible investment that has to be made is the option price of the real option. This irreversible investment enables future cash flows. The timing of when to initiate the irreversible investment is the exercise time of the real option, and has influence on the value of the uncertain future cash flows.

The difficulty with real options is, that unlike a financial asset which is listed at an exchange and its value constantly determined by trading, that the value of a project is limited to a number of legal persons. It is limited to the ones that have the resources to make a project a success could take such investment opportunities.

The real option approach of investments is based on sequential investments. The first investment does not mean that the second investment has to take place. A temporarily shut-down (McDonald & Siegel, 1985), a deferment of the investment (McDonald & Siegel, 1986), an increment of capacity (Bollen, 1999), an option to abandon (Carr, 1988) are important examples of options. Combinations of options can also be made; several options linked together are compounded options. In the compounded options, the underlying of one option is another option. All real option methods have in common that they want the value to reflect the flexibility of the underlying. By valuing the flexibility as an option, the exercise of the option is important for the value of the option. In order to fully use the value of an option, the flexibility has to be optimally executed.

VALUATION – RESEARCH & DEVELOPMENT CONTEXT

In this section, a description of the R&D valuation context will be given. The context will give a view which technique should be used in what circumstance. This is done in order to regard the place of a portfolio of projects of Philips ADL in the valuation literature. This would suggest that real option analysis (ROA) could be applied, but is in an environment in which some Discounted Cash Flow (DCF) methods also could be used. These DCF methods will therefore be described after the R&D context.

The investments in R&D are most of the time not made for the expectation of immediate payoffs. The creation of profitable investment opportunities in the future is the strategic choice for investing in R&D projects. The payoffs from these strategic investments are highly uncertain and come in various forms.

The DCF methods are limited in the uncertain situations of R&D. This does not mean that they are useless. The techniques of ROA and DCF can complement each other, examples in Lint & Pennings (2001), Putten & MacMillan (2004). The level of uncertainty of a project is important for what value method to use. Miller & Park (2002) have created a scheme in which the overlap of DCF methods and ROA methods are displayed, see Figure 3-1. One method for complementing is to assess the project at its volatility and payoff to see which method must be used. High volatility implies a ROA method and a low one a DCF method (Lint & Pennings, 2001).

Another method is used for projects in the 'option zone': a zone in which the uncertainty plays a significant role in valuation of a project. In this method a DCF method and a ROA method are used simultaneously (Putten & MacMillan, 2004). ROA can therefore describe the added value of the flexibility.



FIGURE 3-1 ROA AND DCF ARE COMPLEMENTARY DECISION-MAKING TECHNIQUES
(SOURCE: MILLER & PARK, 2002)

The context of Philips ADL will be, in Figure 3-1, in the intersection of the ellipses. Projects are in the development phase, in which market and technological/-project specific risks are present. Valuations of projects in the intersection of the ellipses of Figure 3-1 have to take the best fitted. DCF lacks the flexibility that is needed for the projects, so the flexibility of options is needed, but the uncertainties of a R&D project are not all market based.

In Figure 3-2 a description is given by Benaroch (2007) of the context in which the value of development projects can be calculated on the basis of an 'active' and a 'passive' NPV. Consequent with Figure 3-1 the 'passive' NPV is based on DCF, while the 'active' NPV is based on ROA. The 'active' NPV gives opportunities for managing flexibility. If the 'active' NPV has been managed to become 'passive' NPV the project is no longer a development project and can be valued based on DCF analysis.



FIGURE 3-2 CONTEXT OF DEVELOPMENT PROJECTS (SOURCE: BENAROCH, ET.AL., 2007)

The uncertainty of projects at Philips ADL decrease over time. The method of valuation needs to cope with that. Figure 3-2 gives an example, the 'active' NPV needs to be managed so investment configurations are generated and valued by option techniques in order to come to the most valuable 'best' configuration. This configuration should develop to the most valuable 'passive' NPV over time. Then it is a DCF method. To value development projects over time, the method needs to cope with a reduction the uncertainties in a project. The value of projects then should be calculated with DCF methods according to Figure 3-1. The constraints of the DCF techniques and the methods within DCF to cope with flexibility will therefore be treated next.

R&D CONTEXT DCF METHODS

From Figure 3-1 it can be seen that the 'pure' real option analysis is not applicable for the valuation method of Philips ADL. This is because the projects of Philips ADL are not based on market/systematic uncertainty but on company specific/ unsystematic uncertainty. 'Pure' DCF methods cannot be applied because it lacks flexibility. The traditional Discounted Cash Flow (DCF) cannot cope with the flexibility. DCF techniques have three main limitations (Herath, Jahera, & Park, 2001):

1. Selecting the right discount rate proposes problems with uncertainties, a high discount rate goes with a high uncertainty, but the level proposes problems. Most of the time the values are in the future and a high discount rate make those values very low as a present value.
2. The flexibility to change decisions is not taken into account with DCF techniques. One investment now does not mean that the second investment has got to be made. These multi-stage investments are important if new information arrives.

3. The investments are seen as a now or never type of decision by the DCF analysis, while the option of waiting is not present in the analysis, because it is discounted away.

There are three main methods to cope with flexibility of projects within DCF techniques (Steffens & Douglas, 2007). These are:

Venture Capitalist – Net Present Value (VC-NPV)

The VC-NPV approach does actually not allow different scenarios but considers the most likely scenario for the project and penalizes for the risk of other scenarios by applying a very high interest rate. In the R&D environment, it is not a good method because the uncertainty in R&D environment decrease while in the VC-NPV is appropriate if the overall uncertainty increases over time.

Expected Net Present Value (E(NPV))

The E(NPV) method specifies different scenarios and assess the probability of every scenario and then calculating the NPV using a relatively high discount rate. Usually three scenarios are specified, the best guess, the best case and the worst case. The E(NPV) is the expected value of the NPV of the different values. Advantage is that the scenarios can be adjusted to the situation.

Decision Tree Analysis (DTA)

The DTA method uses a decision tree, a path of decisions that displays the possible scenarios, and the E(NPV) method. The end points in the decision tree are valued and then the E(NPV) is applied. More over the option variant of this method will be explained in Methods – Tree Approach.

CONCLUSION

The valuation of a project is a measurement of the value on a single moment in time. The projects develop over time, the uncertainty of a development project decreases over time. In order to value all of the projects in a portfolio, only one method can be applied. The projects can be in different development stages, but need to be valued with the same method in order to become comparable with each other. Also the development of a project can be best measured if the measurement of the value is constantly done with the same method, else differences could arise which could be due to a method change.

So a method that can cope with a decrease in uncertainty is required for the Philips ADL context. At the end of the development phase, a NPV method is used to assess the project. The new method to value the projects of Philips ADL should have a similar value at the end of the development phase as the NPV. Then the new method can complement the NPV method that currently only can value the end of the development phase. The real options methods will therefore be searched in order to find the right aspects for this new Philips ADL valuation method.

METHODS CLASSICAL OPTION APPROACH

In order to calculate the 'active' NPV of the portfolio of projects, real option analysis techniques could be used. In literature, it has been tried to apply real option analysis to the R&D environment. This raised questions from within Philips ADL. In order to give a good overview and understanding of option methods, a description of the classical method and its difficulties in a R&D environment are given in this subsection. The tree approach and qualitative approach will be examined after the classical approach.

BLACK - SCHOLES

An option is the value of the right but not the obligation to buy or sell a security within a predetermined time period at a pre-set level, the strike price. Black and Scholes created a closed form solution for the pricing of the option. The closed form is based on modeling the security as a geometric Brownian motion. The pricing is based on the fact that a risk free mixture of assets can be created. The Brownian motion, a stochastic random walk, was first modeled by Louis Bachelier in his PhD thesis *The Theory of Speculation*, 1900. This motion models the free movement of stock with a growth factor μ and a volatility of σ around the μ .

If a stock can be modeled as a geometric Brownian motion, a closed form solution for the price of an option exists. This closed form solution was found by Black and Scholes in 1973. They derived a differential equation from the model. The differential equation has an uncountable number of solutions and depends on which boundary is set to the differential equation. The differential equation is presented in Equation 3-1. Options are priced by setting boundaries. For the simplest case, a European call option on a non dividend paying stock, the boundary is displayed below in Equation 3-2.

$$\frac{\partial f}{\partial t} + rS \frac{\partial f}{\partial S} + \frac{1}{2} \sigma^2 S^2 \frac{\partial^2 f}{\partial S^2} = rf$$
 EQUATION 3-1

With boundary maximum of the stock price minus the strike price at the end of the option period T, this is: $\max(S-K, 0)$ when $t = T$

$$C = S_0 N(d_1) - K e^{-rT} N(d_2)$$
 EQUATION 3-2

Where

$$d_1 = \frac{\ln(S_0/K) + (r + \sigma^2/2)T}{\sigma\sqrt{T}}$$
 EQUATION 3-3

And

$$d_2 = \frac{\ln(S_0/K) + (r - \sigma^2/2)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$
 EQUATION 3-4

Where:

C = call option price

S = stock price (value of the uncertain underlying asset, present value of the payoffs)

K = strike price (the present value of the investment costs)

rf = risk-free rate

T = time to maturity

σ = volatility of the stock (variability of the underlying asset)

The option pricing according to this model has the following assumptions:

1. The stock price follows a geometric Brownian motion with a constant μ and σ .
2. Short selling of securities is allowed, with use of the proceeds.
3. No transactions costs or taxes are present.
4. The securities are perfectly divisible.
5. There are no dividends during the life of the option.
6. No riskless arbitrage opportunities are available.
7. Security trading is continuous.
8. The risk-free rate of interest, r , is constant and the same for all maturities.

The underlying stock of a real option, a project, does not comply with the assumptions of the Black-Scholes model: A project is not a tradable security which can go from one hand to the other, a project is not divisible, short selling of a project is also not possible, the value of a project has not been proven to follow a geometric Brownian motion with a constant μ and σ , or with μ and σ as a function of t . In that case a closed form solution might be possible, but will be difficult to prove.

Nonetheless the Black Scholes Model is applied to price real options (Lint & Pennings 2001) (Luehrman T. A. 1998). A Black Scholes model adaption could be appealing because of the closed form solution and the numeric simplicity, but the lack of transparency can raise serious questions about the quality and validity of the value calculation. Project managers cannot see in what way it is calculated and will reject or at least question the valuation.

An essential part of options is the 'no riskless arbitrage' argument. This argument can only be met if and only if the payoff of the option can be replicated with payoffs that are in the opposite direction. This means that a financial product must be available which pays the same amount of money in the opposite direction. The correlation of this *twin security* with the actual project must be minus 1. With the use of this replication, riskless pricing can be applied. Brealey and Myers (2003) say that the trick with option pricing models is to construct a package that exactly generates the same payoff as the real option. Many of the assets which could be used in this package are not freely traded, this makes the no arbitrage constraint of option pricing not applicable.

The argument of a twin security is implicitly also assumed to exist in a NPV analysis, for the required return rate of a project. The risk neutral valuation of a real option is therefore an estimation of the value if the project would be traded on a market (Brealey & Myers, 2003). This is an argument that uses the NPV method as a reference for using an appropriate discount rate.

Besides the Black and Scholes equation, some other closed form solutions exist. The option for an exchange between one asset and another was developed in 1978 by Margrabe. The difference with the Black and Scholes model is the treatment of the exercise price. In the Black and Scholes model the exercise price is deterministic, while the Margrabe model assumes a stochastic exercise price. Another variant was developed by Geske in 1979, he developed the equations to value compounded options with deterministic exercise prices. This model can be used in R&D, because of the sequential decisions that appear in R&D. Carr made a model which also included stochastic exercise prices in compounded options (1988). The four models are reviewed as real R&D options by Lee & Paxson (2001). Even more estimations have to be made about the structure of projects for these models which make them unsuitable for use in Philips ADL. Difficulties with estimations are described below.

ESTIMATION DIFFICULTIES

If one decides to actually put ROA in action in the R&D environment, difficulties will arise. The input values will be difficult to determine. The method of real options needs information in order to create the desired outcome, the option price. The three main difficulties occur with the estimation of: interest rate, volatility and initial value of the project. These will be discussed next.

INTEREST RATE

In financial options the risk free rate is used for the determination of the option price, this can be done because a replication of the option exists as a portfolio of the traded underlying asset and a risk free bond. The underlying of real R&D options is a non-traded project. The assumption of an existing replication of the option with the underlying asset and a risk free bond is not applicable in the case of a non-traded underlying asset.

If the risk free rate would not be the appropriate discount rate, the question rises which rate should then be applicable? The discount rate should be adjusted for the risk. Market risk is always present. Private risks can be diversified away in a portfolio of financial traded securities (Hull, 2003). For real options, the private risk cannot be diversified away. The risks of the company are real to the underlying of the option. Defining the right amount of private risk is difficult, because it will be hard to establish **what a private risk is and what isn't. let alone to quantify it.**

The **'right' discount** rate for a real option does not exist. Using only the risk-free rate will understate the uncertainty and therefore value the project to high while with the incorporation of the private risk a subjective risk (i.e. utility function) is entering the equation which will tend to overestimate the risks **and therefore undervalue the project. A consensus about the 'right' private risks will be difficult to** establish. Models for establishing an appropriate interest rate for a combination of market and private risk do exist, see Hull (2003).

VOLATILITY

If the systematic (market) and unsystematic (private) risk are seen as interdependent, as in (Cortazar, Schwartz, & Casassus, 2001), then the risk can become one parameter in the classical option model. Financial options use the implied volatility or volatility based on historical data as estimation. These techniques cannot be applied with real options, because the required data is not available. In order to find a good estimation of the volatility of the underlying project in real options, twin security

information can be used if an appropriate twin security exists. The estimated volatility of this twin security is then used to estimate the volatility of the projects' value. Another method that can be used is Monte Carlo simulation. In this method, a cash flow statement is constructed, with distributions and correlations between the different cash flows. A Monte Carlo simulation constructs a return distribution of the total project. The volatility of the project is then the standard deviation of the return distribution.

In real option modeling there is no guidance present on how to deal with private risk; all risk is treated in the same manner using standard option pricing (Borison, 2005). This is a systematic error in the estimations. Volatility is the uncertainty of the NPV of a specific scenario of a single project (Luehrman, 1998). Volatility gives an indication of the risks of an asset, the systematic and the unsystematic risks. The risk of technical failure in the development of a project cannot be appointed to market risk and will be largely driven by company or project specific risk (Steffens & Douglas, 2007).

INITIAL VALUE

For financial options, the stock price is known at the start of an option. This is not known for a research and development project. The value of any research and development project will be difficult to estimate. The uncertainty of the project is such that the outcome of the project will be essential to the value of the future cash flows. The outcome of the project will determine the necessary costs of execution. The revenues of the project are also dependant of the outcome of the project. The current value is dependent on the chances of achieving a desired outcome of a project. This is typically a binominal distribution. either the project achieves a certain state or it doesn't. If it does, the project can be profitable, if it doesn't, the project will be left.

EXERCISE DIFFICULTIES

If, after all the difficulties of estimating the input values, one is still determined to value R&D projects with ROA, more difficulties will arise in the management of the projects. In order to achieve the value of the real R&D options, they need to be exercised optimally.

The exercise price of a real option is the price for implementing the next phase. This price is in many cases not a deterministic price, but will be stochastic. The exercise price of a real option can be, other than with a financial option, a series of cash flows and not just one payment. These sequential costs of the exercise price could affect the value of the option, but in what way is uncertain.

The optimal strategy for financial options is difficult to translate to real options. The strategy that comes with the options should improve value based **management, but it doesn't. This is described by** managers to the overvaluation of the growth opportunities by real options (Copeland & Tufano, 2004). The overvaluation is said to come from poor exercise of the options. Falling asleep (late exercise) seems to be the problem of issuers of non-traded options. Managers tend to exercise their options too late which will result in a significant value loss. This can be due to the fact that exercise dates can be not known in advance, or they can be dependent on the exercise of another real option. The duration of a real option can span for a long time, while a financial option has a precisely known timeframe. There are many issues which could not only influence the value of a real option but also its exercise date; a couple of examples are changes in competition, changes in technology, and all kinds of macroeconomic factors. Execution of the option is in many cases not immediate, the exercise means that the process of exercise can begin. In a production environment this could mean that the machines for production can be installed. Exercise takes time.

MAIN METHODS WITHIN THE CLASSICAL APPROACH

To conclude the classical approach to real options, the two main methods will be described. (Borison, 2005)

The Classic Method

Method:

A replication or tracking portfolio in the market must be identified and calculate the price and volatility. The replication portfolio should be sized to the investment. Then the financial option models could be applied to the replication portfolio.

Assumptions:

A replication portfolio must exist. The market and private risk are treated in the same manner using the standard option pricing tools. (Described in: Amram & Kulatilaka, 1999)

The Subjective Approach

Method:

Use a best estimated guess, i.e. general industry experience, to estimate the price and volatility of the underlying project. Then use these estimates to apply the option pricing tools, the Black and Scholes model.

Assumptions:

The Black Scholes assumptions are assumed, but if they fail, the framework is assumed to hold, only the outcomes become less reliable. (Described in: Luehrman T. A., 1998)

CONCLUSION CLASSICAL APPROACH

Fitting the classical approach to development projects will be difficult and requires assumptions that do not comply with the assumptions of the original model. This leads to the difficulties of establishing the right interest rate, volatility and initial value.

The classical approach will be difficult to manage; the flexibility that it needs to cover is not specified. A non specified flexibility has to be identified first in order to make use of it.

The purpose of the classical approach in real options is to value a project based on market risk. The method uses a constant sigma for the market risk, while in development projects the risk decreases. This makes a method that is meant to value a project based on market risk not suitable for a development project.

METHODS OPTION TREE APPROACH

The underlying process for the valuation of options does not have to be in continuous time. The idea that time takes steps might be a logical one, in real options. An option can often not be exercised immediately. Projects are evaluated after a predetermined period of time. The project will be reviewed and action can take place. These actions are therefore not continuous, so a discrete time process seems logical.

The deterministic approach assumes that the underlying asset follows a discrete, multiplicative stochastic process through time in order to form some sort of 'tree'. The advantage of this model is that is intuitive to use.

The binomial model has a discrete time process, in which the value of the underlying asset S is starting at time $t = 0$. With every time step, Δt , the value of S will become S_u or S_d . Following an up or down movement from the value of S . The probability of an up state, S_u , is p , while the probability of a down state, S_d , is $(1-p)$. If the stock follows a geometric Brownian motion with σ as the volatility over Δt and the expected return over Δt is $e^{r\Delta t}$, then the following equations apply.

$$E[S] = pS_u + (1 - p)S_d = Se^{r_s \delta t} \quad \text{EQUATION 3-5}$$

$$E[S^2] - E[S]^2 = pS_u^2 + (1 - p)S_d^2 - (pS_u + (1 - p)S_d)^2 = \sigma^2 \quad \text{EQUATION 3-6}$$

For solving these two equations, with three unknowns (S_u , S_d and p), a third equation must be present. $S_u = 1 / S_d$ is the equation that was introduced (Cox, Ross, & Rubenstein, 1979). The solution is presented in Equation 3-7. For a time period of two, the process is displayed in Figure 3-3. The value of the option is known at $t = T$, the last t in the tree, $\max(S_u - X, 0)$ or $\max(S_d - X, 0)$. The value and the chances are known, so the value at $t = T - 1$ can also be calculated. The value of the option, C , depends on the value of the up state and the down state.

$$C = \frac{pC_u + (1-p)C_d}{r} \quad \text{EQUATION 3-7}$$

The tree that is created is intuitive in the valuation process and can prove to be very flexible by supporting delay, growth, contraction, compound options.



FIGURE 3-3 BINOMIAL TREE FOR TWO TIME PERIODS

The model of Cox, Ross and Rubenstein (1979) is the standard binominal model. This is not the only discrete time model; some variations to this model were also developed. In 1986 the trinomial model was developed by Boyle. He also developed a five jump model in 1988.



FIGURE 3-4 EXAMPLE OF DECISION TREE AS OPTION TREE (SOURCE: (JÄGLE, 1999))

Jägle (1999) combines the concepts of Technology and Innovation Management (TIM), sequential models of New Product Development (NPD) processes and the binomial tree of real options to the model in which actual success probabilities are applied in the option tree. This way of modeling an option in the R&D environment is suited for the sequential R&D processes. Clear phases can be distinguished and success probabilities can be assigned to the different phases. The value at the end of the tree can be discounted to the present time. An example will be given, presented in Figure 3-4.

The example presents four phases of a hypothetical pharmaceutical new drug development. The four phases present the phases of which the development has to go through in order to become a successful new drug.

Real world vs. risk neutral world

In order to make an option tree, like the one presented in Figure 3-4, the real world and risk neutral world need to be separated. The real world gives the actual transition probabilities. For the probabilities of the example of Jägle, historical success rates could be used, in this case it is established by interviewing representative sample of managers of the industry and some other estimates of a broker and two investment banks. These probabilities have to be converted to risk-neutral probabilities, i.e. leaving no risk in the investment, in order to allow risk neutral valuation, i.e. using the risk free interest rate throughout the option tree for discounting purposes. The risk neutral probabilities are needed in

order to comply with the 'no arbitrage' argument of the Black and Scholes model to allow a risk neutral hedge. This is done as follows:

Per phase:

$$S = p * S^+ * (1-r)^t + (1-p) * S^- * (1-r)^t,$$

Where:

- S = project value
- p = risk neutral probability
- r = risk free rate
- t = length of time period
- q=actual probability



FIGURE 3-6 ONE TIME STEP

Solving for p:

$$p = \frac{(1+r)^t S^- - S^+}{S^+ - S^-} \quad \text{EQUATION 3-8}$$

In Figure 3-4, the risk neutral probabilities are already displayed. The actual probabilities are for Preclinical 47%, Phase I 43%, Phase II 44%, Phase III 80 % (not shown in Figure 3-4). Calculation for Phase III:

$$(80\% * 2000 + 20\% * 0) * ((1/(1+0.11)^2.5) - £1261 - £200) = £1061$$

$$(((1+0,06)^{2.5}) * 1061 - 0) / 2000 = 0,73 = 73 \%$$

The value of option stage *i+1* is factored to the value of option stage *i*. This implies that in stage *i+1* the value is subjected to the same sources of uncertainty as in stage *i*. In R&D, uncertainties about the project will become less, which is not present in the model. Also this kind of tree does not allow interactions between projects which are needed for the Philips ADL context.

COMBINING DECISION TREE AND OPTION TREE

The option tree can be with a decision tree. In all the phases there is room for management decision of continuation or abandonment. Also more difficult trees could be considered for more complex situations, like portfolios. The advantage of the use of this tree is that the risk of the project varies depending on the position in the process. A simple example to illustrate:

Decision tree

A decision tree is a method of modeling a process to decisions and their consequences. They are used in order to reach a goal at the end of a tree. The decision tree allows managerial flexibility in the tree. This flexibility in the decision tree is represented by the decisions a manager can take in order to influence the process and therefore partly the outcome of a project.

Example

An option decision tree is presented in Figure 3-7. The decision tree represents an option to investment in R&D at time $t = 1$. An investment of \$3 million is needed every year for four years, NPV = \$9,32 million. This can become a success or not with a 70-30 probability. The market conditions can be good or poor, with a 30-70 probability. In order to commercialize the created product from R&D, an investment of \$70 million has to be made at time $t = 4$. The value of the product can then be calculated with help of a best case, best guess and a worst case value, displayed in Figure 3-7. A discount rate of 20 % is assumed. For each node the expected NPV is calculated. This leads to a NPV of \$0.81:

$$\begin{aligned} \text{✦ Good market: } & \frac{40\% * \$600 + 20\% * \$100 + 40\% * \$0}{1.2} - \$70 = \$146,70 \text{ million} \\ \text{✦ Poor market: } & \frac{0\% * \$600 + 60\% * \$100 + 40\% * \$0}{1.2} - \$70 = -\$20,00 \text{ million} \\ \text{✦ Success R\&D: } & 30\% * \$146,70 + 70\% * -\$20,00 = \$30,01 \text{ million} \\ \text{✦ Invest R\&D: } & \frac{70\% * \$30,01 + 30\% * \$0}{1.2^4} - \$9,32 = \$0,81 \text{ million} \end{aligned}$$



FIGURE 3-7 EXAMPLE DECISION TREE (SOURCE: STEFFENS, 2007)

To make this example to an option, flexibility has to be allowed in the process. This means that in poor market conditions at $t = 4$, no investment will be done. The value at $t = 4$ is set to the expectation of the best case, best guess, and worst case. So, in a good market the expectation is 146,70 million dollars and in a poor market the expectation is minus 20 million dollars, in which the product will not be commercialized. The value becomes 0 dollars for a poor market. This is presented in Figure 3-8. The value of the investment is now \$6.39:

$$\text{✦ Success R\&D: } 30\% * \$146,70 + 70\% * \$0 = \$38,77 \text{ million}$$

$$\text{✦ Invest R\&D: } \frac{70\% * \$38,77 + 30\% * \$0}{1.2^4} - \$9,32 = \$6,39 \text{ million}$$



FIGURE 3-8 EXAMPLE DECISION OPTION TREE (SOURCE: STEFFENS, 2007)

Problems with estimating the 'right' interest rate are similar to those seen with the classical methods. The estimation of which interest rate to use, will be treated below in the main methods within option tree approach.

MAIN METHODS WITHIN OPTION TREE APPROACH

To conclude the tree approach, the main methods that use tree approaches will be described, the methods use some classical approach features in order to assess market risks. (Borison, 2005)

The MAD (Marketed Asset Disclaimer) Approach

Method:

A cash-flow model of the estimated cash flows of the underlying asset must be built using the CAPM (Capital Asset Pricing Model) based beta in order to calculate the NPV. The estimated inputs have an uncertainty and these should be estimated to conduct a Monte Carlo simulation to the model. The resulting distribution is then used to construct a binomial lattice. The value of the option is calculated on the basis of this lattice.

Assumptions:

No replication of the project exists in the market, the own NPV of the project is seen as the *twin security* of the project. This could be seen as the same strength of arguments as an NPV case. The prices used are assumed to follow a Geometric Brownian Motion, this assumption is needed for the use of a binomial lattice. (Described in Copeland & Antikarov, 2001)

The Revised Classic Approach

Method:

Assess if the investment is dominated by public or private risks. If there are mainly public risks, the classic approach should be applied. If private risk is mainly present, a decision tree should be built that represents the investment alternatives. The probabilities and values in the tree are based on subjective judgment. The option value can be calculated by discounting the end tree points and probabilities using the WACC (Weighted Average Costs of Capital)

Assumptions:

For the public risks, the classical risks apply. For the private risks, the WACC is used because in decision analysis ~~this is set because this is the investor's access to money~~. This reflects the beta of the company. (Described in: Amram & Kulatilaka, 1999)

The Integrated Approach

Method:

The decision tree of the *revised classic* approach should be built for the investment alternatives. The public and private risks should be identified. For the public risks a replication portfolio should be constructed and risk neutral probabilities should be assigned to the tree. For the private risks subjective probabilities should be assigned to the tree. The option value can be calculated by discounting the end tree points to the beginning with the risk free interest rate.

Assumptions:

The approach can be described as *mark to market*: Use the appropriate hedging techniques for the market risks and decision analysis for private risks. (Described in: Smith & Nau, 1995)

CONCLUSION OPTION TREE APPROACH

The option tree approach is an approach that has interesting features for Philips ADL. In combination with decision tree analysis, the private risks of Philips ADL could be assessed. The representation of this method appeals for its simplicity. A tree is constructed in which the events that could happen to a project, or even in an expanded version, a portfolio are modeled. The end notes of this model can be calculated back to present time and a value of the modeled process comes out.



FIGURE 3-9 ILLUSTRATION OF R&D PROCESS

The Philips ADL situation can be recognized in Figure 3-8. The process is illustrated in more detail in Figure 3-9. In the figure, the project-box moves to the end of the project time. If the box is at the end, it can only be in success or in failure. Half way through the project the project has developed in the direction of success while after $\frac{3}{3}$ of the time, the project moved very close to absolute failure. In the example presented in Figure 3-8, the success of R&D is calculated over a time span of 4 years. Also, at Philips ADL, the time span that projects are present in R&D is equivalent to these 4 years. In these 4 years, R&D develops and more could be said about the success probabilities of the R&D process. This time span is long if no information about the progress of the project can be taken in consideration for **the valuation. If the method can be made to model the R&D phase in more detail, more 'exit' decisions** points could be modeled and the expected value of the investment in R&D can be reduced. In Figure 3-9, the question is whether or not investments should be made in the project if, after $\frac{3}{4}$ of the project time, the project is so close to absolute failure.

Creating a more specified R&D phase with this model is difficult for the Philips ADL context. The events of the R&D phase do not allow ordering them in a time sequence. This non-sequential manner of the R&D phase makes it difficult to fit this process in a decision tree. Decision trees in which the

decisions cannot be made in a sequence make it hard to construct the tree, let alone trees in which relationships between different projects are present.

The method that has been developed by Philips ADL for this purpose, described in Chapter 1, using an *option table* rather than a tree is more suited for the purpose of monitoring the development of the value of project during its R&D stage. The overview of the possible outcomes is clearer in the option table, no paths have to be followed in order to come to the outcomes. In a tree, it is clear what the value contribution is of a particular event to the total project. In the option table this cannot be calculated because the events are not in a particular sequence. This is actually more natural modeling of the truth because the value contribution of an event to a project or even a portfolio is nothing if no outcome can be created. In order for the events to become valuable, a group of events/ uncertainties have to occur/ be achieved.

For the use in a portfolio interactions have to be modeled between projects in the R&D stage. Interactions between projects in a portfolio can be modeled in a decision tree. The disadvantage of this is that the decision tree will be complex and hard to construct because an overall scheme of all the projects have to be integrated with each other. An extension of the *option table* method to a portfolio method is more likely to succeed in achieving a tool that can monitor the value of projects in a portfolio.

METHODS QUALITATIVE OPTION APPROACH

The use of the option valuation tools described above seems stretched if the criteria of a replication portfolio cannot be met. The assessment of private risks in a decision tree is a method of quantifying the value of the project. Borison states that if the underlying assumptions of the classical methods are **violated, the valuation is limited to "qualitative results"** (Borison, 2005). A qualitative approach could then be used to assess technology projects. This assessment can use real option thinking in its methodology. McGrath and MacMillen (2000) give a framework that provides a qualitative view on technology projects by using real options reasoning. Their STAR (Strategic Technology Assessment Review) framework is seen in Figure 3-10.



FIGURE 3-10 STAR FRAMEWORK (SOURCE: (MCGRATH & MACMILLEN, 2000))

The argument to use a qualitative approach is compared with the genetic characteristics of a pair of breeding animals. The breeding cannot predict the exact features of the new breed, but one can make some intelligent predictions. The same counts for technology projects, they can be mapped but the final outcome of the project remains uncertain. Based on previous research the new project more or less potential can be assigned to it. A believe that a precise calculation of a option value is not meaningful, on the basis on the above mentioned uncertain estimation of the parameters, does not mean that the intuition on the value of the projects should be used to assess the technology projects.

The framework above is then set to 15 factors on which a project should be assessed. The factors are:

- | | |
|---|-----------------|
| 1. Assessing Demand | (15 parameters) |
| 2. Adoption Demand | (11 parameters) |
| 3. Blocking | (12 parameters) |
| 4. Competitive Response | (9 parameters) |
| 5. Increasing Sustainability | (9 parameters) |
| 6. Standards Capture Potential | (7 parameters) |
| 7. Commercialization Costs | (11 parameters) |
| 8. Commercialization Cost Advantages | (6 parameters) |
| 9. Leveraging Resources for Commercialization | (11 parameters) |
| 10. Industry Novelty | (8 parameters) |
| 11. Development Cost Considerations | (21 parameters) |
| 12. Spillovers | (10 parameters) |

- | | |
|----------------------------|-----------------|
| 13. Potential Damage | (14 parameters) |
| 14. External Uncertainties | (18 parameters) |
| 15. Internal uncertainty | (20 parameters) |

The advantage about a qualitative framework, like this STAR framework, is that exercising the tool provides good guidelines for discussions and coming to a universe understanding of the project by the total project team. Execution management of this tool becomes more difficult, there will be always projects that may have to be abandoned and coming to good guidelines for this is a hard task. With this framework there are 182 parameters that need attention and a score between 1 and 7 need to be assigned to it. Those are a lot of judgments that need to be made. This must be done several times per year in order to keep track and monitor the project. This could lead to some nonchalance when assigning the scores.

CONCLUSION QUALITATIVE APPROACH

The qualitative approach is not a serious option for Philips ADL, a valuation of a portfolio is required, and this approach does not take the value in consideration. What it does take in consideration are both private and market risks. A project expert scores all the individual parts of the risks. This flat structure of the scoring method is what could be applied if other option methods cannot be applied. What is attractive of this method is that it is straightforward in assessing the risks and scoring the projects.

DISCUSSION

Real option literature gives a couple of different models that could be applied in the valuation of flexible, growing, projects. These models try to give a precise image of the modeled world. An understanding that the modeled world and the real world are not one and the same is essential to interpret the outcomes of the different models. The real world is complex and difficult; the uncertainty about underlying processes is not without reason.

With real options, there is uncertainty about the initial value of the project and of the full investment that must be made to do the total project, as calculated in a NPV case. The decision to commit to the total project is postponed with the help of real option techniques in order to allow better information to surface. The decisions that are postponed must be taken at some point in time. The actions of managers on the project that is under consideration can make them partial in the decision making process. The

uncertainty in the real options could allow this to happen. Two arguments are identified by Adner & Levinthal (2004) that deal with the organizational process and the exercise of the real options.

The first argument says that managers have the incentive to keep projects alive, especially if there are sunk costs involved (Adner & Levinthal, 2004). The managers can buy by the incremental amount the full upside of the option, while the incremental amount can rise which would not have made it a profitable choice at the start of the lifetime of the option. If negative information about the amount of investment keeps surfacing, the project can make a huge loss while the individual decision on one investment of the option looks like the profitable thing to do.

The second argument states that uncertainty can still be present even at the time of exercise. The options' value can improve, but if uncertainties remain open, this will create a situation in which it is logically unconvincing to keep the option open. But because of the uncertainty, an argument can be given that given enough investment and time, the project will deliver. Adner and Levinthal (2004) therefore suggest that rules about exercising options must be made upfront.

CONCLUSION

'What can be learnt from the theoretical models in valuation literature and real option literature in particular for the Philips ADL context?'

The literature search has provided a context of valuation literature and real option literature in specific. It has been determined that the valuation of R&D projects is difficult. This is due to the length of the development time and that it is hard to determine 'how far' the project is in its development before cash flows can be generated. If the project is at the end of its development DCF techniques provide the standard valuation methods. At the beginning of the development phase, the flexibility of real option valuation is required in order to cope with all the possible outcomes of a project from its development. For Philips ADL, a method is needed that adjusts for risks that a project is facing in the development phase.

Valuation based on DCF techniques were already known at Philips ADL, but some methods to make the valuation methods more flexibly have been presented at the beginning of the chapter. This were three methods, namely: VC-NPV (Venture Capitalist Net Present Value), E(NPV) (Expected Net Present Value), and DTA (Decision Tree Analysis). Further real option literature has been searched for valuing the flexibility of a project, the unsystematic risks it faces. In real options literature, three

approaches have been distinguished: a classic approach, an option tree approach and a qualitative approach.

In the classic approach, the market risks come forward. The market risks stay the same over time while private risks decrease over time in a R&D project. This makes it not suitable for assessing the private risks of a R&D project. It could be helpful in assessing the market value of outcomes of a R&D project. Difficulties with estimating the input variables of the classic approach arise when these are assigned to value R&D projects. Allowing management flexibility of the private risks is not possible in a classic approach.

In the option tree approach, there are two methods, a option tree and a decision tree. In the option tree approach the actual development process can be modeled according to the phases it goes through. The phases can be achieved or not and so a tree is constructed. This tree must then be filled with probabilities that phases can be achieved and a value at every end point of the tree. Then risk neutral probabilities can be created for the tree and valuation can take place, based on the risk free rate and the underlying tree. For the decision tree variant the approach is similar, the subjects of one tree jump are not only phases of development but can also be decisions, market conditions, or events. In a decision tree, risk neutral probabilities cannot be calculated. This makes that the interest rate used remains a matter of discussion.

In the qualitative approach to real option a scoring model is used based on option thinking. The scoring model assesses all kind of risks and uncertainties that could threaten the value of the project. This summation of risks could for projects are a checklist that could help in order to determine the relevant factors that could be used in an option tree.

CHAPTER 4 MODEL SPECIFICATION

This chapter answers the following research question: *‘What model can be specified, regarding the requirements and criteria?’*

The new portfolio value calculation model is defined by extending the concept of the previous project valuation model to a portfolio valuation model. This is done by first describing in what way the concept of the project valuation model can be extended to the new portfolio valuation model. This will lead to an overview of what the portfolio calculation method should do. The assumptions that have to be made to which the portfolio calculation model has to comply will be treated next. Following the calculations of the model will be stated and made explicit in a small example.

The valuation of projects within Philips ADL has been described in Chapter 1. This valuation method lacks value relationships between projects in a portfolio. Within the real option literature a search has been conducted in order to find valuation methods of portfolios that can include these portfolio effects. A model or method, which can comply with the demands described in Chapter 2, has not been found. A new method has been constructed. This has been done on the basis of the existing method. The demand for the model is to value a portfolio, complying with the following criteria:

- An overview of the value dependencies between projects
- A valuation of projects and the relationships between projects
- A portfolio risk assessment for all the individual parts of the structure
- A non-sequential model for the structure of the valuation must be used
- A good overview of the uncertainties per project in the structure
- A comprehensible figures must be presented as the outcomes of the model
- A valuation of the total portfolio in different segments must be present

CONCEPT

In one project, a couple of possible outcomes will be defined. The project team will pursue only valuable outcomes. The valuable outcomes are defined in scenarios. Other outcomes will not be adopted by one of the business groups and will therefore have no value. The project valuation method covers this process. A schematic overview of one project can be seen in Figure 4-1.



FIGURE 4-1 SCHEMATIC OVERVIEW OF ONE PROJECT

With the extension of one project to a portfolio of projects the situation becomes more complex. Projects can interact with each other, and the scenarios that contain interactions are dependent on two projects in order to be realized. Scenarios are defined within projects, a scenario with relationships to other projects remains defined in one project. This makes one project dependent of another project for specific outcomes. An overview of a portfolio situation can be seen in Figure 4-2.



FIGURE 4-1 ILLUSTRATION OF 4 PROJECTS WITH INTERACTIONS

The valuation method that is used for one project, like for Figure 4-1, needs to be adjusted in order to value Figure 4-2. The model that has been developed for the valuation of a portfolio is schematically presented in Figure 4-3. The assumptions made and calculations required to come to the outcomes will be the subject in the remainder of this Chapter.



FIGURE 4-2 SCHEMATIC OVERVIEW OF PORTFOLIO VALUATION

In this model, all the risks that a project faces in the development phase are defined in uncertainties. The uncertainties are divided in three groups, namely uncertainties managed within the project, uncertainties managed within the portfolio, uncertainties from outside the portfolio. The last group of uncertainties cannot be managed within the portfolio and the project is therefore dependent on events of others. The uncertainties managed within the portfolio are links between projects. This is done so that the same uncertainties are not defined multiple times in different projects. Expert assessment helps in the definition of the scenarios. Uncertainties are assigned to the scenarios. These uncertainties must be overcome for the scenario to occur. The scenarios can be defined through communication between market experts and project experts. The iteration between scenarios and uncertainties will provide this communication and improve the exploration of the valuable scenarios. The market experts will value the created scenarios. If this is done, the value of the projects, relationships, portfolio and the value risks of the individual uncertainties can be calculated. The value risks are the influences that individual

uncertainties have on the value of the portfolio; this will be further explained in the calculations paragraph.

ASSUMPTIONS

The portfolio valuation on the basis of Figure 4-3 is based on assumptions in which the calculations of the project value, value of interactions and the risk on individual uncertainties are valid.

The expert assessment of the uncertainties is complete

The uncertainties are assessed per project by the project team. All of the risks that the project will face in order to become successful in a scenario is captured in one of the defined uncertainties. Iteration after the scenario valuation takes place, so that the final scenario definition and uncertainty definition will be the result of communication between project and market experts. The project experts assign probabilities to the uncertainties. These probabilities are project group estimations of overcoming a uncertainty, this is reviewed by an outside expert.

The uncertainties are independent and unique

In this model there are three groups of uncertainties, namely managed within the project, within the portfolio and outside the project. All these uncertainties are the building blocks of this model. The value of the projects is based on the probabilities that the uncertainties can be overcome. Essential in this calculation is that the probability of accomplishing one uncertainty does not have any effect on any of the other uncertainties. All uncertainties have to be unique, if they are not unique, risks are modeled multiple times in the portfolio which will neglect the value of relationships in a portfolio.

The model can only hold if and only if the uncertainties are defined as independent. They must be defined independent of the other uncertainties, not only within one project, but in the entire portfolio. The uncertainties must be defined in such a way that they cannot influence each other. This brings extra care in the expert assessment of the uncertainties, some underlying uncertainties might be grouped and that group of underlying uncertainties must be independent of other events in the project. This group of uncertainties must then be assessed what the chance is that this group is overcome.

The uncertainties are non-sequential

The situation at Philips ADL requires that the sequence of overcoming the uncertainties is modeled in a non-sequential manner. This is one of the requirements that have been set for this

model. Instead of applying a tree in which the uncertainties are overcome in a sequential manner, the uncertainties are listed in a table. This can be seen in Table 4-1. The uncertainties are listed in groups of uncertainties as they are identified by the experts and a 1 is displayed if they need to be overcome for a particular scenario.



TABLE 4-1 OPTION TABLE

Interactions are defined in one direction and individual

Interactions between projects can also lead to valuable scenarios. This is schematically displayed in Figure 4-4. A scenario must be assigned to a project; they must pursue the scenario in order for it to occur.



FIGURE 4-4 SCHEMATIC VIEW OF PROJECT INTERACTION

The scenario is likely to fit more with one project than another, and the scenario is defined within that project. A scenario is constructed of uncertainties, so the scenario remains dependent of uncertainties in the other project. This can also be seen in Table 4-1, in the group of uncertainties which are linked to other projects. The schematic view of project interaction is changed to Figure 4-5.



FIGURE 4-5 SCHEMATIC VIEW OF PROJECT INTERACTION IN THE MODEL

The goal for this adjustment is that all of the relationships between projects in a portfolio are only modeled once. The value that is created in a scenario by the relationship between projects in the portfolio is then valued once in the portfolio and not multiple times.

The scenarios are created by uncertainties. The relationships can be in a positive or negative manner. If the link is in a positive manner the uncertainty has to be overcome, while for the negative relationship the uncertainty must not be overcome. This construction makes sure that all scenarios in the portfolio that depend on that uncertainty in a positive or negative manner cannot contradict. No matter what the outcome of the independent uncertainties is, no scenarios can be achieved that cannot exist together.

Scenario Valuation contains the market risks, not market changes

The value of the different scenarios is an assessment made by experts. This value is an estimation of what the scenario is worth if that outcome of the project will be executed. The assessment values the market situation and the risks that come with the market introduction of that scenario. The market risks are only present after the scenario is achieved and must therefore be captured in the valuation of the scenario. The market can change over time. This is a threat that can occur during the period that is needed for a scenario to be achieved. This threat must be identified and defined in the *outside* uncertainties. Different scenarios will then be defined and valued with and without the market change threat.

Scenario Value Estimation

In the application of this model that has been developed, the scenario value can be described in two possible manners. The first manner is a fixed number; this number is the result of estimation in which all the uncertainties in the following investments are discounted. The second manner is assessing the market by a curve. The curve that is created will represent the feeling of the uncertainties that are present about the market value of the scenarios. This has been inserted in the tool because the experts do not like to make an assessment and then only give one value. This value may represent uncertainties present in the further valuation but in the development of a project an expert does not want to be pinned down to an assessment that is represented in one number. The curve is assessed in an option manner. If a scenario is achieved, the decision for exercise is there. This exercise decision will not be positive if the estimated market value is negative. Therefore a Black Scholes formula is used to calculate the value of the option. This value can then be used as value of the scenario. Figure 4-6 shows an example of this application in the tool.

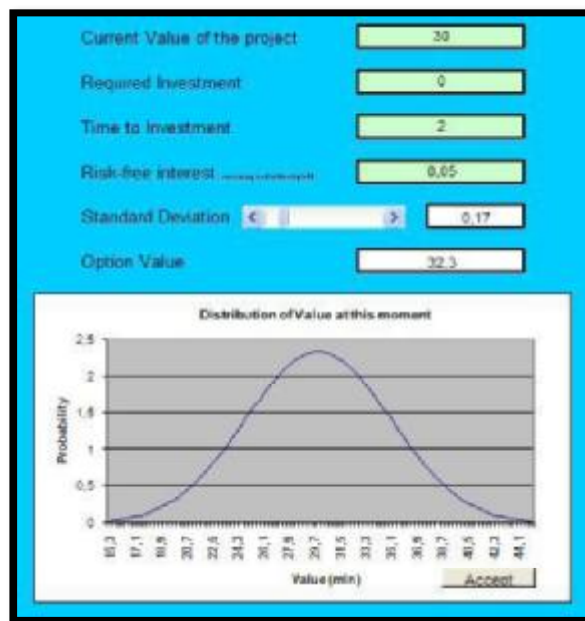


FIGURE 1-6 ESTIMATING SCENARIO VALUE

Scenario Valuation is segmented

The scenario value of a project/ technology can be in different segments of the market. A structure of segments allows the value to be seen on different segments can be valuable because this will give an insight in the market that a project is aiming at. Market experts on the different segments can be used for better judgments on the inputs. Parts of the organization which are responsible for particular segments of the market can have insight in the option value for their part of the market. Hierarchy in the segmentation allows the model to aggregate to different market levels. This can also be seen in Table 4-1.

Scenarios are ranked at project level

The scenario with the highest value is the one that is most profitable for the project, it is important for the option value which scenario is pursued first (see Project Value calculation). The project will then pursue this scenario first, if this is scenario cannot be achieved, the second highest will be pursued. This is ranked at project level because this will give the highest value per project. This is the most likely for projects to pursue. The case in which this does not bring the highest value for the portfolio is when there is a special case with a negative connection. This negative connection can cause one project to pursue a scenario which will lead to overcoming uncertainties that for another projects' scenario should not be overcome and not overcoming the uncertainty will lead to a much higher value of that scenario relative to the scenario that wants to overcome the uncertainty. Caution with negative relationships between projects should be held and these relationships will therefore need extra research.

No interest rate is applied

The purpose of an interest rate is to compensate the investment for the risk that is taken with that investment. The unsystematic risks are assessed in this model and the value of the option is reduced by the probabilities of that risks. During the time span that a the value of a project is calculated within this model, no systematic, market risks are present to the projects in the portfolio. The market risks are incorporated in the scenario values. Because of the time value of money, a risk free interest rate should be applied in the model. Currently this is not present in the model but it should be and will be in Chapter 7, Recommendations.

CALCULATIONS

The input part of Figure 4-3 has been structured and described by the assumptions that are made. With this structure, the value of the projects in the portfolio, the value of the project interactions and the value risks of individual uncertainties can be calculated.

Project Value

The project value is defined as the contributed value of the projects' scenarios. The uncertainties that are managed within the project might contribute value to other projects but this does not contribute to the scenarios of that project. That value does therefore not contribute to the project value but will be defined in the value impact of the project. The scenario with the highest value for the project will be pursued first, then the second highest and so on.

The value of project p is the summation of the multiplication of the chance that scenario j is achieved and the value of scenario j of project p , for all j 's. This is shown in the equation below.

$$V_p = \sum_{j=1}^n P(S_{c_{j,p}}) * NPV_{S_{c_{j,p}}}$$

Project p has n scenarios, S_{c_j} has the j^{th} highest value.

The chance that a scenario is achieved is dependent of the chance that the scenario can occur and the unsuccessfulness of the higher valued scenarios. The scenario will only be pursued if the higher valued scenarios are not achieved. This is shown in the equation below.

$$P(S_{c_{j,p}}) = P(S_{c_{j,p}} \text{ is feasible}) * (1 - P(S_{c_{1,p}} \text{ is feasible})) * \dots * (1 - P(S_{c_{j-1,p}} \text{ is feasible}))$$

The chance that scenario j of project p is feasible, i.e. the chance that scenario will be achieved given that the scenario is tried to achieve. In other words: the success chance of scenario j given the scenarios 1 till $j-1$ failed. This is shown in the equation below.

$$P(S_{c_{j,p}} \text{ is feasible}) = P(U_{h,j,p=1 \text{ for } h=1,\dots,f | S_{c_{j',p}} \text{ unsuccessful for all } j' < j})$$

Where: $U_{1,j,p} \dots U_{f,j,p}$ denote all f uncertainties in scenario j of project p .

If uncertainties of the different scenarios overlap, the lowest ranked scenario can only occur if the higher ranked scenarios failed on uncertainties that did not overlap. This is why the rank of the

scenarios is important; the probability of lower ranked scenarios is limited to the failure of previous scenarios.

Vector calculations

In the developed tool of this model, vector calculations are used for the part of the calculations where the $P(Sc_{j,p} \text{ is feasible})$ is calculated. The application of the model as a tool in Microsoft Excel uses these vector calculations because it can be better programmed. There are a limited number of possible combinations of the uncertainties. A selection of these combinations makes a scenario possible. If scenarios with a higher value cannot be achieved, an even more limited number of possible remains possible. These combinations are made to vectors and assessed in the tool. In the example at the end of this chapter the vector calculation will be used to assess the scenario probability.

Portfolio Value & Value impact

The interactions in the portfolio are defined in one direction and individually, the construction of the portfolio is made in such a way that the value of a project is accounted for once. The sum of the value of the projects in the portfolio is therefore the value of the portfolio, see equation below. The value of the interactions is accounted in the value impact of a project. The value impact of a project is the value what the uncertainties of one project have on the entire portfolio excluding the value of the own project. Values of projects that depend on more uncertainties than their own projects' will come forward in this value.

$$V_{portfolio} = \sum_{i=1}^k V_i$$

The value of a portfolio with k projects is the sum of the value of the projects.

The value impact of a project could be calculated by assessing all of the projects uncertainties on the contributing value of the uncertainty to all of the other projects in the portfolio. The uncertainties that will have an impact on other projects have already been structured per project. This can be seen in Table 4-1, the project of the uncertainties managed within the portfolio is a list of the interactions and these need to be assessed for the value impacts.

The value impact of a uncertainty, which is managed outside the project but within the portfolio, has impact on the scenarios for which it is required to be overcome. If the uncertainty cannot be overcome, the scenarios cannot be realized. A scenario is accomplished for the project in which it is defined. The

contribution of the scenario value to the project value cannot be divided over the uncertainties, because these are not sequential. So the value can be discounted back to the different uncertainties. The contribution of the scenario value is therefore appointed to the project in which it is managed and to all the projects that have uncertainties in that scenario it is appointed as a project impact value.

$$VI_i = \sum_{r=1}^k VI_i(r) , r \neq i$$

The total value impact of project i on the portfolio is the summation of the Value Impact of project i on every individual project p in the portfolio.

$$VI_i(p) = \sum_{j=1 \dots n, \text{any}(U_{h,p}=i)} P(\text{Sc}_{j,p}) * NPV_{\text{Sc}_{j,p}}$$

The Value Impact of project i on project p is the summation of all scenarios j of the multiplication of the chance at Scenario j given the presence of uncertainties of project i and the value of scenario j of project p .

Value Risk & Value Potential of Individual Uncertainties

The uncertainties are defined once in one project, other projects link to these uncertainties if they need to be overcome. This linkage troubles the view on important uncertainties; the influence that one uncertainty can have on the total portfolio value cannot be seen and needs to be calculated to get a good overview of the risks of individual uncertainties on the total portfolio. This can be important, if the total value of the portfolio is dependent on a couple of uncertainties, they can be prioritized. The risk of an individual uncertainty describes what happens to the portfolio if the uncertainty fails.

$$VR(U_{h,p}) = V_{(portfolio)} - V_{(portfolio|U_{h,p}=0)}$$

The Value Risk of Uncertainty h of project p is the value of the portfolio minus the value of the given Uncertainty h of project p is zero.

Reducing the uncertainties will increase the value of the portfolio. The value that can be gained with overcoming one uncertainty is the value potential of an uncertainty. This is important for the management of the portfolio so it can be seen what needs to be resolved in order increase the value of the portfolio.

$$VP(U_{h,p}) = V_{(portfolio|U_{h,p}=1)} - V_{(portfolio)}$$

The Value Potential of Uncertainty h of project p is the value of the given Uncertainty h of project p is one minus the value of the portfolio.

The value potential and the value risk of a uncertainty cannot be seen separately, the sum of the value potential and the risk determine the total influence of that uncertainty on the portfolio, while the value risk shows the progression that has already been made in that influence and the value potential shows the value progression that still has to be made in order for the value to be locked in the portfolio and spread over the remaining uncertainties.

EXAMPLE

Consider a portfolio of 2 projects, presented in Figure 4-7. They both exist of two uncertainties. For project 1, there are 3 scenarios with the values of 100, 50 & 20 Euros. The scenarios of project 1 are formed by the combinations of the two uncertainties and one uncertainty of project 2. The combinations of the two projects can be seen in Figure 4-6.

Vectors

The vectors of possible outcomes based on the uncertainties for project 1, the vectors are placed vertical with the uncertainties horizontal:

Uncer 1-1	0	1	0	0	1	0	1	1
Uncer 1-2	0	0	1	0	1	1	0	1
Uncer 2-1	0	0	0	1	0	1	1	1

For project 2:

Uncer 2-1	0	1	0	1
Uncer 2-2	0	0	1	1

Scenario probability calculation

Scenario calculation for project 1:

- Scenario 1 of project 1 will only succeed in case that:
Vector [Uncer1-1, Uncer1-2, Uncer2-1] = [1, 1, 1], which is:
 $0,70 * 0,80 * 0,60 = \underline{33,60\%}$

- ✦ Scenario 2 of project 1 will only succeed if and only if:
Vector [Uncer1-1, Uncer1-2, Uncer2-1] = [1, 1, 0], in case of vector [1, 1, 1] scenario 1 is achieved. The scenario probability is therefore:
 $0,70 * 0,80 * (1 - 0,60) = \underline{22,40\%}$
- ✦ Scenario 3 of project 1 will only succeed if and only if:
Vector [Uncer1-1, Uncer1-2, Uncer2-1] = [1, 0, 1], in case of vector [1, 1, 1] scenario 1 is achieved. The scenario probability is therefore:
 $0,70 * (1 - 0,80) * 0,60 = \underline{8,40\%}$

Scenario probability calculation for project 2:

- ✦ Scenario 1 of project 2 will only succeed in case that:
Vector [Uncer2-1, Uncer2-2] = [1, 1], which is:
 $0,60 * 0,50 = \underline{30,00\%}$
- ✦ Scenario 2 of project 2 will only succeed if and only if:
Vector [Uncer2-1, Uncer2-2] = [0, 1], in case of vector [1, 1] scenario 1 is achieved. The scenario probability is therefore:
 $(1 - 0,60) * 0,50 = \underline{20,00\%}$
- ✦ Scenario 3 of project 2 will only succeed if and only if:
Vector [Uncer1-1, Uncer1-2] = [1, 0], in case of vector [1, 1] scenario 1 is achieved. The scenario probability is therefore:
 $0,60 * (1 - 0,50) = \underline{30,00\%}$

Project & Portfolio Value

The option value of project 1 is:

$$0,336 * 100 + 0,224 * 50 + 0,084 * 20 = \underline{\text{€ } 46,48}$$

The option value of project 2 is:

$$0,30 * 80 + 0,20 * 30 + 0,30 * 10 = \underline{\text{€ } 33,00}$$

This makes the portfolio value $46,48 + 33,00 = \underline{\text{€ } 79,48}$

Value Impact

Project 2 does have a value impact on project 1; uncertainties of project 2 are present in project 1.

Value Impact of project 2 on project 1:

$$VI_2(1) = 0,336*100 + 0,084*20 = \underline{\text{€ } 35,28}$$

The value impact of project 2 on project 1 is present because uncertainty 2-1 is needed for scenario 1 & 3 of project 1. The value risk and potential of uncertainty 2-1 is therefore calculated next.

Value Risk & Potential

The Value Risk of uncertainty 2-1.

Value of portfolio if uncertainty 2-1 fails:

- ONLY scenario 2 of project 1 remains as possible outcome, vector [1, 1, 0], remaining probability is:

$$0,70*0,80 = \underline{56,00 \%}$$

- ONLY scenario 2 of project 2 remains as possible outcome, vector [0, 1], remaining probability is:

$$\underline{50,00 \%}$$

- The value of the projects:

$$\text{Project 1} = 0,56*50 = \underline{\text{€ } 28,00}$$

$$\text{Project 2} = 0,50*30 = \underline{\text{€ } 15,00}$$

$$VR(\text{uncertainty 2-1}) = (46,48 + 33,00) - (28,00 + 15,00) = \underline{\text{€ } 36,48}$$

The Value Potential of uncertainty 2-1.

Value of portfolio if uncertainty 2-1 is overcome:

- ONLY scenario 1 & 3 of project 1 remains as possible outcomes, vectors [1, 1, 1] and [1, 0, 1], remaining probabilities are:

$$\text{Scenario 1: } 0,70*0,80*1 = \underline{56,00 \%}$$

$$\text{Scenario 3: } 0,70*(1-0,80)*1 = \underline{14,00 \%}$$

- ONLY scenario 1 & 3 of project 2 remains as possible outcome, vectors [1, 1] and [1, 0], remaining probabilities are:

$$\text{Scenario 1: } 1*0,5 = \underline{50,00\%}$$

$$\text{Scenario 3: } 1*(1-0,5) = \underline{50,00\%}$$

✦ The value of the projects:

$$\text{Project 1} = 0,56 \cdot 100 + 0,14 \cdot 20 = \underline{\text{€ } 58,80}$$

$$\text{Project 2} = 0,50 \cdot 80 + 0,50 \cdot 10 = \underline{\text{€ } 45,00}$$

$$\text{VP(uncertainty 2-1)} = (58,80 + 45,00) - (46,48 + 33,00) = \underline{\text{€ } 24,32}$$

Total Influence of uncertainty 2-1 is:

$$36,48 + 24,32 = \underline{\text{€ } 60,80}$$



FIGURE 4-7 PORTFOLIO EXAMPLE

CONCLUSION

The created model calculates the value of a portfolio, the $V_{portfolio}$. This is done by applying Figure 4-3 to the portfolio of projects. The structure of the calculation of the portfolio valuation is important for Philips ADL in order to get a clear insight of the projects and the relations between them in the portfolio.

A good overview of the uncertainties per project has been achieved by dividing the uncertainties into three categories; the first is managed by the project, the second is managed elsewhere in the portfolio and the third is from outside the portfolio. Category two and three are therefore linkages but give the overview of the uncertainties per project.

The valuation is non-sequential; this is achieved by using the uncertainties as deliverables for a scenario. For these deliverables no sequence of resolving/ overcoming is required. This creates freedom for managing the uncertainties to a certain level. The uncertainties of the highest valued scenario should be attempted to be resolved first, the valuation method does not sequence the uncertainties but it does assume a sequence in pursuing the scenarios.

Valuation of the total portfolio in different segments is done through the expert assessment of the scenarios. The value of a scenario is divided in different segments and a hierarchal structure allows the value input to change for the different market hierarchies and so be adjusted for every business part of the organization.

A valuation of the relationships between projects has been achieved through the linkage of the uncertainties in the scenarios. The value of relationships between projects cannot be divided, because no value can be appointed to individual uncertainties of a scenario. The overview of the value dependencies between projects can be reached by displaying the value impacts of all the projects. The calculations make this possible and this will be done in the next Chapter.

A portfolio risk assessment can be done by calculating the influence of all the individual uncertainties on the value of the portfolio. This is the risk under the *ceteris paribus* condition. The influence of an uncertainty is calculated assuming that the other uncertainties remain the same. A real change comes if an uncertainty becomes a certainty and then a new valuation must be executed in order to get a good overview.

CHAPTER 5 TOOL APPLICATION

This chapter answers the following question: *'Can the newly specified model be applied in practice?'*

This research question will be answered in this chapter will start with an introduction that defines what is needed in order to be apply the newly specified model in practice. Then the technology of the portfolio that will be used for this application test will be explored. In order to use the model, inputs are needed. These will be described and evaluated next. These inputs generate outcomes of the model which will be described and evaluated by project and portfolio experts. Then the requirements that were set for the model in Chapter 2 can be evaluated in the conclusions.

THIS CHAPTER IS CONFIDENTIAL

INTRODUCTION

In order to achieve ~~the research goal~~, *'To improve the current project value calculation method to a practical portfolio model, for Philips ADL, so it can be used to calculate the value structure of projects in a technology portfolio, in order to improve project assessment.'*, a model has been developed and an application has been made in Chapter 4. The model has to prove its functionality. This is done by applying the tool version of the model to a portfolio of projects at Philips ADL. An evaluation of the application can be done on the hand of the requirements that have been set for the model in Chapter 2. The requirements are:

1. The model must provide a value structure, quantifying the value of projects and the project interactions
2. The portfolio structure must be relatively easy to create
3. Outcomes of the model must be easy to understand
4. The model must be easily adjustable to every company level

Requirement 2 is the only requirement that is applicable to the inputs of the model. For requirement 2, it has to be determined what makes the structure of the model relatively easy to create. In order to judge whether or not the structure is 'easy' to create, the inputs of the model are examined using three questions:

1. *What are the inputs?*
2. *What is needed to require the inputs?*
3. *Do the inputs fit the model?*

These three questions are answered in the Subsection *Input*. The first of the three questions has already been answered in Chapter 4, namely uncertainties, scenarios, and scenario values. But these will be described in the light of the HID portfolio, which will be used for this application test.

The requirements 1, 3, and 4 are requirements for the outcome of the model. In order to evaluate these requirements, the outputs of the test on a portfolio of projects at Philips ADL are used. For evaluating the outputs of the test, the following four questions need to be answered:

1. *What are the outputs/ results from the test?*
2. *Do the outputs/ results provide the 'right' information?*
3. *Are the outputs/ results understandable for the users?*
4. *Can the outputs/results be adjusted to fit every company level?*

These questions are answered in the Subsection *Output*. The results of the test will be presented in the answer to the first question, while a review by portfolio -, and project managers will answer the other questions.

HID PORTFOLIO

In the text box HID Technology a description of HID is given. The HID portfolio is chosen for analysis because this is the technology which has the most technological development in it for Philips ADL. The portfolio consists of many projects, in which there are many small projects. These small projects are not assessed because the effect of these projects on the portfolio would be minimal.

HID TECHNOLOGY

HID stands for High Intensity Discharge. The technology is similar to the fluorescent technology; in a gas filled tube between two electrodes an arc is created. The arc causes a metallic vapor to produce a radiant energy. The electrodes in a HID lamp are relative close together; they are only separated by a couple of centimeters. The electrodes are of tungsten and placed at the end of the tubes. The tube is filled with gas and metal salts, they are highly pressurized in the tube. This way an extreme high temperature can be reached within the tube. The metallic elements vaporize and form plasma which produces a visible radiant energy. The plasma is increasing the intensity of the light produced by the arc and reduces the power consumption. The HID technology will produce more visible radiant energy than the fluorescent technology. The HID lamps will not produce any phosphors. The efficiency of the HID technology is higher compared to fluorescent and incandescent lamps.

INPUTS

In this subsection the questions, 'What are the inputs?', 'What is needed to require the inputs?', and 'Do the inputs fit the model?' will be answered. The inputs for the models are uncertainties, scenarios, and scenario valuations. These have been required by meetings with project managers. These meetings will be handled first so that it is clear where the information of the inputs is retrieved. For the third question all the inputs are taken together to see if they fit the model. They are taken together because they influence each other and must therefore be seen as one for the model.

MEETINGS

UNCERTAINTIES

The uncertainties have been assessed per project. For each project a meeting was scheduled with the project leader and the key uncertainties were established, by a conversation which would go through the whole project. Uncertain events in projects are grouped so the group can form independent uncertainties. Questioning about the obstacles makes sure that the defined uncertainties are independent; the questions were leading to assessments of the uncertainties to higher aggregation levels.

First all the uncertainties were established, the milestone stages were used to go through the project. The projects 'own' uncertainties are assessed first, then the relationships and influences with other projects in the portfolio are examined. Then the uncertainties and threats outside the portfolio are assessed. Then the uncertainties are discussed individually. If an uncertainty is discussed, the independence is again checked with the assessment of the probabilities. The chance that an uncertainty

can be overcome has a first estimate of the project leader with whom the meeting is. Then the results of his or her first estimates are reviewed with the rest of the project team.

SCENARIOS

A scenario is defined as a collection of uncertainties which as a group are expected to have a value. Making these combinations has been done in the same meetings as in which the uncertainties have been established. This turned out to be a sequential process, first the uncertainties are identified then combinations can be made. The combinations are not made by assessing all the individual possibilities of uncertainty combinations. Some uncertainties are a must for projects while others are seen as extra features. Simple reasoning will create sensible outcomes for the project. If an outcome turns out to be worthless, it will not be accounted for in the tool. In this first test the scenario valuation has not been done by commercial specialists, in which case no conversation could take place about what is and isn't a valuable scenario. This was all established in the meetings and evaluation of the meetings with the project managers, which will also come forward in the scenario valuation.

SCENARIO VALUATION IN SEGMENTS

The HID portfolio contains projects that focus on different aspects of the markets. During the meetings with the project leaders, the segments on which the project focuses. This creates a segmentation of the market. On the basis of the segmentation created the value of a scenario is estimated on that segment. For the projects that are almost finished the estimation of the values in the segmentation is more based on a created business case while for projects that are less far in the development stage the values have been estimated by the project leaders. This made most of them uncertain during the meeting because some had not a good feeling about it. Especially small projects that are less far in the development phase experience difficulties with the value estimation. For the future this should be done by the business groups. This is then done by people who are closer to the market. This should deliver better estimations.

MODEL FITTING

'Do the inputs fit the model?' the short answer to this question would be 'Yes' In order to come to this short answer, the package of uncertainties and scenarios is examined. This package creates the

structure of the model. In order to determine if the package of uncertainties and scenarios can be used for the model, so if the package fits the model, two parts of the package can be examined:

1. Does defying the uncertainties and the scenarios of multiple uncertainties create problems?

In the test that has been done no problems have been present in defying the uncertainties or even the scenarios. To start with the defying the uncertainties, in order to exactly know whether or not the individual uncertainties of a project are independent of one another is not exactly known. Defying the uncertainties in such a way that different parts of the project are grouped together in one uncertainty makes it possible for the uncertainties to be defined in an independent matter.

The scenarios are defined by creating groups of uncertainties, if all the uncertainties are overcome, the scenario is achieved. Defying the scenarios did not present any problems; the scenarios can freely choose its uncertainties from the project in which the scenario is defined and from all projects in the portfolio. The test did not show many relationships between the different projects. But from the relationships between projects that were present it was no problem to define where the responsibility for scenarios were, in which project they should be defined. It has not been the case that only part of uncertainties should be overcome for a scenario. The way that the uncertainties have been defined did not create problems for the scenarios. This is the case because the uncertainties are dependent group of events but they are dependent because they represent a specific part of the project that must all succeed in order for the uncertainty to be overcome or even be valuable for the project.

2. Does the number of uncertainties and scenarios of multiple uncertainties created not get to large in order to describe the entire situation?

The manner, in which the uncertainties are defined, makes sure that the uncertainties per projects are not specified in too much detail. This makes sure that the number of uncertainties does not become too large to handle and assess for their success rate.

The number of scenarios is linked to the number of uncertainties, when there are many uncertainties present, the possibilities the different groups of uncertainties create a valuable outcome also increases. In the creating the scenarios, two criteria are taken in consideration. These are, technical feasibility, and

commercial value. In words: the scenario must have a complete function or product as outcome that also has a potential value in the market. With these criteria scenarios are formed, so other possibilities are not even taken in consideration. This makes that only the scenarios that really add value to the project are defined.

OUTPUT

The following questions have been asked in the introduction of this chapter:

1. *What are the outputs/ results from the test?*
2. *Do the outputs/ results provide the 'right' information?*
3. *Are the outputs/ results understandable for the users?*
4. *Can the outputs/results be adjusted to fit every company level?*

The first and last question will be answered in the Subsection *Results*. In this Subsection the results will be specified in *value*, *risks*, and *HIF's*. The results are presented and explained with the pictures of the developed tool as guidelines. The results can be specified to the company levels if the levels are pre-set in the inputs.

The other three questions will be answered by the project managers of this application test and two portfolio managers. This will be done in the Subsection *Review*.

RESULTS

What are the outputs/ results from the test?

The estimation of all the uncertainties and the valuation of the scenarios will produce results in the tool. Before this tool was available the Innovation Improvement Manager tried to make a good picture of the option value of the HID portfolio.

FIGURE 5-1 THE'S PLOTTED AGAINST THE PROJECT VALUE IN OCTOBER 2007

The value of the portfolio could not be estimated by the addition of the value of the projects, this can be seen in this same picture because first estimation about the single parts had to be made on intuition. This is hard to quantify and discussion about this can arise. The projects could not be modeled well to create portfolio value. The new tool is able to model this kind of results.

Can the outputs/results be adjusted to fit every company level?

For the Innovation Improvement manager it is now easy to see the value of the projects on different segment levels. These levels can be adjusted to various levels of the organization so that the people responsible for particular segments can get a good insight in the value of their segment and if that is sufficient enough. The segments have to be set in the inputs, as mentioned in *Inputs*. Then all the following results can be created for every pre-set segment.

VALUE

FIGURE 5-2 PORTFOLIO VALUE FOR THE HID SEGMENT

RISKS

New for the tool is a risk assessment of the individual uncertainties, this was not foresighted at the beginning of this assignment. The risk assessment can give a good insight if there are a lot of relationships between the projects where the risks are for the portfolio. In Figure 5-3 the risk analysis is displayed.

FIGURE 5-3 RISK ANALYSIS FOR THE HID PORTFOLIO

FTE'S

In Figure 5-4 the option value is plotted against the number of Full Time Equivalentents that are assigned to the project. If the assignment is good the project should be approximately on the same linear line, estimating that one FTE contributes approximately the same value to a project.

FIGURE 5-4 OPTION VALUE PLOTTED AGAINST THE FTE'S

REVIEW

'Do the outputs/ results provide the 'right' information?' and 'Are the outputs/ results understandable for the users?' will be answered by the portfolio managers as well as the project managers.

PORTFOLIO MANAGERS

PROJECT MANAGERS

CONCLUSION

Can the newly specified model be applied in practice?

In order to validate if the newly developed model, it has been applied to a portfolio of projects within Philips ADL. The model should meet the requirements:

- The portfolio structure must be relatively easy to create
- The model must provide a value structure, quantifying the value of projects and the project interactions
- The outcomes of the model must be easy to understand
- The model must be easily adjustable to every company level

The inputs have been required through conversations with the project managers of the projects present in the portfolio. This provided the structure of uncertainties for the portfolio. Commercial market experts could not be used for this test, so the assessment of the market values has been done by the project managers. The Innovation Improvement manager, Ruud Gal, has been satisfied with the

effort needed in order to create the structure and for the future, updating the portfolio structure. The number of uncertainties and scenarios in the tool has not escalated to a large number and could be defined without problems.

The model creates on the basis of the portfolio structure, a portfolio value picture in which the value of all the projects is shown, is cumulative so that the portfolio value is the total length of the project values. The interactions between projects is displayed by overlapping the project values in the portfolio value picture, see Figure 5-2. This picture quantifies the values of the projects and the value of the project interactions. On top of that, the value risks to which the portfolio is exposed can be displayed, see Figure 5-3. All the individual uncertainties are set to what their value influence is and what the current status is. Also the number of FTE's per project can be plotted against the value of the project, see Figure 5-4. According to the portfolio managers, this created an understandable view of the portfolio.

All of the outcomes can be adjusted to all kind of segments that are created in the portfolio structure in the beginning. The scenario values are divided in the different segments, so the inputs can be chosen. The outcomes are then automatically adjusted to the inputs.

The projects managers and the portfolio managers understood the outcomes of the model. They judged that the tool could improve portfolio assessment. They also thought that the tool could improve scenario thinking within projects. Some doubts have been mentioned by some project managers about the correctness of the input information.

CHAPTER 6 CONCLUSIONS & RECOMMENDATIONS

The goal for this research project has been:

To improve the current project value calculation method to a practical portfolio model, for Philips ADL, so it can be used to calculate the value structure of projects in a technology portfolio, in order to improve project assessment.

In the process of reaching this goal, the following research questions have been answered:

What is the scope of a (new) portfolio value calculation model within Philips ADL?

The scope of the new value calculation model contains two parts, the value process and the model purpose. The value process is the process in which three kinds of projects are present, Platform, Product Creation Process, and Functional Creation Process, projects. Managing these projects in their start phase determines what value will be created in the future for Philips Lighting. The purpose of the new portfolio value calculation model is that the use of the model can be defined as using the value calculation model in order to provide a comprehensible value structure of a portfolio with the purpose of improving investment decision in the portfolio by Philips ADL management. The structure must be easily creatable and maintainable, a comprehensible method must be made to calculate the value of projects and interactions, value structure must be accurate are defined as the user needs.

What are the requirements & criteria of the new value calculation model?

The following requirements can be set from the goal and the scope of the project:

- ✦ The model must provide a value structure, quantifying the value of projects and the project interactions
- ✦ The portfolio structure must be relatively easy to create
- ✦ Outcomes of the model must be easy to understand
- ✦ The model must be easily adjustable to every company level

These requirements lead to the following criteria:

- An overview of the value dependencies between projects
- A valuation of projects and the relationships between projects
- A portfolio risk assessment for all the individual parts of the structure
- A non-sequential model for the structure of the valuation must be used
- A good overview of the uncertainties per project in the structure
- A comprehensible figures must be presented as the outcomes of the model
- A valuation of the total portfolio in different segments must be present

What can be learnt from the theoretical models in valuation literature and real option literature in particular for the Philips ADL context?

From theory, it could be found that the option tree approach is an approach that has interesting features for Philips ADL. In combination with decision tree analysis, the 'private' risks of Philips ADL could be assessed. The representation of this method appeals for its simplicity. A tree is constructed in which the events that could happen to a project, or even in an expanded version, a portfolio are modeled. The end notes of this model can be calculated back to present time and a value of the modeled process comes out. The 'in-house' developed approach is similar to this approach, only does not assume a sequence in the events. Disadvantage of this is that the individual events cannot be valued to their contribution. This is actually closer to reality because an event in itself is worthless, only in a combination with other events synergy occurs and the combination becomes valuable.

What model can be specified, regarding the requirements?

The model that is specified in Chapter 4 is a development of the project value calculation method to a portfolio method. In this method, all the risks that a project faces in the development phase are defined in uncertainties. The uncertainties are divided in three groups, namely uncertainties managed within the project, uncertainties managed within the portfolio, uncertainties from outside the portfolio. The last group of uncertainties cannot be managed within the portfolio and the project is therefore dependent on events of others. The uncertainties managed within the portfolio are links between projects. This is done so that the same uncertainties are not defined multiple times in different projects. Expert assessment helps in the definition of the scenarios. Uncertainties are assigned to the scenarios. These uncertainties must be overcome for the scenario to occur. From this structure, the value of the projects, relationships, portfolio and the value risks of the individual uncertainties can be calculated.

Can the newly specified model be applied in practice?

An application test to a real portfolio has been executed in order to answer this question. The inputs of this test have been required through conversations with the project managers of the projects present in the portfolio. This provided the structure of uncertainties for the portfolio. Commercial market experts could not be used for this test, so the assessment of the market values has been done by the project managers. The Innovation Improvement manager, Ruud Gal, has been satisfied with the effort needed in order to create the structure and for the future, updating the portfolio structure. The number of uncertainties and scenarios in the tool has not escalated to a large number and could be defined without problems. Project managers and two portfolio managers have reviewed the test. The projects managers and the portfolio managers understood the outcomes of the model. They judged that the tool could improve portfolio assessment. They also thought that the tool could improve scenario thinking within projects. Some doubts have been mentioned by some project managers about the correctness of the input information.

RECOMMENDATIONS

Portfolio development over time

The developed model does not show value development over time. The model provides a snapshot of the value of the portfolio. The development of the portfolio value over time is still an issue that has to be tackled; projects are stopped and added to the portfolio. The development of individual projects can be made by plotting their value against time. This should be done for their value as well as for the impact value. This will show in what way the importance of the project in the portfolio develops.

Interest rate

In the current tool there has been no interest rate applied. A risk neutral interest rate should be used in order to compensate for the time value of money. Systematic risks are accounted for in the scenario valuation. Unsystematic risks are accounted for in the developed model, so the risk free interest rate remains. The year in which projects are scheduled for market introduction is known, so all the information needed for this is present in the tool.

Hybrid relationship programming

In the tool there is a option that the relationship between projects is not the same built on one uncertainty but can be filled in on own assessment. This can be used for success of a scenario or even the total project. This can create hybrid relationship between projects in which the dependence in twofold. This dependency can create a loop within the software and will block the program. Dummy variables should be created in order to maintain the independence of the uncertainties.

Further Research

In the current tool, the number of FTE's assigned to a project can be plotted against the value of the project. In order for this to be optimized boundaries of project processes are needed for optimizing the number of FTE that can be assigned to a project. The portfolio value can then be used in order strategically appoint the number of FTE to projects in order to maximize the value of the portfolio. What boundaries are needed for this could be an interesting research question.

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CHAPTER 8 APPENDIX A

Public pbOK As Boolean

Function OptionProbability(ByVal RiskVector As Range, _
ByVal RisksPerOutputScenarioMatrix As Range) As String

Dim i, j, ColumnIndex, ArrowRow, ArrowCol, NrOfVectorsInScenario As Long, _
RiskVectorLength As Integer, Match As Boolean, _
PossibleOutputScenarioVectors() As Single, _
ProbabilityNonOverlapWithEarlierScenario() As Single, _
OptionProbabilityFormula As String, _
ProbabilityVectorFormula As String

On Error GoTo ErrorExit

Application.ScreenUpdating = False
RiskVectorLength = RiskVector.Rows.Count

While RiskVectorLength > 1 And _
(RiskVector.Cells(RiskVectorLength, 1).Value = 0 Or IsEmpty(RiskVector.Cells(RiskVectorLength, 1).Value))
RiskVectorLength = RiskVectorLength - 1
Wend

Application.Volatile
If RiskVector Is Nothing Then
MsgBox "Macro Ended, RiskVector Empty"
Application.StatusBar = ""
Application.ScreenUpdating = True
End
End If
If RisksPerOutputScenarioMatrix Is Nothing Then
MsgBox "Macro Ended, Risks per Output Scenario Matrix Empty"
Application.StatusBar = ""
End
Application.ScreenUpdating = True
End If

ColumnIndex = RisksPerOutputScenarioMatrix.Columns.Count
ReDim PossibleOutputScenarioVectors(RiskVectorLength, 1)

For i = 1 To RiskVectorLength
If Not IsEmpty(RiskVector.Cells(i, 1).Value) Then
If RisksPerOutputScenarioMatrix.Cells(i, ColumnIndex).Value = 1 Then
For j = 1 To UBound(PossibleOutputScenarioVectors, 2)
PossibleOutputScenarioVectors(i, j) = 1
Next
Else
' The PossibleOutputScenarios Double
ReDim Preserve PossibleOutputScenarioVectors(RiskVectorLength, 2 * UBound(PossibleOutputScenarioVectors, 2))
' Copy the left half into the right half
For ArrayCol = 1 To 0.5 * UBound(PossibleOutputScenarioVectors, 2)
For ArrayRow = 1 To i - 1
PossibleOutputScenarioVectors(ArrayRow, CInt(0.5 * UBound(PossibleOutputScenarioVectors, 2) + ArrayCol)) = _
PossibleOutputScenarioVectors(ArrayRow, ArrayCol)
Next
PossibleOutputScenarioVectors(i, ArrayCol) = 1
Next
Next
End If
End If
Next

ReDim ProbabilityNonOverlapWithEarlierScenario(UBound(PossibleOutputScenarioVectors, 2))
For ArrayCol = 1 To UBound(PossibleOutputScenarioVectors, 2)
ProbabilityNonOverlapWithEarlierScenario(ArrayCol) = 1
Next

```

' for all previous output scenarios
For j = 1 To ColumnIndex - 1
' for all possible output scenarios
For ArrayCol = 1 To UBound(PossibleOutputScenarioVectors, 2)
' only considering output scenarios that are not yet overlapping with previous
' output scenarios
If ProbabilityNonOverlapWithEarlierScenario(ArrayCol) = 1 Then
' let's allow those output scenarios that do not have a 1 at those rows
' where any of the previous output scenarios have a 1
' we assume overlap
ProbabilityNonOverlapWithEarlierScenario(ArrayCol) = 0
' check for every row
For i = 1 To RiskVectorLength
' if there is a row where not both have a 1
If RisksPerOutputScenarioMatrix.Cells(i, j).Value = 1 Then
If Not PossibleOutputScenarioVectors(i, ArrayCol) = 1 Then
' only consider those where assumed overlap still holds
If ProbabilityNonOverlapWithEarlierScenario(ArrayCol) = 0 Then
' there is no overlap, so it is a possible scenario
ProbabilityNonOverlapWithEarlierScenario(ArrayCol) = 1
End If
End If
End If
Next
End If
Debug.Print ArrayCol, "=", ProbabilityNonOverlapWithEarlierScenario(ArrayCol)
Next
Next

OptionProbability = 0
OptionProbabilityFormula = "=0"
For ArrayCol = 1 To UBound(PossibleOutputScenarioVectors, 2)
If ProbabilityNonOverlapWithEarlierScenario(ArrayCol) = 1 Then
ProbabilityPerVector = 1
ProbabilityVectorFormula = "1"
For i = 1 To RiskVectorLength
If Not IsEmpty(RiskVector.Cells(i, 1).Value) Then
If PossibleOutputScenarioVectors(i, ArrayCol) = 1 Then
ProbabilityPerVector = ProbabilityPerVector * RiskVector.Cells(i, 1).Value
ProbabilityVectorFormula = ProbabilityVectorFormula & "*" & Replace(RiskVector.Cells(i, 1).Address, "$", "")
Else
ProbabilityPerVector = ProbabilityPerVector * (1 - RiskVector.Cells(i, 1).Value)
ProbabilityVectorFormula = ProbabilityVectorFormula & "(1-" & Replace(RiskVector.Cells(i, 1).Address, "$", "") & ")"
End If
End If
Next
OptionProbability = OptionProbability + ProbabilityPerVector
OptionProbabilityFormula = OptionProbabilityFormula & "+" & ProbabilityVectorFormula
End If
Next
OptionProbability = OptionProbabilityFormula
Application.ScreenUpdating = True

Exit Function

ErrorExit:
' MsgBox "Error occurred, Macro Ended"
Application.StatusBar = ""
Application.ScreenUpdating = True
End Function

Function SelectedSegment() As String

Dim LastRow, Rw, Cl As Integer

With Sheets("Segmentation")
LastRow = .Range("B4:Z65536").SpecialCells(xlCellTypeLastCell).Row
For Rw = 4 To LastRow
Cl = 2
While IsEmpty(.Cells(Rw, Cl)) And Cl < 30

```

```

        CI = CI + 1
    Wend
    If CI < 30 Then
        ' We have found something
        .Cells(Rw, 100).Value = String(4 * (CI - 2), " ") & CStr(.Cells(Rw, CI).Value)
    End If
Next

Unload FormSelectSegment
'add items to the list box from a worksheet (Column CV = Column 100)
FormSelectSegment.ComboBox1.RowSource = _
    .Range("CV4:CV" & CStr>LastRow)).Address(external:=True)
'display the list until an item is selected or cancel pressed
pbOK = False
Do
'note: userform activate event displays the drop down list
'and sets the focus to the combobox
    FormSelectSegment.Show
    'check value of pbOK that was set by the buttons on the form
    If Not pbOK Then
        End
    Else
        Exit Do
    End If
Loop
'only if an item is selected does the code exit the loop
If FormSelectSegment.ComboBox1.ListIndex <= -1 Then
'if no item selected....
'remove any entry if one was made
    FormSelectSegment.ComboBox1.Value = Null
    End
End If
SelectedSegment = FormSelectSegment.ComboBox1.Value
'unload the userform
Unload FormSelectSegment
End With
End Function

Function TargetSegment>LastRow As Integer) As Integer

With ActiveSheet
    Unload FormTargetSegment
'add items to the list box from a worksheet (Column CV = Column 100)
FormTargetSegment.ComboBox1.RowSource = _
    .Range("E4:E" & CStr>LastRow)).Address(external:=True)
'display the list until an item is selected or cancel pressed
pbOK = False
Do
'note: userform activate event displays the drop down list
'and sets the focus to the combobox
    FormTargetSegment.Show
    'check value of pbOK that was set by the buttons on the form
    If Not pbOK Then
        End
    Else
        Exit Do
    End If
Loop
'only if an item is selected does the code exit the loop
If FormTargetSegment.ComboBox1.ListIndex <= -1 Then
'if no item selected....
'remove any entry if one was made
    FormTargetSegment.ComboBox1.Value = Null
    End
End If
If Trim(FormTargetSegment.ComboBox1.Value) = "" Then
    TargetSegment = LastRow + 1
Else
    TargetSegment = FormTargetSegment.ComboBox1.ListIndex + 4
End If

```

```

        'unload the userform
        Unload FormTargetSegment
    End With
End Function
Sub SortScenarios()

Dim EndColumn As Integer

With ActiveSheet
    EndColumn = .Range("IV3").End(xlToLeft).Column
    .Range(Cells(2, 6), Cells(42, EndColumn)).Sort Key1:=Range("F17"), Order1:=xlDescending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlLeftToRight
End With
End Sub
Function SelectedProject(ProjCnt As Integer) As String

With ActiveSheet
    Unload FormSelectProject
    'add items to the list box from a worksheet (starting at A1000)
    FormSelectProject.ComboBox1.RowSource = _
        Sheets("Segmentation").Range("A1000:A" & CStr(1000 + ProjCnt - 1)).Address(external:=True)
    'display the list until an item is selected or cancel pressed
    pbOK = False
    Do
        'note: userform activate event displays the drop down list
        'and sets the focus to the combobox
        FormSelectProject.Show
        'check value of pbOK that was set by the buttons on the form
        If Not pbOK Then
            End
        Else
            Exit Do
        End If
    Loop
    'only if an item is selected does the code exit the loop
    If FormSelectProject.ComboBox1.ListIndex <= -1 Then
        'if no item selected...
        'remove any entry if one was made
        FormSelectProject.ComboBox1.Value = Null
        End
    End If
    SelectedProject = FormSelectProject.ComboBox1.Value
    'unload the userform
    Unload FormSelectProject
End With
End Function
Sub SelectedDeliverable(DelivCnt As Integer, DepType As Integer, SelDel As String)

With ActiveSheet
    Unload FormSelectedDeliverable
    'add items to the list box from a worksheet (starting at A1000)
    FormSelectedDeliverable.ComboBox1.RowSource = _
        Sheets("Segmentation").Range("A1000:A" & CStr(1000 + DelivCnt - 1)).Address(external:=True)
    'display the list until an item is selected or cancel pressed
    pbOK = False
    Do
        'note: userform activate event displays the drop down list
        'and sets the focus to the combobox
        FormSelectedDeliverable.Show
        'check value of pbOK that was set by the buttons on the form
        If Not pbOK Then
            End
        Else
            Exit Do
        End If
    Loop
    'only if an item is selected does the code exit the loop
    If Not FormSelectedDeliverable.OptionButton3.Value And _
        FormSelectedDeliverable.ComboBox1.ListIndex <= -1 Then
        'if no item selected...

```

```
'remove any entry if one was made
  FormSelectedDeliverable.ComboBox1.Value = Null
End
End If
SelDel = Sheets("Segmentation"). _
  Cells(1000 + FormSelectedDeliverable.ComboBox1.ListIndex, 1).Formula
If FormSelectedDeliverable.OptionButton1.Value Then
  DepType = 1
Else
  If FormSelectedDeliverable.OptionButton2.Value Then
    DepType = 2
  Else
    DepType = False
  End If
End If
'unload the userform
Unload FormSelectedDeliverable
End With
End Sub

Sub CompressSheet()

Dim Row As Integer

With ActiveSheet
  For Row = 4 To 66
    If .Range("IV" & CStr(Row)).End(xlToLeft).Column = 1 And IsEmpty(.Cells(Row, 1)) Then
      .Rows(Row).Hidden = True
    End If
  Next
  .Range("IV1").Value = "H"
  With Application
    .EnableEvents = True
    .Calculation = xlAutomatic
    .MaxChange = 0.001
  End With
End With
End Sub

Sub DeCompressSheet()

With ActiveSheet
  .Rows("1:65536").Hidden = False
  .Range("IV1").Value = ""
  With Application
    .EnableEvents = False
    .Calculation = xlManual
    .MaxChange = 0.001
  End With
End With

End Sub

Sub ToggleCompress()

If ActiveSheet.Range("IV1").Value = "" Then
  CompressSheet
Else
  DeCompressSheet
End If
End Sub
Sub SheetChange(Target As Range)

Dim CI As Integer, _
  aCell As Range, _
  aCl1 As Range, _
  aSht As Worksheet, _
  EndColumn As Integer, _
  aSht2 As Worksheet, _
  SheetsSorted As Boolean, _
```

```
OptionProbFormula As String, _
CharEndPos As Double, _
CharPrevEndPos As Double, _
CharStartPos As Double, _
aFormulaStr As Integer, _
NrOfPartitions As Integer
```

```
Application.EnableEvents = False
```

```
With ActiveSheet
```

```
    If .Name = "Black-Scholes Calculator" Or _
        .Name = "Segmentation" Or _
        .Name = "Portfolio Value" Or _
        .Name = "Option Value vs fte" Or _
        .Name = "Sensitivity Analysis" Or _
        Left(.Name, 7) = "Project" Then
        ' No action required
        Exit Sub
    End If
    ' beyond row 42 no action is required
    If Target.Row > 42 Then
        Exit Sub
    End If
    ' Row three determines the nr of columns to be treated
    EndColumn = .Range("IV3").End(xlToLeft).Column
    ' If the year of market introduction is changed, the sequence of the sheets may have to be cahnges
    ' is in the order of market introduction
    If Target.Address = "$E$3" Then
        SheetsSorted = False
        For Each aSht2 In ThisWorkbook.Sheets
            If (Not SheetsSorted) And _
                (Not aSht2.Name = "Black-Scholes Calculator") And _
                (Not aSht2.Name = "Segmentation") And _
                (Not aSht2.Name = "Portfolio Value") And _
                (Not aSht2.Name = "Option Value vs fte") And _
                (Not aSht2.Name = "Sensitivity Analysis") And _
                Left(aSht2.Name, 7) <> "Project" Then
                ' Compare expected market introduction
                If aSht2.Cells(3, 5).Value > ActiveSheet.Cells(3, 5).Value Then
                    SheetsSorted = True
                    ActiveSheet.Move Before:=aSht2
                End If
            End If
        Next
        ' If SheetsSorted is still false, the sheets were sorted fine at the start
        ' SheetsSorted = true
    End If
    Set aCell = Intersect(Target, .Range(Cells(4, 6), Cells(15, EndColumn)))
    If (Not aCell Is Nothing) Then
        If CStr(Target.Value) = "?" Then
            Sheets("Black-Scholes Calculator").Cells(140, 1).Value = ActiveSheet.Name
            Sheets("Black-Scholes Calculator").Cells(141, 1).Value = Target.Address
            Sheets("Black-Scholes Calculator").Select
            Cells(2, 6).Select
            Exit Sub
        End If
    End If
    ' the risk scenario interaction maybe changed. if so tham
    ' Calculate the new option value formulas corresponding with the changes in the sheet
    Set aCell = Intersect(Target, .Range(Cells(24, 6), Cells(42, EndColumn)))
    If Not aCell Is Nothing Then
        Application.StatusBar = "Calculate Option Value Formulas"
        For CI = 6 To EndColumn
            OptionProbFormula = OptionProbability(.Range("C24:C42"), .Range(.Cells(24, 6), .Cells(42, CI)))
            ' the build of formula's is rather inefficient in terms of formula lengths, that may
            ' if not treated lead to out of memory errors, because the formula does not fit the cell size
            ' so we check the length of the formula upfront
            If Len(OptionProbFormula) < 250 Then
                .Cells(43, CI).Formula = OptionProbFormula
            Else
```



```

' we have an issue the formula is too long. we have to split it over more than one cell
' and sum the total
' we will use the same column starting at row 50000 going towards 60000
' the algorithm is looking for the "+" operator in order to sum the total
' first we remove the "=" in OptionProbFormula to ease the writing formula's later
OptionProbFormula = Right(OptionProbFormula, Len(OptionProbFormula) - 1)
NrOfPartitions = 0
CharStartPos = 1
CharEndPos = InStr(CharStartPos, OptionProbFormula, "+")
While CharEndPos <> 0 'this means that the remaining formula does not contain any "+"
    ' let's partition the formula
    ' end this loop as soon as the part of the formula string exceed 250 characters or

    While CharEndPos - CharStartPos < 250 And CharEndPos <> 0
        CharPrevEndPos = CharEndPos + 1
        CharEndPos = InStr(CharPrevEndPos, OptionProbFormula, "+")
    Wend
    ' we have finished another partition
    NrOfPartitions = NrOfPartitions + 1
    ' let's get it in the right way in the right cell
    If CharEndPos = 0 Then
        ' end of OptionProbFormula is reached
        CharPrevEndPos = Len(OptionProbFormula) + 2 ' the + 2 is to compensate for the subtraction
        ' let's put the sum string in row 43, C1
        .Cells(43, C1).Formula = "=sum(" & CCol(C1) & "50000:" & CCol(C1) & CStr(49999 + NrOfPartitions) & ")"
    End If
    ' and place the formula in the right cell
    .Cells(49999 + NrOfPartitions, C1).Formula = "=" & Mid(OptionProbFormula, CharStartPos, CharPrevEndPos - CharStartPos - 1)
    CharStartPos = CharPrevEndPos
Wend
End If
Next
End If
Application.StatusBar = ""
End With
Application.EnableEvents = True

End Sub
Sub AcceptVOCString()

Application.EnableEvents = False

With Sheets("Black-Scholes Calculator")
    Sheets(.Cells(140, 1).Value).Range(.Cells(141, 1).Value).Value = _
        CStr(.Cells(2, 6).Value) & "/" & _
        CStr(.Cells(4, 6).Value) & "/" & _
        CStr(.Cells(6, 6).Value) & "/" & _
        CStr(.Cells(8, 6).Value) & "/" & _
        CStr(.Cells(10, 7).Value)
End With
Sheets(Sheets("Black-Scholes Calculator").Cells(140, 1).Value).Select
Range(Sheets("Black-Scholes Calculator").Cells(141, 1).Value).Select

Application.EnableEvents = True

End Sub
Function CCol(ByVal Col As Integer) As String
Dim c2 As Integer, _
    c1 As Integer

If Col > 26 Then

    c2 = Int(Col / 26)
    c1 = Col - c2 * 26
    If c1 = 0 Then
        c1 = 26
        c2 = c2 - 1
    End If
    CCol = Chr(c2 + 64) & Chr(c1 + 64)
Else

```

```

c1 = Col
CCol = Chr(c1 + 64)
End If

End Function
Sub SheetSelectionChange(ByVal Target As Range)

Dim aCell As Range, _
aCellContainsNameOfSegment As Boolean, _
aCellRow As Integer, _
SegmentArray As Variant, _
aSht As Worksheet, _
ProjCount As Integer, _
SelectedItem As String, _
DeliverableFromOtherProjectCount As Integer, _
PositiveDependent As Integer, _
SelectedKeyDelivery As String, _
EndColumn As Integer, _
cell As Range

With ActiveSheet
If .Name = "Black-Scholes Calculator" Or _
.Name = "Segmentation" Or _
.Name = "Portfolio Value" Or _
.Name = "Option Value vs fte" Or _
.Name = "Sensitivity Analysis" Or _
Left(.Name, 7) = "Project" Then
' No action required
Exit Sub
End If
EndColumn = .Range("IV3").End(xlToLeft).Column
If Target.Cells.Count = 1 Then
If Not Intersect(Target, Columns("E:E")) Is Nothing Then
Select Case Target.Row
Case 17
aCellRow = 4
While Not IsEmpty(.Cells(aCellRow, 5))
aCellRow = aCellRow + 1
Wend
aCellRow = aCellRow - 1
.Cells(17, 5).Formula = "=E" & CStr(TargetSegment(aCellRow))
' Now we have to sort the NPV's for the scenarios, in such a way that
' the scenario with the highest NPV comes first
' this also means adaptation of the Risk-Scenario matrix in the same column
.Cells(17, 5).Copy Destination:=.Range(Cells(17, 6), Cells(17, EndColumn))
For Each cell In .Range(Cells(17, 6), Cells(17, EndColumn))
With cell
.Value = VOC(cell.Value)
.NumberFormat = "##.##"
End With
Next
SortScenarios
Case 4 To 15
' let's figure out whether target points at a segment name
aCellRow = 4
Set aCell = .Range("E" & CStr(aCellRow))
aCellContainsNameOfSegment = False
While Not aCell.Row = 16 And Not aCellContainsNameOfSegment
If aCell.Value = Target.Value Then
aCellContainsNameOfSegment = True
Else
aCellRow = aCellRow + 1
Set aCell = .Range("E" & CStr(aCellRow))
End If
Wend
If aCellContainsNameOfSegment Then
Target.Value = SelectedSegment
End If
End Select

```

```

End If
If Not Intersect(Target, .Range("A32:A37")) Is Nothing Then
    ' We adress here dependencies from other projects
    ProjCount = 0
    For Each aSht In ThisWorkbook.Sheets
        If (Not aSht.Name = "Black-Scholes Calculator") And _
            (Not aSht.Name = "Segmentation") And _
            (Not aSht.Name = "Portfolio Value") And _
            (Not aSht.Name = "Option Value vs fte") And _
            (Not aSht.Name = "Sensitivity Analysis") And _
            (Not aSht.Name = ActiveSheet.Name) And _
            Left(aSht.Name, 7) <> "Project" Then
            Debug.Print aSht.Name
            Sheets("Segmentation").Cells(1000 + ProjCount, 1).Value = aSht.Name
            ProjCount = ProjCount + 1
        End If
    Next
    Target.Value = SelectedProject(ProjCount)
    ' So the project where a dependency occurs is identified,
    ' noew lets get the uncertainty it self
    DeliverableFromOtherProjectCount = 0
    Set aSht = Sheets(Target.Value)
    For Each aCell In aSht.Range("B24:B42")
        If Not IsEmpty(aCell) And aCell.Row < 31 Or aCell.Row > 38 Then
            Sheets("Segmentation").Cells(1000 + DeliverableFromOtherProjectCount, 1).Formula _
                = "=" & aSht.Name & "!" & aCell.Address
            DeliverableFromOtherProjectCount = DeliverableFromOtherProjectCount + 1
        End If
    Next
    SelectedDeliverable DeliverableFromOtherProjectCount, PositiveDependent, SelectedKeyDelivery
    If Not PositiveDependent = 3 Then
        ' User will NOT define the project dependency
        Target.Offset(0, 1).Formula = Replace(SelectedKeyDelivery, "$", "")
        Target.Offset(0, 1).Copy Destination:=Target.Offset(0, 2)
        Target.Offset(0, 1).Copy Destination:=Target.Offset(0, 3)
        If PositiveDependent = 2 Then
            With Target.Offset(0, 2)
                .Formula = "=1 - " & Right(.Formula, Len(.Formula) - 1)
            End With
            With Target.Offset(0, 3)
                .Value = "=1 - " & Right(.Formula, Len(.Formula) - 1)
            End With
        End If
    Else
        ' User defines dependency, select the cell to be adjusted by the user
        Intersect(Range(Target.EntireRow), Columns("B:D")).ClearContents
        Target.Offset(0, 1).Select

        End If
        With Range(Target.Offset(0, 2), Target.Offset(0, 3))
            .NumberFormat = "0%"
            .HorizontalAlignment = xlCenter
            .VerticalAlignment = xlCenter
            With .Font
                .Name = "Arial"
                .FontStyle = "Regular"
                .Size = 14
            End With
        End With
    End If
End If
End With
End Sub
Sub PortfolioAnalysis(ByVal Target As Range)

Dim aSht As Worksheet, _
    ProjCount As Integer, _
    InterDepCount As Boolean, _
    Rw As Integer, _
    Cl As Integer, _

```

OptionValue As Single, _
ProjectFound As Boolean, _
Col As Integer, _
Row As Integer, _
PreviousNode As Integer, _
EndRow As Integer, _
EndColumn As Integer, _
FormulaString As String

```

Application.EnableEvents = False
With Sheets("Portfolio Value")
    If Not Intersect(Target, .Range("C2:H2")) Is Nothing Then
        .Cells(2, 3).Value = SelectedSegment()
        .Range("A3:IV65536").ClearContents
        ProjCount = 0
        .Cells(4, 3).Value = "Project"
        For Each aSht In ThisWorkbook.Sheets
            ' Let's create the project axis on row 4 with all the names of the projects
            If (Not aSht.Name = "Black-Scholes Calculator") And _
                (Not aSht.Name = "Segmentation") And _
                (Not aSht.Name = "Portfolio Value") And _
                (Not aSht.Name = "Option Value vs fte") And _
                (Not aSht.Name = "Sensitivity Analysis") And _
                (Not aSht.Name = ActiveSheet.Name) And _
                Left(aSht.Name, 7) <> "Project" Then
                Debug.Print aSht.Name
                ProjCount = ProjCount + 1
                .Cells(4, 3 + ProjCount).Value = aSht.Name
                .Cells(5, 3 + ProjCount).Value = aSht.Cells(3, 5).Value
                CopySegmentRow aSht, .Cells(2, 3).Value
            End If
        Next
        Row = 5
        For Each aSht In ThisWorkbook.Sheets
            ' Go through all project sheets once more and address the inter-dependencies
            If (Not aSht.Name = "Black-Scholes Calculator") And _
                (Not aSht.Name = "Segmentation") And _
                (Not aSht.Name = "Portfolio Value") And _
                (Not aSht.Name = "Option Value vs fte") And _
                (Not aSht.Name = "Sensitivity Analysis") And _
                (Not aSht.Name = ActiveSheet.Name) And _
                Left(aSht.Name, 7) <> "Project" Then
                EndColumn = aSht.Range("IV3").End(xlToLeft).Column
                For Cl = 6 To EndColumn
                    If Not IsEmpty(aSht.Cells(3, Cl)) Then
                        ' No interaction with other projects assumed
                        InterDepCount = False
                        For Rw = 32 To 37
                            If Not IsEmpty(aSht.Cells(Rw, Cl)) Then
                                ProjectFound = False
                                Col = 1
                                ' Walk through the row of projects and look for a match
                                While Not ProjectFound And ProjCount >= Col
                                    If aSht.Cells(Rw, 1).Value = .Cells(4, 3 + Col).Value Then
                                        ProjectFound = True
                                    Else
                                        Col = Col + 1
                                    End If
                                Wend
                                If Not InterDepCount Then
                                    InterDepCount = True
                                    Row = Row + 1
                                End If
                                If Left(aSht.Cells(Rw, 3).Formula, 4) = "=1 -" Then
                                    ' this means that this value is only released, if other deliverables in other projects
                                    ' are not met. This option value has to be added
                                    .Cells(Row, 3 + Col).Value = ""
                                Else
                                    If Not .Cells(Row, 3 + Col).Value = 1 Then
                                        ' avoid that double dependencies disturb the classification in column B

```

```

        .Cells(Row, 3 + Col).Value = 1
        ' set classification in Column B
        .Cells(Row, 2).Value = 2 ^ (Col - 1) + .Cells(Row, 2).Value
    End If
End If
End If
Next
' if no interdependence found only the project analysed has to be indicated
If Not InterDepCount Then
    Row = Row + 1
End If
ProjectFound = False
Col = 1
' Walk through the row of projects and look for a match
While Not ProjectFound And ProjCount >= Col
    If aSht.Name = .Cells(4, 3 + Col).Value Then
        ProjectFound = True
    Else
        Col = Col + 1
    End If
Wend
.Cells(Row, 3 + Col) = 1
.Cells(Row, 3).Value = "=" & aSht.Name & "!" & aSht.Cells(46, Cj).Address
' set classification in Column B
.Cells(Row, 2).Value = 2 ^ (Col - 1) + .Cells(Row, 2).Value
End If
Next
End If
aSht.Select
Next
.Select
' We are going to sort the table that is created on time-to-market (Row 5)
.Range(Cells(4, 4), Cells(Row, 3 + Col)).Sort Key1:=Range("E4"), Order1:=xlAscending, Header:=xlGuess, _
    OrderCustom:=1, MatchCase:=False, Orientation:=xlLeftToRight
' We are going to sort the table that is created
.Range(Cells(6, 2), Cells(Row, 3 + Col)).Sort Key1:=Range("B6"), Order1:=xlAscending, Header:=xlGuess, _
    OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom

' Now we are going to sum the option values with the same sort value
PreviousNode = .Cells(Row + 1, 2).Value
If .Cells(Row, 3) < 0.01 Then
    .Rows(Row).EntireRow.Delete
End If
Row = Row - 1
While Row > 5
    If .Cells(Row, 3) = 0# Then
        ' if the result = 0 remove this project from the list
        .Rows(Row).EntireRow.Delete
    Else
        ' integrate rows dealing with the same nodenumber into one row
        If .Cells(Row, 2).Value = PreviousNode Then
            .Cells(Row, 3).Formula = .Cells(Row, 3).Formula & " + " & Right(.Cells(Row + 1, 3).Formula, Len(.Cells(Row + 1, 3).Formula) - 1)
            Rows(Row + 1).EntireRow.Delete
        End If
        PreviousNode = .Cells(Row, 2).Value
    End If
    Row = Row - 1
Wend
EndRow = .Range("B65536").End(xlUp).Row
' Now we are going to correct the option value of the individual project sheets, due to impact on other projects
For Col = 4 To ProjCount + 3
    FormulaString = "=0"
    For Row = 6 To EndRow
        If .Cells(Row, Col).Value = 1 Then
            FormulaString = FormulaString & "+" & Right(.Cells(Row, 3).Formula, Len(.Cells(Row, 3).Formula) - 1)
        End If
    Next
    Sheets(.Cells(4, Col).Value).Cells(52, 7).Formula = FormulaString
Next

```

```
' remove the projects with no value
Col = ProjCount + 3
While Col > 3
  If EndRow = 6 Then
    If .Cells(6, Col) * .Cells(EndRow, Col) = 0# Then
      ' Sumproduct does not works on vectors of length = 1
      .Range(.Cells(4, Col), .Cells(EndRow, Col)).Delete (xlShiftToLeft)
      ProjCount = ProjCount - 1
      Col = Col - 1
    Else
      Col = Col - 1
    End If
  Else
    If WorksheetFunction.SumProduct(.Range(.Cells(6, Col), .Cells(EndRow, Col)), _
      .Range(.Cells(6, 3), .Cells(EndRow, 3))) = 0# Then
      .Range(.Cells(4, Col), .Cells(EndRow, Col)).Delete (xlShiftToLeft)
      ProjCount = ProjCount - 1
      Col = Col - 1
    Else
      Col = Col - 1
    End If
  End If
Wend
' And now we are going to make the graphic. First we generate the void
' Rows
Row = 6
EndRow = (.Range("B65536").End(xlUp).Row - Row + 1) * 2 + Row - 1
For Row = 6 To EndRow
  .Rows(Row + 1).Insert
  .Rows(Row).Copy Destination:=.Rows(Row + 1)
  Row = Row + 1
  For Col = 1 To ProjCount
    If .Cells(Row, 3 + Col).Value = 1 Then
      .Cells(Row, 3 + Col).Value = 0
      .Cells(Row - 1, 3 + Col).Formula = .Cells(Row - 1, 3).Formula
    Else
      .Cells(Row - 1, 3 + Col).Value = 0
      .Cells(Row, 3 + Col).Formula = .Cells(Row, 3).Formula
    End If
  Next
Next
CreateChart Sheets("Portfolio Value"), Range(Cells(6, 4), Cells(Row - 1, 3 + ProjCount))
End If
End With
' Sensitivity Analysis
SensitivityAnalysis
' Option Value versus ADL fte
OptionValuePerFTEAnalysis
Sheets("Portfolio Value").Select
Application.EnableEvents = True

End Sub
Sub CopySegmentRow(Sht As Worksheet, Segment As String)

Dim aCellRow As Integer, _
    CellFound As Boolean, _
    EndColumn As Integer, _
    cell As Range

With Sht
  aCellRow = 4
  CellFound = False
  While Not CellFound And Not IsEmpty(.Cells(aCellRow, 5))
    If Trim(Segment) = Trim(.Cells(aCellRow, 5).Value) Then
      CellFound = True
    Else
      aCellRow = aCellRow + 1
    End If
  End While
  .Cells(17, 5).Formula = "=E" & CStr(aCellRow)
End With
```

```
' Now we have to sort tge NPV's for the scenarios, in such a way that
' the scenario with the highest NPV comes first
' this also means adaptation of the Risk-Scenario matrix in the same column
EndColumn = .Range("IV3").End(xlToLeft).Column
.Select
.Cells(17, 5).Copy Destination:=.Range(Cells(17, 6), Cells(17, EndColumn))
For Each cell In .Range(Cells(17, 6), Cells(17, EndColumn))
    With cell
        .Value = VOC(cell.Value)
        .NumberFormat = "##.#"
    End With
Next
SortScenarios
End With
End Sub
Sub CreateChart(ByVal Sht As Worksheet, ByVal Rng As Range)

With Sht
    .ChartObjects.Delete
    .Select

    With .ChartObjects.Add _
        (Left:=50, Width:=500, Top:=ActiveCell.Top + 20, Height:=400)
        .Chart.ChartType = xlBarStacked
    End With
    With .ChartObjects(1).Chart
        .SetSourceData Source:=Range(Rng.Address), PlotBy:=xlRows

        .SeriesCollection(1).XValues = Intersect(Rows(4), Rng.EntireColumn)

        .HasTitle = True
        .ChartTitle.Characters.Text = "Option Value for Segment " & Sheets("Portfolio Value").Cells(2, 3).Value
        .ChartTitle.Font.Size = 10

        .Axes(xlCategory, xlPrimary).HasTitle = True
        .Axes(xlCategory, xlPrimary).AxisTitle.Characters.Text = "Projects"
        .Axes(xlCategory, xlPrimary).AxisTitle.Font.Size = 10

        .Axes(xlCategory).TickLabels.Font.Size = 10

        .Axes(xlValue, xlPrimary).HasTitle = True
        .Axes(xlValue, xlPrimary).AxisTitle.Characters.Text = "Option Value (MEuro)"
        .Axes(xlValue, xlPrimary).AxisTitle.Font.Size = 10

        .HasLegend = False

        For SeriesNr = 2 To Rng.Rows.Count Step 2
            With .SeriesCollection(SeriesNr)
                With .Border
                    .Weight = xlThin
                    .LineStyle = xlNone
                End With
                .Shadow = False
                .InvertIfNegative = False
                .Interior.ColorIndex = xlNone
            End With
        Next
    End With
End With
Application.EnableEvents = True
End Sub

Sub SensitivityAnalysis()

Dim aSht As Worksheet, _
    NrOfDeliverables As Integer, _
    Rw As Integer, _
    OriginalValue As Single, _
    CurrentOptionValue As Single, _
```

```

Col As Integer, _
PortfolioEndColumn As Integer

Application.ScreenUpdating = False

Sheets("Sensitivity Analysis").Range("3:65536").ClearContents
PortfolioEndColumn = Sheets("Portfolio Value").Range("IV4").End(xlToLeft).Column
NrOfDeliverables = 0

For Col = 4 To PortfolioEndColumn
    With Sheets(Sheets("Portfolio Value").Cells(4, Col).Value)
        .Select
        For Rw = 24 To 41
            If Not IsEmpty(.Cells(Rw, 3)) And _
                Not .Cells(Rw, 3).HasFormula Then

                NrOfDeliverables = NrOfDeliverables + 1
                'in order to fill target
                Sheets("Sensitivity Analysis").Cells(NrOfDeliverables + 3, 3).Value = _
                    Trim(.Name) & ": " & CStr(.Cells(Rw, 1).Value) & ", " & CStr(.Cells(Rw, 2).Value)
                OriginalValue = .Cells(Rw, 3).Value
                CurrentOptionValue = SegmentValue()
                ' if it is exactly 0 things go wrong, because the macro thinks it is an empty row
                .Cells(Rw, 3).Value = 0.000001
                Sheets("Sensitivity Analysis").Cells(NrOfDeliverables + 3, 4).Value = SegmentValue()
                Sheets("Sensitivity Analysis").Cells(NrOfDeliverables + 3, 5).Value = CurrentOptionValue - _
                    Sheets("Sensitivity Analysis").Cells(NrOfDeliverables + 3, 4).Value
                .Cells(Rw, 3).Value = 1
                Sheets("Sensitivity Analysis").Cells(NrOfDeliverables + 3, 6).Value = SegmentValue() - CurrentOptionValue
                If Sheets("Sensitivity Analysis").Cells(NrOfDeliverables + 3, 6).Value < 0.01 Then
                    ' if sensitivity is zero remove this row and restore the number of deliverables
                    Sheets("Sensitivity Analysis").Rows(NrOfDeliverables + 3).EntireRow.ClearContents
                    NrOfDeliverables = NrOfDeliverables - 1
                End If
                .Cells(Rw, 3).Value = OriginalValue
            End If
        Next
    End With
Next
Sheets("Sensitivity Analysis").Range("C4:F" & CStr(NrOfDeliverables + 3)).Sort Key1:=Sheets("Sensitivity Analysis").Range("F4"), _
    Order1:=xlAscending, Header:=xlGuess, OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom
CreateBarChart Sheets("Sensitivity Analysis").Range("C4:F" & CStr(NrOfDeliverables + 3))
Application.ScreenUpdating = True

End Sub
Function SegmentValue()

Dim CI As Integer, _
    OptionValueForSegment As Single, _
    EndRowPortfolioAnalysis As Integer, _
    EndColumnPortfolioAnalysis As Integer

With Sheets("Portfolio Value")
    EndRowPortfolioAnalysis = .Range("B65536").End(xlUp).Row
    EndColumnPortfolioAnalysis = .Range("IV6").End(xlToLeft).Column
    SegmentValue = 0
    For CI = 4 To EndColumnPortfolioAnalysis
        SegmentValue = Application.WorksheetFunction.Max(SegmentValue, Application.WorksheetFunction.Sum(.Range(.Cells(6, CI),
            .Cells(EndRowPortfolioAnalysis, CI))))
    Next
End With

End Function

Sub CreateBarChart(Rnge As Range)

With Sheets("Sensitivity Analysis")
    .ChartObjects.Delete
    .Select

```



```
With .ChartObjects.Add _
    (Left:=50, Width:=500, Top:=Cells(2, 2).Top + 20, Height:=400)
    .Chart.ChartType = xlBarStacked
End With
With .ChartObjects(1).Chart
    .SetSourceData Source:=Rnge, PlotBy:=xlColumns
    .Location where:=xlLocationAsObject, Name:="Sensitivity Analysis"
    .HasTitle = True
    .ChartTitle.Characters.Text = "Sensitivity Analysis"

    .Axes(xlCategory, xlPrimary).HasTitle = False
    .Axes(xlValue, xlPrimary).HasTitle = False
    .HasLegend = False
    .HasDataTable = False
    With .Axes(xlCategory).TickLabels
        With .Font
            .Name = "Arial"
            .FontStyle = "Regular"
            .Size = 4
            .Strikethrough = False
            .Superscript = False
            .Subscript = False
            .OutlineFont = False
            .Shadow = False
            .Underline = xlUnderlineStyleNone
            .ColorIndex = xlAutomatic
            .Background = xlAutomatic
        End With
    End With
    With .SeriesCollection(1)
        With .Border
            .Weight = xlThin
            .LineStyle = xlNone
        End With
        .Shadow = False
        .InvertIfNegative = False
        .Interior.ColorIndex = xlNone
    End With
End With
End Sub

Sub OptionValuePerFTEAnalysis()

Dim Rw As Integer, _
    EndColumn As Integer, _
    EndRow As Integer, _
    Cl As Integer

With Sheets("Option Value vs fte")

    .Range("2:65536").ClearContents
    Sheets("Portfolio Value").Rows("2:4").Copy _
        Destination:=.Rows("2:4")

    Sheets("Portfolio Value").Range("B6").CurrentRegion.Copy _
        Destination:=.Range("B4")

    Rw = 7
    While Not IsEmpty(.Cells(Rw, 3))
        .Rows(Rw).EntireRow.Delete
        Rw = Rw + 1
    Wend

    .Rows("5").Insert
    EndRow = .Range("B65536").End(xlUp).Row
    EndColumn = .Range("IV4").End(xlToLeft).Column
    For Cl = 4 To EndColumn
        .Cells(6, Cl) = Application.WorksheetFunction.Sum(.Range(.Cells(7, Cl), .Cells(EndRow, Cl)))
    Next Cl
End With
End Sub
```

```

.Cells(5, Cl) = Sheets(.Cells(4, Cl).Value).Cells(3, 4).Value
Next
CreateScatterGraph .Range(.Cells(5, 4), .Cells(6, EndColumn))

End With
End Sub
Sub CreateScatterGraph(Rng As Range)
'
' Macro1 Macro
' Macro recorded 2008-04-27 by Gal
'
'
With Sheets("Option Value vs fte")
.ChartObjects.Delete
.Select

With .ChartObjects.Add _
(Left:=50, Width:=500, Top:=Cells(2, 2).Top + 20, Height:=400)
.Chart.ChartType = xlXYScatter
End With
With .ChartObjects(1).Chart
.ChartType = xlXYScatter
.SetSourceData Source:=Rng, PlotBy:=xlRows
.Location where:=xlLocationAsObject, Name:="Option Value vs fte"
.HasTitle = True
.ChartTitle.Characters.Text = "Option Value vs. ADL fte"
.Axes(xlCategory, xlPrimary).HasTitle = True
.Axes(xlCategory, xlPrimary).AxisTitle.Characters.Text = "fte"
.Axes(xlValue, xlPrimary).HasTitle = True
.Axes(xlValue, xlPrimary).AxisTitle.Characters.Text = "Option Value"
.Legend.Delete
With .PlotArea
With .Border
.ColorIndex = 16
.Weight = xlThin
.LineStyle = xlContinuous
End With
.Interior.ColorIndex = xlNone
End With
With .Axes(xlValue).MajorGridlines.Border
.ColorIndex = 2
.Weight = xlHairline
.LineStyle = xlContinuous
End With
End With
End With
End Sub

Function VOC(InpStr As String) As Single 'VOC = Value of Call as Single
' Blakes Scholes

' S is the stock price of the underlying stock. If we expect the stock to pay
' specific dividends before the option expires, we should subtract the present
' value of those dividends from the stock price and use this 'adjusted stock
' price' as the relevant input for this equation.
' X is the exercise, or strike, price of the option.
' r is the risk-free rate
' T is the expected life of the option in years.
' Sigma2 is the variance of the underlying security.
' d1 = (ln(S/X) + (r + Sigma2/2) x T)/SqrRoot(T)
' d2 = d1 - SqrRoot(T)
' iStrPart As Integer
' VOC = Value of Call Option
' VOC = S x N(d1) - X x exp(-r x T) x N(d2)
' N(z) = NORMDIST(z,0,1,true) in excel

Dim S As Single, _
X As Single, _

```

```
T As Single, _
Sigma As Single, _
d1 As Single, _
d2 As Single, _
r As Single, _
StrStart As Integer, _
StrEnd As Integer

If InStr(InpStr, "/") = 0 Then
  VOC = CSng(InpStr)
Else
  StrEnd = 1
  For IstrPart = 1 To 4
    StrStart = StrEnd
    StrEnd = InStr(StrStart + 1, InpStr, "/")
    Select Case IstrPart
      Case 1
        S = CSng(Left(InpStr, StrEnd - 1))
      Case 2
        X = CSng(Mid(InpStr, StrStart + 1, StrEnd - StrStart - 1))
      Case 3
        T = CSng(Mid(InpStr, StrStart + 1, StrEnd - StrStart - 1))
      Case 4
        r = CSng(Mid(InpStr, StrStart + 1, StrEnd - StrStart - 1))
    End Select
  Next
  Sigma = CSng(Right(InpStr, Len(InpStr) - StrEnd))
  d1 = (Log(S / X) + (r + Sigma ^ 2 / 2) * T) / (T ^ 0.5)
  d2 = d1 - T ^ 0.5
  VOC = S * WorksheetFunction.NormDist(d1, 0, 1, True) - _
    X * Exp(-r * T) * WorksheetFunction.NormDist(d2, 0, 1, True)
End If

End Function
```

CHAPTER 9 APPENDIX B

STRICTLY CONFIDENTIAL									
Compress On/Off									
Relative Risk Business Case? (also other products)									
Project Name	Ultimo System	Expected Next Milestones	FTE coming 3 months	Expected Market Introduction	Output Scenario 2	Output Scenario 1	Output Scenario 3	Output Scenario 4	Output Scenario 5
Project Number	MS-3		8,5	2011	No LED Commercialization, Hot Flexible, Dimming 50%	No LED Commercialization, Hot Flexible, Dimming 50%	No LED Commercialization, Hot Flexible, Dimming 50%	No LED Commercialization, Hot Flexible, Dimming 50%	LED Commercialization, Hot Flexible, Dimming 50%
					IND Indoor	170,	110,	110,	95,
Responsible	Key Deliverable	Estimated Probability of Success (Current Date)	Estimated Probability of Success (2 months From now)	Impact on product spec, time - to - market, business					
Uncertainties managed within the project									
ADL	System Cost Reduction to 85% compared to reference (Desk+)	80%	65%	Cost level	1	1	1	1	
ADL	Decoupled Operation of lamps	80%	65%	Lowering the cost to develop special lamps for niche applications or regional regions, while keeping the number of businesses	1	1	1	1	
ADL	Hot Flexible at 20% higher system cost	90%	90%	Important for Hospitality & Offices	1		1	1	
ADL	Dimming at 50%	90%	90%		1	1		1	
Uncertainties related to outcomes of other projects in the portfolio									
Uncertainties outside the portfolio									
LED	No Substantial LED penetration in 20-20W CDM market at 2015 (28%)	70%	70%		1	1	1		
					Probability per Scenario	38.3%	4.0%	4.0%	0.4%

CHAPTER 10 APPENDIX C

Microsoft Excel file of the case.