Development of Cost of Delay Model to Prioritise Projects

Master of Science Thesis

PERNILLA LYDÉN

Department of Product and Production Development
Division of Product Development
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2014

Development of Cost of Delay Model to Prioritise Projects

PERNILLA LYDÉN

Department of Product and Production Development
Division of Product Development
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-77 21 000

The Master Thesis was performed in cooperation with SKF

Printed by Reproservice
Gothenburg, Sweden 2014

Abstract

At the Product Development department at SKF, as for many product development companies, there is not always enough resources to run all on-going product development projects with full capacity. In order to decide which projects to prioritise when allocating resources rational facts such as strategic fit, economic benefit, and business risk are used. One problem related to using these parameters when prioritising projects is that the different product development teams have different opinions on how to prioritise the projects. A more consistent parameter would be the economic consequences of the priorities, however, today this is difficult to acquire an overview of. The product development department is in need of a more consistent way of prioritising that is based on economic facts and that everyone can understand and agree with. The purpose of this thesis is to develop a model that calculates the Cost of Delays of product development projects in a way that will optimise the profit of the project portfolio.

In order to get a deeper understanding of project economics and the problems related to prioritising projects a literature study and an empirical study has been performed. Other product development companies have also been contacted in order to investigate how they prioritise projects and if they take the Cost of Delay into consideration. The result of the studies has then been summarised in order to establish a list of specifications, which defines the aimed achievements of the Cost of Delay model. The list of specifications has been used as a base to generate a number of concepts from which the most promising one has been chosen for further development.

The developed Cost of Delay model calculates the changed project profit that a delayed market introduction would cause. The calculations are based on the increased cost that comes with delaying a project in relation to what initially was planned. The model is designed so that it will be easy to use in the daily work and the outcome is easy to overview. The outcome of the model for different projects will be gathered in one document in order to enable comparison of the projects' Cost of Delay and the result will, together with the project parameters used today, enable the company to prioritise the projects.

Keywords: *cost of delay, project prioritisation, product development projects, managing multiple projects*

Acknowledgements

This master thesis has been carried out at the department of Product and Production Development, Division of Product Development at Chalmers University of Technology in cooperation with SKF AB.

First, I would like to gratefully thank my supervisor Göran Lindsten and the initiator of this thesis Paolo Andolfi for providing the opportunity to carry out this master thesis within the Product Development department at SKF. I would like to thank them and my supervisor and examiner at Chalmers University of Technology Dr. Erik Hulthén for the provided guidance and feedback along the project.

Further, I would like to express my most sincere gratitude to the employees at SKF who allowed me to ask questions and contributed with valuable information and thoughts that led to a deeper understanding of the subject area of this thesis.

Last, I would like to thank the participating companies in the study of how other companies prioritise product development projects:

- GKN Aerospace Engine Systems
- Volvo Cars
- Svenska Cellulosa AB SCA
- Modul-System HH AB
- Aros Electronics AB
- KG Spennare AB
- Value Model

Gothenburg, August 2014

Pernilla Lydén

Table of Contents

Appendix

1. Introduction

This chapter provides a background to the master thesis, a description of the problem, and an introduction of the concept of Cost of Delay. The purpose, objective, and the actors and stakeholders of the thesis are also presented, as well as the research questions and delimitations.

1.1 Background

SKF is a Swedish company that has offered technical solutions ever since it was founded in 1907. The first product that the company was producing was a double row ball bearing. SKF is today a global company that offers bearings and units, seals, mechatronics, services, and lubrication systems (SKF, 2014).

At the department Product Development of the Industrial Market business area at SKF in Gothenburg different product development teams are working with a number of product development projects simultaneously. It is not unusual that the projects share resources and activities, which requires coordination and prioritisation of projects. In 2008, Lean product development was introduced to the Product Development department. The introduction of Lean involved a Lean room where the planned projects are listed, where from six projects are chosen, which the organisation is ready to start working with simultaneously. This number of projects to work with simultaneously is the most profitable amount because there are usually three persons working on each project and there are in total around 18 developers at the department. These six projects are the on-going projects that are listed in a prioritised order. The prioritisation is based on rational facts such as strategic fit, economic benefit, and business risk. The product development teams have continuous meetings in the Lean room to coordinate the projects and the related activities. The use of Lean product development has lead to a more structured way of working and a better overview of the on-going projects and the allocated resources.

1.2 Problem formulation

One problem related to the prioritisation of product development projects is that the teams have different opinions on how to prioritise the projects when it comes to sharing resources. The project parameters that are used to prioritise the projects today are rather speculative, which easily leads to disagreements between the teams. A more consistent parameter would be the economic consequences of the priorities, however, today this is difficult to acquire an overview of. The product development department is in need of a more consistent way of prioritising, which is based on economic facts and that everyone can understand and agree with.

1.3 Definition of Cost of Delay (CoD)

The Cost of Delay (CoD) is the consequences in terms of cost and lack of income for not completing a specific work on time (Lean for Change, 2012). For manufacturing these costs are homogeneous as they have predictable and repetitive flow (Reinertsen, 2009, pp. 2). For product development the CoD for projects differ as they have high variability, nonrepetitive, and nonhomogeneous flow. The CoD within product development can take the form of higher project costs due to a longer development time, lost sales during the delay, and in some cases lost market shares during the product's life cycle due to that competitors have had time to introduce competing products to the market earlier (The Newredo Blog, 2013). Using the CoD within decision-making when prioritising product development projects will highlight economic consequences, avoid conflicts due to different opinions, and speed up planning.

1.4 Purpose

The purpose of the thesis is to develop a calculation model that uses few variables to calculate the CoD of product development projects. The model will be used to prioritise product development projects and is aimed to create a shared understanding between the different development teams of how to prioritise projects and to optimise the profit of the project portfolio.

1.5 Actors and stakeholder

The owner of the calculation model of CoD will be the organisation that wants the model to be used in order to optimise the profit of the project portfolio for self-aligning bearings. The end-user of the model is mainly going to be the decision maker, who is the project manager. The decision maker will use the model together with other parameters when prioritising projects. The team that is going to develop the model is going to consist of the author of the thesis, the supervisor of the thesis, Göran Lindsten, and other employees at SKF who will contribute to the progress of the thesis. It is important that all team members are getting something out of being involved in the work, such as professional development and taking part of the result for instance.

The use of the model will in first hand affect the product development teams in terms of the project prioritising procedure where the aim is to achieve a shared understanding of how the projects will be treated. Other departments within the organisation might also be affected by the use of the model. Departments like Market, Business Development, Sales, and Manufacturing that are also part of the projects and planning these together with product development. Activities within the organisation that might also be affected are testing and prototyping. These activities possesses parts of the resources that are allocated among the projects, when a consistent way of prioritising is used it might be easier for them to plan the activities.

When basing the decisions partly on economic factors it might be easier for the finance department to forecast and calculate expected profit. This will motivate the department to provide the economic information needed for the model. Finally, the customer of the model will together with the organisation get a shared understanding of how their project will be treated.

1.6 Research questions

The five following research questions have been formulated for the thesis. The questions covers the areas of the principle of CoD, how the model of CoD should be designed and how other companies prioritise product development projects.

1. *Why should the product development department base their decisions on CoD when prioritising projects?*

2. *What economic factor has the largest influence on the CoD?*

3. *How should the model be designed to be user friendly and how should the outcome of the model be presented to be as understandable as possible?*

4. *Which is the most profitable way of working, with one project at a time or with several projects in parallel?*

5. *How does other companies prioritise product development projects?*

1.7 Delimitations

The focus of the thesis will be on the department Product Development of the Industrial Market business area at SKF in Gothenburg. Focusing on this department will be enough to verify the performance of the model of CoD.

The model is not going to take all possible cost variables into account, only the two to three variables that have the largest influence. This is to keep it simple enough to make the model easy to use in daily operations. The model is only going to be applicable on external product development projects that are aimed for customers, not on internal projects.

The model should require software that is commonly used, this in order to make it possible for anyone who might need the model within the organisation to use it.

2. Theoretical framework

This chapter provides the theoretical framework for the thesis that has been used as a base when summarising the empirical findings, developing the model of CoD, and analysing the result. The framework covers the areas of Technical Readiness Level (TRL), product development flow, product development economics, and how to calculate the CoD.

2.1 Technical Readiness Level (TRL)

In the 1980's the National Aeronautics and Space Administration (NASA) developed a measurement system called Technical Readiness Level (TRL) to assess the maturity level of evolving technology (Boardmansauser, 2006). The measurement system consists of nine Technical Readiness Levels (TRLs) where each TRL corresponds to a certain maturity level (NASA, 2012). Each TRL has a number of parameters that the technology projects are evaluated against in order to assign the right TRL depending on the project's progress. The nine TRLs are shown in figure 1. Since the 1980's this measurement system has been used by other organisations, which have adapted it to their own technology area. (Boardmansauser, 2006).

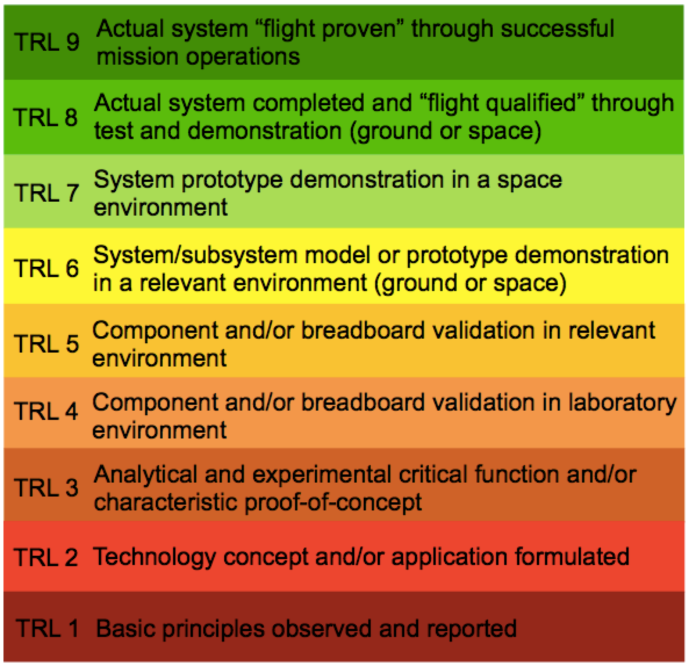


Figure 1 The nine different Technical Readiness Levels at NASA (NASA, 2012).

2.2 Product development flow

This section covers areas related to how to create product development flow. The subject areas portfolio management, problems related to managing multiple projects, capacity utilisation, and sequencing work are presented.

2.2.1 Portfolio management

The product portfolio is the constellation of intended, on-going, and recently ended product development projects (Ulla Sebestyén, 2006, pp. 144). The product portfolio helps the management to allocate resources and plan the projects in relation to each other. When having a larger number of viable projects than the organisation has capacity for to work with simultaneously these have to be prioritised. The prioritisation tells what projects to put resources on and when to do it. In order for the organisation to prioritise the projects a number of key project parameters is defined (Ulla Sebestyén, 2006, pp. 147). What parameters to use depend on the organisation, project, and products' conditions, but three parameters that should be included are strategic fit, business risk, and economic benefit.

By creating a table (see table 1) where the projects in the project portfolio and short information about them are listed together with the key parameters, the projects can be graded how well they fulfil these (Ulla Sebestyén, 2006, pp. 153). The table enables to compare the projects within the project portfolio with each other and to prioritise them.

Table 1 Project portfolio of on-going and queuing projects (Ulla Sebestyén, 2006, pp. 153).

	Parameter			Information		
Project	Strategic fit	Business risk	Economic benefit	Status	Start date	End date
A	Medium	Low	High	Queuing	January 2015	March 2017
B	High	High	Medium	On going	May 2014	October 2015
C	Low	High	High	On going	March 2013	February 2015

2.2.2 Problems related to managing multiple projects

It is common that organisations have a simultaneous project setting when structuring their operations today (Engwall & Jerbrant, 2003). Reasons for why organisations choose to work this way are a more competitive business environment, limited resources, and narrowing windows of opportunities (James & Lowell, 2002).

There are several problems related to managing multiple projects. Based on a study performed by Engwall and Jerbrant where two cases were studied, both managed multiple projects simultaneously, these were some of the identified problems:

- Re-allocation of resources were made on a daily basis
- There was a continuous discussion about which projects to allocate available resources to
- If one project was delayed it affected several other projects negatively
- Short term-problem solving was common
- There were competition for limited resources among project managers

However, there are also advantages that come with structuring the operations this way (James & Lowell, 2002). One example is that the uneven intensity as projects usually have does not have that major impact on the efficiency as the developers can alternate between the projects depending on which project that has high intensity at the moment.

2.2.3 Capacity utilisation

The capacity of how much work during a certain period of time an organisation is capable of has an upper limit (Ulla Sebestyén, 2006, pp. 144). If the organisation choose to only use parts of its capacity it will lead to that the personnel gets underemployed and the organisation will get a lower profit than what is possible. If the organisation on the other hand choose to overload its capacity it will lead to that the employees is forced to work with several projects at the same time, which leads to a larger number of setup times and longer setup times. This leads to both increased lead times and cycle times, which results in a lower profit and project delays.

2.2.4 Sequencing work

By estimating the CoD for projects and the task duration for product development operations the most profitable way of sequencing the work can be scheduled (Reinertsen, 2009, pp. 191-195). There are three different cases that are the most common ones for how the CoD and the task duration are distributed for the projects. There is one principle that is appropriate to apply on each case respectively, which are described in the following sections.

Shortest Job First (SJF)

In cases where the product development projects have the same CoD but different duration for a certain operation it is preferable to do the shortest job first (SJF) (Reinertsen, 2009). One example of this is visualised in figure 2. The figure shows the work sequence for three projects with the same CoD but different durations, where the red area represent the CoD. The chart to the left in figure 2 depicts an A-B-C sequence, where Project A does not cause any delay cost, Project B cause a delay cost while waiting for Project A, and Project C cause a delay cost while waiting for both Project A and B. In the chart to the right in figure 2 the opposite sequence is depicted, a C-B-A sequence, which means the longest job first. As the red area in the figure shows, this results in a much higher CoD.

Project	Duration	CoD
A	1	3
B	3	3
C	10	3

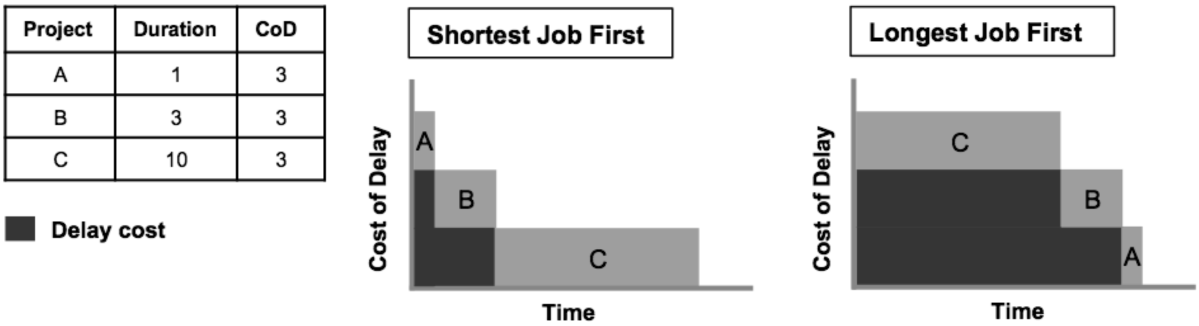


Figure 2 How to sequence the work when the projects have different duration but the same CoD (Reinertsen, 2009, pp. 193).

High Delay Cost First (HDCF)

In cases where the product development projects have different CoD but the same durations for a certain operation it is preferable to do the high delay cost first (HDCF) (Reinertsen, 2009). By delaying the projects with low CoD, the total CoD will be lower than in the opposite case, this is visualised in figure 3.

Project	Duration	CoD
A	3	10
B	3	3
C	3	1

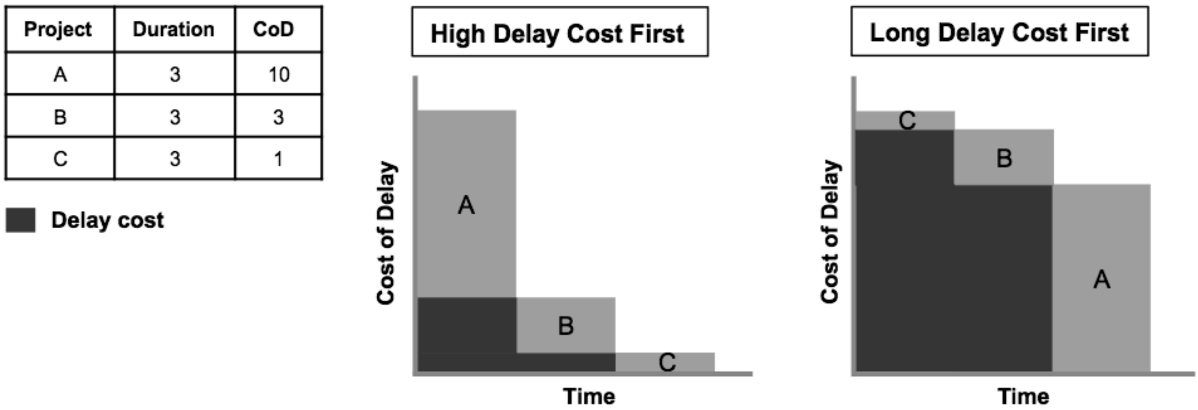


Figure 3 How to sequence the work when the projects have the same duration but different CoD (Reinertsen, 2009, pp. 194).

Weighted Shortest Job First (WSJF)

In those cases where the product development projects have both different CoD and duration for a certain operation it is preferable to do the weighted shortest job first (WSJF) (Reinertsen, 2009). The weighting is calculated by dividing the CoD with the duration, which the priority is made after, see figure 4.

Project	Duration	CoD	Weight = CoD/Duration
A	1	10	10
B	3	3	1
C	10	1	0,1

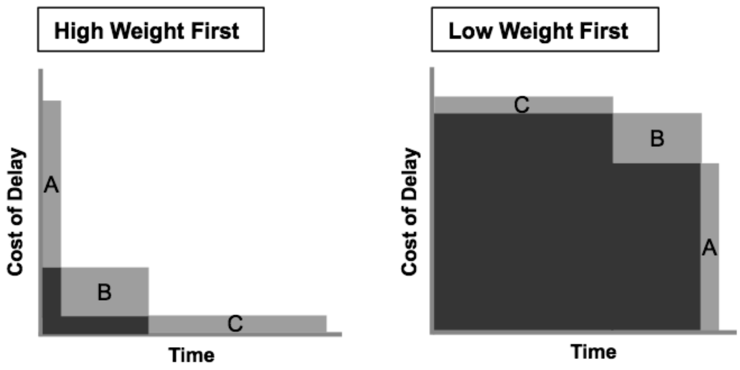


Figure 4 How to sequence the work when the projects have both different duration and CoD (Reinertsen, 2009, pp. 195).

2.3 Product development economics

This section presents the product development economic principles used within the thesis. These are the principles of design-in-process (DIP), sunk cost, and time-to-market (TTM).

2.3.1 Design-in-Process (DIP)

In manufacturing the term work-in-process (WIP) inventory is usually used, which is the inventory of partially finished goods in the production process waiting for completion (Accounting Tools, 2013). Within product development the analogy term for this is design-in-process (DIP), with the difference that it refers to partially finished product development project instead of goods (Reinertsen, 2009, pp. 55). The largest difference between goods and product development project is that goods are physically objects while product development projects are information and virtually invisible. This makes it difficult to know the exact amount of DIP inventory, why product developers are usually blind to it and do not realise that it is a problem. One of the largest problems that occur when DIP is high is that cycle times are long and can lead to that competitors are ahead when it comes to reach the market.

The cost of WIP and DIP

To calculate the cost of WIP the amount of WIP inventory can be calculated in order to multiply this with the cost of material, labor, and machine and overhead per unit (Accounting Tools, 2013). A less time-consuming way is to assign a standard cost to the percentage completion of the goods. The same principle can be used to calculate the cost of DIP by assigning a standard cost to the percentage completion of a product development project.

2.3.2 Sunk cost

A cost that has already been incurred and cannot be recovered is called sunk cost in business decision-making (Ulrich & Eppinger, 2012, pp. 375). These costs are irreversible outflows and cannot be affected in any way. Sunk costs should not be included in an economic choice when it comes to decisions whether a not completed project should continue or if a new project should be started (Reinertsen, 2009, pp. 46-47). The decision should rather be based on which of the two projects will give the highest return on the remaining investment for each of the projects.

2.3.3 Time-to-market (TTM)

The importance of time-to-market (TTM) for a product differs depending on what type of product it is (Smith & Reinertsen, 1998, pp. 7-8). If there is a radical innovation time-to-market can be important in order to be ahead of competition. Being ahead of competition can result in larger market share, higher profit margins until competition keeps up, and of course a competitive advantage. If there on the other hand is an incremental innovation an early introduction may not be as important when it comes to competitive advantage but it can lead to increased sales and an extended product sales life.

A late introduction can in both cases result in a shorter product sales life and a decreased market share, see figure 5.

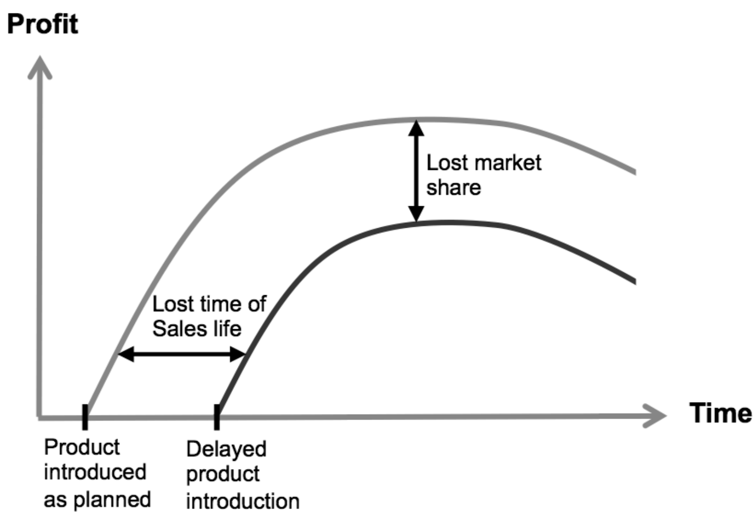


Figure 5 The two different types of losses that a delayed product introduction might lead to.

2.4 How to calculate the CoD

Theory suggests a limited number of methods on how to calculate the CoD for product development projects. This section presents two different methods that are most suitable for the industry that SKF operates in.

2.4.1 Sensitivity analysis with respect to market introduction date

When using this method a baseline model, also called a Business Case, see figure 6, is used as a base (Smith & Reinertsen, 1998, pp. 25-28). The baseline model is usually created in the very beginning of a product development project and shows the expected profit of the project during its life cycle or over a ten-year period. The profit is the result of all activities, from project costs during the development time, product costs to produce the product, to sales data including sales price and unit sales.

Baseline Product Profit Model	Year							
	0	1	2	3	4	5	6	7
Sales price [Euro]			7033	6330	5697	5127	4614	4153
Market size [units]			10000	20000	40000	60000	40000	20000
Market share			10%	10%	10%	10%	10%	10%
Unit sales			1000	2000	4000	6000	4000	2000
Euro sales			7033000	12660000	22788000	30762000	18456000	8306000
Unit cost [Euro]			3516	3446	3377	3309	3243	3178
Cost of goods sold [Euro]			3516000	6892000	13508000	19854000	12972000	6356000
Gross margin [Euro]			3517000	5768000	9280000	10908000	5484000	1950000
Gross margin			50%	45,60%	40,70%	35,50%	29,70%	23,50%
Engineering [Euro]	2000000	2000000	1000000	100000	100000	100000	100000	100000
Marketing [Euro]			1125280	2025504	3645907	4921975	2935185	1328933
General & Administrative [Euro]			351650	632970	1139346	1538117	922870	415292
Operating expense [Euro]	2000000	2000000	2476930	2758474	4885253	6560092	3976055	1844225
Profit before tax (PBT) [Euro]	-2000000	-2000000	1040070	3009566	4394601	4346864	1509164	105237
Cumulative PBT [Euro]	-2000000	-4000000	-2959930	49636	4444237	8791101	10300265	10405502
Returns of sales (PBT/Euro sales)			14,80%	23,80%	19,30%	14,10%	8,20%	1,30%
Cumulative sales [Euro]			100004900					
Cumulative gross margin [Euro]			36906531					
Cumulative PBT [Euro]			10406502	Baseline				
Average percent gross margin			36,90%					
Average percent return on sales			10,40%					

Figure 6 Baseline product profit model for the project's life cycle. The cumulative profit is marked in red (Smith & Reinertsen, 1998, pp. 27).

A sensitivity analysis is performed by creating variations in the baseline model that that will be the result of a postponed market introduction date (Smith & Reinertsen, 1998, pp. 28-34). How the variations will take form depends on the type of product. The three most usual cases are:

- The product is inelastic and has small competition where a delayed product introduction would not decrease the unit sales but instead create a pent-up demand that will even up the profit, see figure 7. In this case the CoD will take the form of a shorter product sales life.

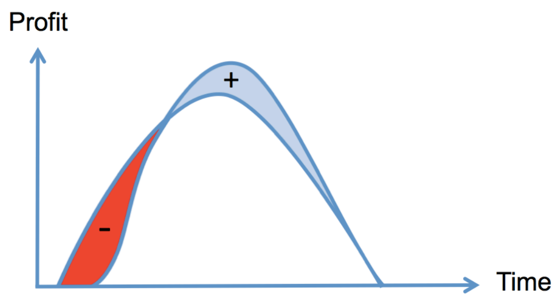


Figure 7 The changed profit due to a delay for a product with little competition. The area between the sales curves for the two scenarios marked with a minus is the sales loss, while the area marked with a plus is the sales due to a pent-up demand (Smith & Reinertsen, 1998, pp. 34).

- The marketplace determines the peak in market demand and not the product introduction. The sales curve will remain the same shape if the product introduction is delayed but downscaled and thus lead to a smaller sales peak, see figure 8. Example of a product group that this applies to is electrical devices such as mobile phones and computers.

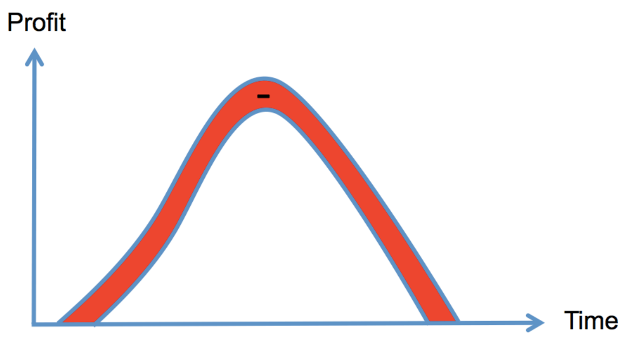


Figure 8 The changed profit due to a delay where the marketplace determines the peak in market. The area between the sales curves for the two scenarios marked with a minus is the sales loss (Smith & Reinertsen, 1998, pp. 34).

- A third case is markets where the company that is first out on the market with a product gets most market shares and it is difficult for competitors to gain these. In this case a late product introduction will result in high CoD in terms of lost sales, see figure 9. One example of a product group that this applies to is medical devices.

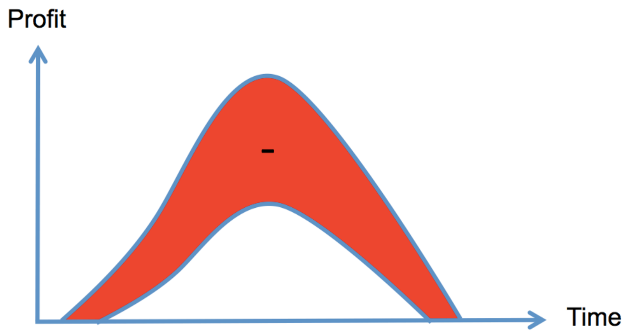


Figure 9 The changed profit cased by a delay where the Company first out on the market gets most market shares. The area between the sales curves for the two scenarios marked with a minus is the sales loss (Smith & Reinertsen, 1998, pp. 34).

By making realistic changes of the market share and unit sales in the baseline model that will occur for the current product because of a postponed market introduction date, changes in the total profit will show. One example is shown in figure 10 where the changes caused by a project delay corresponding to figure 8 are marked in red.

Baseline Product Profit Model	Year							
	0	1	2	3	4	5	6	7
Sales price [Euro]			7033	6330	5697	5127	4614	4153
Market size [units]			10000	20000	40000	60000	40000	20000
Market share			3%	8%	9%	9%	9%	9%
Unit sales			300	1600	3600	5400	3600	1800
Euro sales			2109900	10128000	20509200	27685800	16610400	7475400
Unit cost [Euro]			3516	3446	3377	3309	3243	3178
Cost of goods sold [Euro]			1054800	5513600	12157200	17868600	11674800	5720400
Gross margin [Euro]			1055100	4614400	8352000	9817200	4935600	1755000
Gross margin			50%	45,60%	40,70%	35,50%	29,70%	23,50%
Engineering [Euro]	2000000	2000000	1000000	100000	100000	100000	100000	100000
Marketing [Euro]			337584	1620403	3281316	4429777	2657866	1196040
General & Administrative [Euro]			105495	506376	1025411	1384305	830583	373762
Operating expense [Euro]	2000000	2000000	1443079	2226779	4406728	5914083	3588450	1669802
Profit before tax (PBT) [Euro]	-2000000	-2000000	-387979	2387653	3945141	3902177	1348248	84713
Cumulative PBT [Euro]	-2000000	-4000000	-4387979	-2000326	1944815	5846992	7195240	7279953
Returns of sales (PBT/Euro sales)			-18,40%	23,80%	19,20%	14,10%	8,10%	1,10%
Cumulative sales [Euro]			84518670					
Cumulative gross margin [Euro]			30528874					
Cumulative PBT [Euro]			7279953	Lower profit				
Average percent gross margin			36,10%					
Average percent return on sales			8,60%					

Figure 10 Changes in the baseline product profit model due to a delayed introduction (Smith & Reinertsen, 1998, pp. 33).

By creating other variations in the baseline model sensitivity analyses can be performed for other project parameters as well (Smith & Reinertsen, 1998, pp. 23). There are four key parameters that usually have impact on the project profit, where market introduction date is one, the other three parameters are product unit cost, product performance, and development project expense, see figure 11.

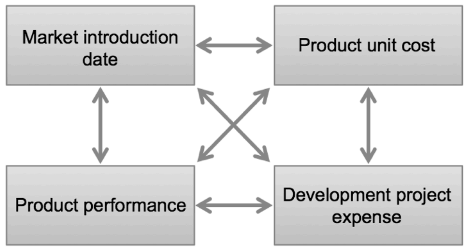


Figure 11 Four key parameters having influence on the project profit (Smith & Reinertsen, 1998, pp. 23).

By analysing how these project parameters influence the project profit decision rules can be created to use when making trade-offs between the parameters (Smith & Reinertsen, 1998, pp. 34-37). These decision rules can be created by scale down the parameter's total impact on the project life cycle profit to more manageable values. Example of values for the four different project parameters is:

Market introduction date	500 Euro = 1 month introduction delay
Product unit cost	100 Euro = 1 % product cost overrun
Product performance	200 Euro = 1 % performance shortfall
Development project expense	50 Euro = 1 % expense overrun

By formulating an equation using these decision rules as coefficients the product life cycle profit can be calculated for changes in the parameters. The equation can be approximated as linear as only smaller changes will be made in the baseline model.

2.4.2 Long product life

In markets where the technology change slowly and the products have lives that extend over decades the sales far into the future has little impact on the CoD (Smith & Reinertsen, 1998, pp. 38). By looking at an extreme case where the product has an infinite life the sales curves for the two scenarios where the first one is if the product is introduced as planned and the other one if the product introduction is delayed, will eventually converge. In this case the CoD will only consist of the lost sales before the two curves converges, which can be approximated as the area of a parallelogram (see figure 12).

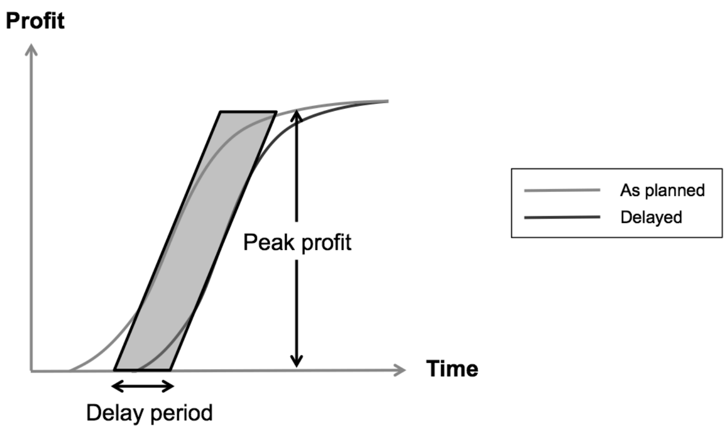


Figure 12 The CoD for products with long sales life can be approximated as the area of a parallelogram (Smith & Reinertsen, 1998, pp. 39).

3. Methodology

In this chapter the methodology used during the project process is presented. The different phases of the process are visualised in figure 13. Each phase is described in the following sections.

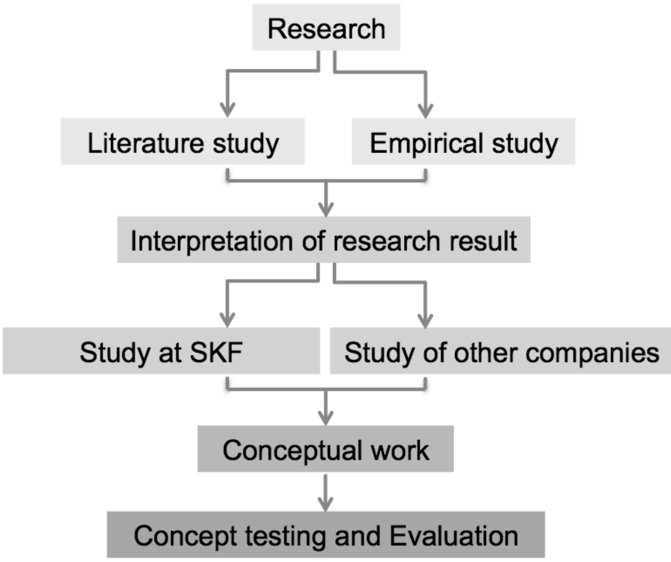


Figure 13 The different phases of the process for the thesis work.

3.1 Research approach

For this project a qualitative research approach has been applied. A qualitative approach means that the collected data consists of words rather than quantified data (Bryman & Bell, 2011). This approach was suitable as the purpose of the research was to study how the prioritisation of product development project is performed at SKF today and problems related to this, how they manage the project economics at SKF, and how other companies prioritise projects. The theory related to the study has been generated through an inductive approach, which means that the theory is generated based on the result of the qualitative research (Bryman & Bell, 2011). How the research has been carried out is described in the following sections.

3.2 Literature study

In order to acquire a deeper insight into the theory related to the thesis subject a literature study was carried out. The individual subjects were chosen based on the collected data in the qualitative research in order to achieve a deeper understanding for the result of it. Theory was studied within the areas product development flow, product development economics, and methods on how to calculate the CoD. Based on the collected data in the qualitative research different theories were tested and evaluated to determine what theory was relevant in this case. The literature study was performed using literature, reports, articles, and the Internet.

3.3 Empirical study

The main purpose of the empirical study was to acquire a deeper understanding of the organisation at SKF that is related to product development projects and to find out about the employees opinion about it. Another part of the empirical study was to investigate how other companies prioritise projects. How these two studies were performed is described in the following sections.

3.3.1 Study of how the prioritisation of projects is performed at SKF today

One-to-one interviews were conducted with employees at SKF in Gothenburg. The interviewees were employees within different departments that in some way are affected by the prioritisation of product development projects. These departments were Business Development, Market, Sales, Technical Sales, Product Development, and Product Engineering. The purpose of conducting these interviews were to collect qualitative data to acquire a deeper insight into how the work is structured today, their thoughts around the problem of prioritising projects, and the developers' opinions of how they would prefer to work with the model of CoD. The interviews were semi-structured, which means that an interview guide was used to guarantee that certain topics were covered but the order and formulation of the questions might varied (Bryman & Bell, 2011). The interviews lasted for 30 to 60 minutes and the interview guides used were designed for each department in order to get as much information out of the interviews as possible. The interview guides for the different departments are seen in Appendix I-VI. All interviews except for one were conducted face-to-face and was audio recorded and transcribed. The one that was not conducted face-to-face were conducted through email contact. The collected data from the interviews was later used to create a list of specifications for the CoD model, see Section 3.4.

3.3.2 Study of how other companies prioritise projects

Other companies were contacted in order to investigate how they prioritise product development projects and if they take the CoD into consideration. The purpose of this study was to collect qualitative data to be able to answer the research question about how other companies prioritise projects. A number of companies were contacted to which the following questions were submitted:

- How do you prioritise product development projects in the daily work when it comes to allocate shared resources among the projects?

- Are you taking the *Cost of Delay* of projects into consideration when prioritising projects in the daily work?

Different companies were contacted through two different approaches. The first one was by using Wingquist Laboratory VINN Excellence Centre, which is collaboration between Chalmers University of Technology and a number of Swedish technology driven companies. The second approach was by personally sending emails to previously known contact persons at different companies. The following companies were contacted:

- GKN Aerospace Engine Systems
- Volvo Cars
- Svenska Cellulosa AB SCA
- Modul-System HH AB
- Aros Electronics AB
- KG Spennare AB
- Value Model

3.3.3 Ethical considerations

With respect to all participants within the empirical study ethical considerations have been made. These considerations have been in form of that all involved parties have received a short introduction of the purpose of the thesis and have had the option to decline. All participants are anonymous to ensure that no harm or invasion of privacy is made.

3.4 Interpretation of research result

The research result from the empirical study was interpreted and summarised using different types of methods. An affinity diagram (Shah, 1998) was created based on the interview transcripts from the empirical study. Searching for relevant comments and statements, which then are divided into suitable themes, creates an affinity diagram. By using this method, the most important and relevant information was identified and highlighted. A summary of the current situation relating project prioritisation at SKF was written based on this diagram.

The result of the affinity diagram was then together with the initiator's requirements used to create a list of specifications for the model of CoD. A list of specifications defines the aimed achievements of the end result by translating the customer needs into requirements and wishes (Ulrich & Eppinger, 2012). Requirements are criteria for what the end result has to fulfil, and wishes criteria for what is desirable that the end result fulfil. Some parts of the result from the empirical study had to be translated into more technical definitions while some parts could be used directly.

3.5 Conceptual work

Once a deeper understanding of the problem and conclusions had been made based on the result from the research study, the conceptual work of the model of CoD began. The process for the conceptual work was divided into three main phases: generation of concepts, evaluation and selection of concept, and prototyping and concept testing.

3.5.1 Generation of concepts

The concept generation started with brainstorming, both individually and together with the supervisor, Göran Lindsten, and the initiator, Paulo Andolfi at SKF. By conducting brainstorming sessions in different constellations all possible ideas for concepts came to surface. A number of different sub-solutions were sketched up and discussed. In order to structure the different sub-solutions a Morphological matrix was created (Zwicky, 1969). A Morphological matrix is used to structure sub-solutions by categorising them into which sub-function each of them belongs to. By creating a Morphological matrix different concept combinations can be created in a systematic way.

3.5.2 Evaluation and selection of concept

The generated concepts were then evaluated and narrowed down using two different types of concept selection matrices: elimination matrix and Pugh selection matrix. By first using an elimination matrix the concepts were evaluated in terms of if they fulfilled the specifications (see Section 3.4) for the end result or not (Pahl & Beitz, 1995). The concepts that did not fulfil the requirements were removed from the process. By then using a Pugh selection matrix to evaluate if the remaining concepts fulfilled the wishes for the end result, the concept that fulfilled most of these was kept in the process (Pugh, 1990).

3.5.3 Prototyping and concept testing

The remaining concept, generated during the conceptual work, was tested iteratively in a way similar to a design-build-test cycle to avoid functional gaps in the model (Wheelwright & Clark, 1992, pp. 223-226). By developing the model of CoD in this way, the design was refined continuously, based on the verifications of the models performances and the end-users opinion. The final model was created in an Excel spread sheet and was applied on an example project in order to verify the working mode of it.

4. Empirical findings

This chapter includes a summary of the result of the empirical study. First, the result of the study of how the prioritisation of product development projects is performed at SKF is presented. Second, the result of how other companies prioritise projects is summarised.

4.1 Study of how the prioritisation of projects is performed at SKF today

The result of the study of how the prioritisation of product development projects is performed at SKF is divided into a number of categories to make it easier to overview. These categories are mainly based on to which question the statements are answers to. The transcripts of the interviews are not included in the report due to confidentiality reasons.

4.1.1 How the work is structured today

At SKF the Technical Readiness Level (TRL) (NASA, 2012) has been used as an inspiration source to label the maturity level of their technology. The overall distribution of the different levels from one to nine is shown in figure 14.

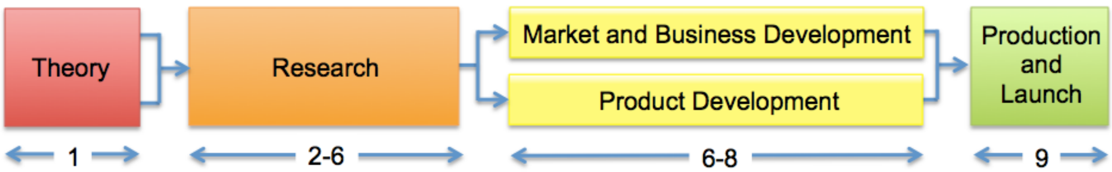


Figure 14 The nine different Technical Readiness Level's at SKF.

In the first level the technology only consist of theory. At level two to six the technology is in the research and development stage, this means that there is no specific product at this stage the focus is rather on technology. Level six to eight consist of two parallel processes, one for Market and Business Development, and one for Product Development. These two processes has a dialogue with level one to six why level six overlap these activities. How the process looks like in more detail for Product Development is shown in figure 15. At level nine it is time to start producing and launch the product.

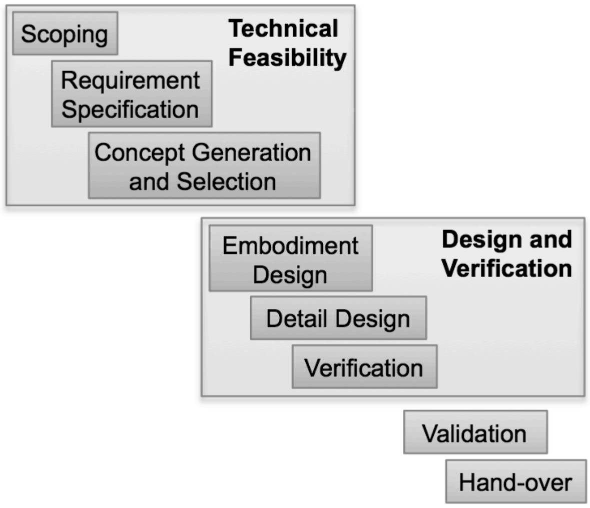


Figure 15 The product development process at SKF.

When deciding which ideas to start up projects for a Business idea evaluation is done for the ideas before they enter the Product Development process. The Business idea evaluation is done using a template created in an Excel document where the idea is graded for each of the following criteria:

- Customer need
- Business potential
- Cost to develop
- Organisational feasibility
- Strategic alignment
- Probability of technical success
- Fit to SKF capabilities

If the idea achieves a high enough grading in the Business idea evaluation, a project is started based on the idea for which a Business Case evaluation is done. This is also done using a template created in an Excel document where the project is graded for each of the following criteria:

- Customer & market match
- Value for SKF
- Speed
- Organisational feasibility
- Strategic alignment
- Probability of technical success
- Fit to SKF capabilities

The projects that are evaluated as valuable to work with are then prioritised in an order. The prioritisation is primarily based on how well the projects fulfil the parameters strategic fit, business risk, and economic benefit, as suggested by Ulla Sebestyén (2006). From these projects six ones are chosen to work with simultaneously.

4.1.2 Interaction between the different departments

The Product Development department is a central organisation and receives requests from different directions within the product line Self-aligning bearings, see figure 16.

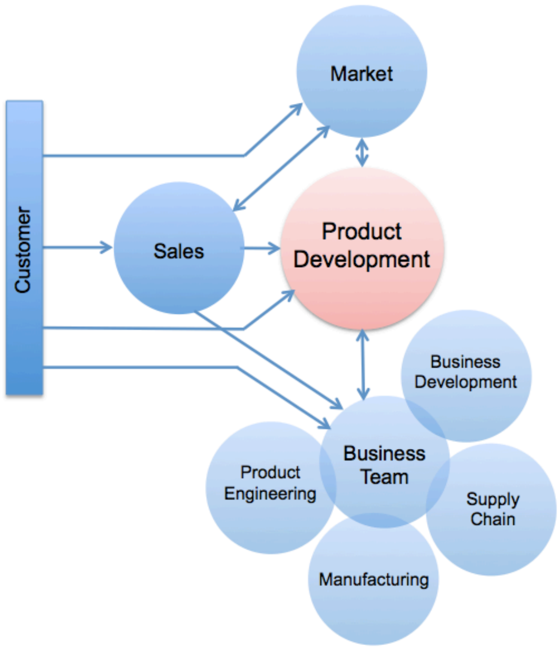


Figure 16 The figure shows from which directions the Product Development department receives requests.

The requests can come directly from the customer, or they can come from the Market department, Sales department, or from Business Development and Manufacturing sites all over the world. Product development projects can also appear based on that the developers see a gap in the product line.

The customer also sends requests to different departments at SKF in Gothenburg, depending on the type of request. SKF Gothenburg has a business team that is a cross-functional team with representatives from Business Development, Supply Chain, Manufacturing, and Product Technology. Product Technology is the representative for Product Development and is responsible of designing variants of bearings based on design rules developed by the Product Development department. The business team has regular meetings where they discuss which requests to undertake and in which order.

The department with most contact with the customer is the Sales department. They receive requests from the customer but are also looking for new business opportunities for which they send requests both to the Market department, Product Development department, and Business Development departments.

The Market department receive requests direct from the customer and are also looking for new business opportunities together with the Sales department. When working with New Market Offerings (NMO) and New Customised Offerings (NCO) the Market and the Product Development department have a close collaboration (see Section 4.1.1).

4.1.3 How projects are prioritised today

When prioritising which projects to work with there are a number of parameters that the different departments take into consideration, the ones mentioned are the most usual ones were:

- Strategic alignment
- Balance long-term projects with smaller cases
- Gap in the product line
- Many inquiries
- Level of urgency
- How well the Business Case is substantiated
- Achievability
- Resource availability
- Critical Customer Complaint
- Technologically edge compared to the competition
- Manufacturability

4.1.4 Trade-offs between project parameters

When developing products there are almost always trade-off's that has to be done between different project parameters (Smith & Reinertsen, 1998, pp. 23). The project parameters that most of the interviewed SKF employees mentioned usually contradict with each other were product performance and product unit cost. One employee stated:

"Cost and performance almost always collide, often it is a high pressure on lowering the product cost while increasing the product performance. After all, it is mature products that we provide where it is hard to argue that one can raise the product price."

4.1.5 How the prioritisation of projects affects other departments and opinions on project delay

A common opinion among the employees at other departments than the product development department at SKF was that they experience that it is difficult to get resources dedicated to the projects they work with. One employee stated:

"You do not get a budget for the project you are working with and it has no resources dedicated, it is up to you to ensure that you get priority at the product development department."

One reason for this is that the employees at the Product Development department have different special skills with limited resources at each area of competence. The fact that there are limited resources at the product development department can be one factor that may leads to project delays. One employee mentioned another factor:

"Delays may be due to the complexity of the project or if the product is a new or uncertain solution."

Another common opinion was concerning the importance of time-to-market. That the customer has become more demanding regarding fast answers and deliveries and that they are turning to competitors if they do not get this. Two employees stated:

”We need to be faster when it comes to provide price information to the customer, today we are much slower than the competition.”

“We must put up a target image, we may not need to reach the target image, perhaps it is more important that we are 80 % right and 100 % on time. We can always do a little bit better, and for each month and day we lose business opportunities and money.”

4.1.6 Numbers of projects at a time

A common answer to the question about how many projects one person work with simultaneously at the different departments was two to three projects, one employee stated:

“Usually we might have two or three activities at once because if you cannot work with one because you are waiting for something you can work with the other one.”

There were many opinions about the total number of projects that the departments are working with at the same time, three employees stated:

“We have a tendency to think that all projects are essential, we take on so many activities at once that nothing really gets done properly.”

“There is a tendency to have too many projects going on at the same time and to have too few dedicated resources.”

“I would have studied the customers I have, which ones are the most important customers, which ones are the most important markets, and so I would pick out two or three customers who belong to what I believe is the future.”

4.1.7 The products’ life cycle

One main aspect in order to be able to calculate the CoD for a project is to know how long the product’s life cycle is (see Section 2.4.1). Two answers to the question about how long the products’ life cycles are at SKF were:

“Many of our products are actually 100 years old basically, so we as a company have an inability to manage the life-cycle perspective, it is not in our product or corporate nature.”

“Generally, SKF is pretty bad at cleansing out the product portfolio so a lot of the products live forever basically. The ones that becomes a standard offering and becomes a part of our product catalogue will live there until you do some upgrading. For some product lines, I know that there is a very long tail with products that there are not a great demand of.”

4.1.8 Business Case

Information about how the financial part of the product development projects was obtained at the Market Department. A template is used to create a Business Case for each product development project where the profit over a ten-year period is estimated, one employee stated:

"We create a Business Case that calculates how much money we think we will get and how much it will cost to do this project. We make an initial Business Case in the early stages, which is then refined along the way in the process."

The Business Case basically consists of four parts:

1. Sales assumptions
2. Product cost, including material cost and manufacturing cost
3. Projects cost divided into Business Development cost, Product Development cost, and Manufacturing cost
4. How much investment is required, such as new machines for instance

4.1.9 Opinions on how to work with the calculation model of CoD

The quotes below describes some of the employees', who will be the end-user of the calculation model of CoD, preferences for the design of the model:

"It would be good if the cost of delay of all activities were calculated in the model."

"It is always good if you can compare the projects."

"Charts are always a clear way of presenting the output."

"It would be interesting to see partial calculations as well, then one can see what happens if we take this step and so."

"A tool to clearly show the costs of projects would also be helpful in discussions about how far quotas of resources are met. We need to get better at making this visible for those who are actually asking for our help."

4.2 Study of how other companies prioritise projects

In this section a summary of the answers to the two questions stated (see Section 3.3.2) is presented, on section for each question. Due to confidentiality reasons the companies are named with letters instead of their real names. The full answers are seen in Appendix VII-XIII.

4.2.1 Prioritisation of Projects

Regarding the question about how the prioritisations are performed for product development projects in the daily work when it comes to allocate shared resources, these were the key parameters that the companies takes into consideration:

"Strategic reasons, new materials, and where we want to be in X number of years."
– Company A

"Economic risk, cost, and delays against the ability of doing the work."
– Company B

"Informal discussions and politics can have large influence, also what type of project it is. It can look different within one company from project to project. For the projects in one product portfolio some is driven by strategic reasons, while other by economic reasons for instance."
– Company D

"Sales potential, how much work is left before launching, probability of problems arising, investments required, and realistic unit cost."
– Company E

"Value of the project once the product is out on the market, chances to succeed, how the project has proceed so far, and market changes."
– Company F

"It is usual that we perform consequence analyses. We often prioritise time prior cost."
– Company G

4.2.2 Cost of project delays

On the question about if the companies are taking the CoD of projects into consideration when prioritising projects in the daily work, these were the answers:

"We have no delays, if we realise that a project will not be profitably we close it down, given that the marketing and production of the product has not started yet."
– Company A

"We take cost of delay into consideration. It gets important not only to look at the economic consequences but also the risk for an increased need of resources."
– Company B

"Prioritisations are done if necessary alternatively if we should put external resources on the project in order to meet the time schedule."
– Company C

"We have not defined the cost of delays in a systematic way but when the projects are in the final phase of the process the cost consequences gets really clear. We do not have any method to calculate cost of delays in earlier stages."
– Company C

"This is an interesting and important measurement, but I personally consider that this only should be used to prioritise different alternatives within one single project. To prioritise between projects I think one should measure what you want and what you not want, to quote Taguchi – "If you want quality don´t measure lack of quality". I do not personally know any company using this as the most important measurement to prioritise projects."
– Company D

"For us the cost of delay primarily consists of suspended or missed sales of the new product."
– Company E

"Project delays are taken into account but only the time in it self, not the cost of delays. It is, in my opinion, an over-controlled system one both must stick to the budget AND time. Because if you are behind on time it means that you have to put extra resources to deliver on time."
– Company F

"Often, we see it from a customer perspective, where the customer's wishes and requirements are highly valued."
– Company G

4.3 List of specifications

Based on the initiator's requirements on the calculation model of CoD (see Section 1.5) and the end-users' preferences (see Section 4.1.9) a list of specifications were created, see Table 2. The list consists of both requirements (R) and wishes (W) and are divided into the categories Input to the model, Output to the model, and Usability of the model.

Table 2 The List of Specifications for the model of CoD where R stands for requirement and W for wish.

Criteria	R/W
Input	
Few variables	R
Accurate enough to base decisions on	R
Output	
Generate the outcome CoD	R
Visualise capacity utilisation	W
Generate the outcome in trade-off parameters	W
Enable comparison between different projects	R
Visualise partial calculations	W
Usability	
Easy to use	R
Easy to understand the outcome	R
Not require software that is not commonly used	R

5. Result

This chapter presents the result of the conceptual work for the calculation model of CoD. The process of concept generation and evaluation and selection of concepts are described and how this lead to the final calculation model. How the final model was tested to verify the working mode of it is also described. Throughout this chapter the two different scenarios for the product development projects will be referred to as Scenario 1, which is the one where the project will follow the time plan, and Scenario 2, which is the one where the project is being delayed.

5.1 Generation of concepts

Based on the methods mentioned in Section 2.4 on how to calculate the CoD for product development projects and the result of the empirical study, different concepts of calculation models were generated.

5.1.1 Generation of sub-solutions

By conducting brainstorming sessions, individually and together with the supervisor, Göran Lindsten, and the initiator, Paulo Andolfi at SKF, a number of different sub-solutions were sketched up and discussed. In order to structure the different sub-solutions a Morphological matrix was created, see table 3. The matrix consists of two categories of functions: Calculate the CoD, and Visualisation of outcome. The different sub-solutions to these two functions are described in the following sections.

Table 3 The Morphological matrix for the model of CoD.

		Solution				
Function		**1**	**2**	**3**	**4**	**5**
A	**Calculation of the CoD**	Sensitivity analysis of the Business Case with respect to development time	Equation using the most important variables	Long product life	Calculation of the integral for the two sales curves	
B	**Visualisation of outcome**	Bar charts	Graphs	Capacity utilisation	Numbers	Tables

Solution 1A - Sensitivity analysis of the Business Case with respect to market introduction date

This solution involves changing the input parameters in the existing Business Case they are using today for product development projects that market introduction date has influence on. These parameters could be project cost or sales volume for instance, when editing how these change due to a delayed market introduction it will be possible to calculate the lost profit (Smith & Reinertsen, 1998). One example of the lost profit caused by changes in sales volume due to a one-year delayed product introduction is shown in figure 17 and 18 where the changes are marked in red. The figures of the Business Case are not the real ones due to confidentiality reasons, they are only illustrations to show the principle of the solution.

Cash flow [EUR]		Year					
		0	1	2	3	4	5
	Sales volume [pcs]:	0	0	1000	2000	5000	6000
	Sales price [EUR]:	0	0	300	300	300	300
	Product cost per unit [EUR]:	0	0	200	200	200	200
	Gross profit [EUR]:	0	0	100000	200000	500000	600000
	Project cost [EUR/h]:	100	100	100	100	100	100
	Time on project [h]:	1000	1000	100	20	0	0
	Total project cost [EUR]:	100000	100000	10000	2000	0	0
	Accumulated profit per year [EUR]:	-100000	-100000	90000	198000	500000	600000

Accumulated profit [EUR]:	1188000

Figure 17 Example of a simplified Business Case for a product development project.

Cash flow [EUR]		Year					
		0	1	2	3	4	5
	Sales volume [pcs]:	0	0	0	1000	2000	5000
	Sales price [EUR]:	0	0	0	300	300	300
	Product cost per unit [EUR]:	0	0	0	200	200	200
	Gross profit [EUR]:	0	0	0	100000	200000	500000
	Project cost [EUR/h]:	100	100	100	100	100	100
	Time on project [h]:	1000	1000	1000	100	20	0
	Total project cost [EUR]:	100000	100000	100000	10000	2000	0
	Accumulated profit per year [EUR]:	-100000	-100000	-100000	90000	198000	500000

Accumulated profit [EUR]:	488000

Figure 18 The changed accumulated profit due to a one-year delay marked in red.

Solution 2A - Equation using the most important variables

By experimenting with the economic variables used today to calculate the project profit, the ones with the largest influence on the total profit were found (see figure 19). By using them to create an equation (see Equation 1) in Excel, the lost profit per week that a delay would cause for a certain project could be calculated.

Project A	
Sales volume/week [pcs]:	800
Sales price [EUR]:	500
Product cost/unit [EUR]:	360
Project cost/week [EUR]:	3000
Cost of Delay [EUR/week]=	**115000**

Figure 19 List of the most important variables having influence on the project profit.

$$CoD = \frac{project\ cost}{week} + \frac{sales\ volume}{week} \times \frac{sales\ price}{unit} - \frac{sales\ volume}{week} \times \frac{product\ cost}{unit} \qquad \text{Equation 1}$$

Solution 3A - Long product life

Most of the products that SKF provides have long products lives. In such cases do the sales curves for Scenario 1 and 2 converge according to Smith & Reinertsen, 1998. The CoD will in large extent be caused by the lost profit before the two sales curves converge, which can be approximated as the area of a parallelogram, see figure 20 and Equation 2.

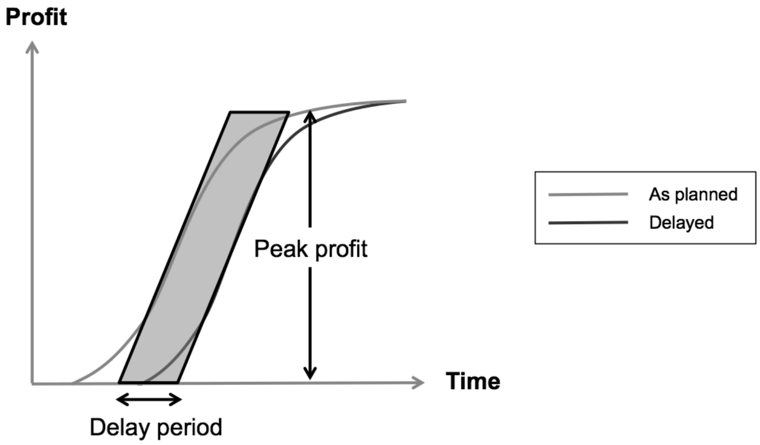


Figure 20 The CoD for product with long sales life can be approximated as the area of a parallelogram. The blue sales curve corresponds to Scenario 1 and the red sales curve to Scenario 2 (Smith & Reinertsen, 1998, pp. 39).

$$CoD = Peak\ profit \times Delay\ period \qquad \text{Equation 2}$$

Solution 4A - Calculation of the integral for the two sales curves

One way to calculate the CoD would be to calculate the integral for the two sales curves for Scenario 1 and 2 over a ten-year period. The sales curve should be based on the most important variables having influence on the profit of the product development projects. By creating a graph in Excel of the two different scenarios, an Excel function can be used to create a trendline for each scenario together with its equation, see figure 21. The CoD corresponds to the area between the two curves, which can be calculated trough integration where the interval could be chosen from the decision point to the tenth year, see Equation 3.

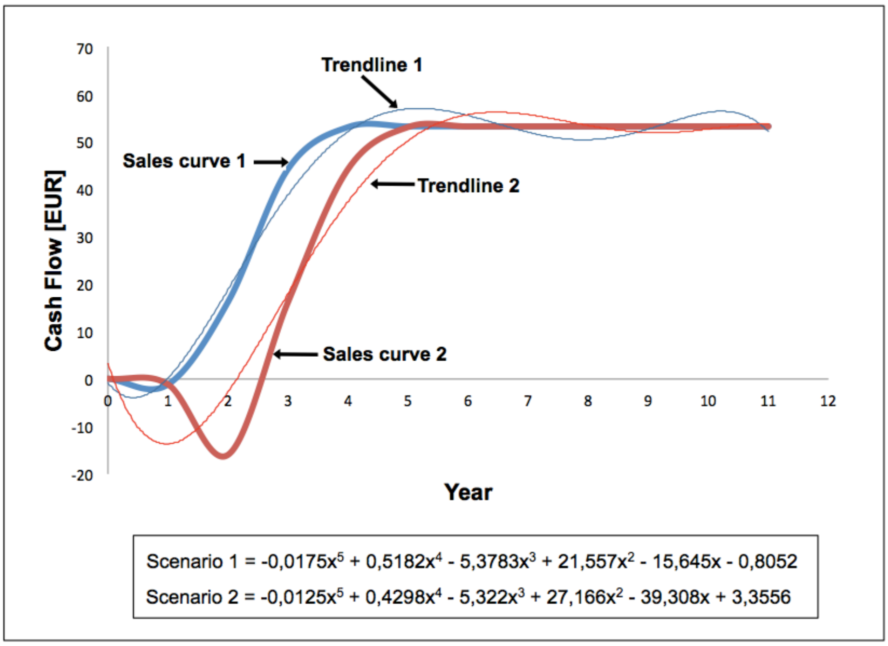


Figure 21 A trendline is created for each sales curve for the two scenarios in order to calculate the area between these, which corresponds to the CoD.

$$CoD = \int_{Decision\ point}^{Year\ 10} \left(Scenario\ 1(x) - Scenario\ 2(x)\right)dx \qquad \text{Equation 3}$$

Solution 1B – Bar charts

The CoD could be presented in a bar chart, see figure 22, where the eventual lost profit for different projects could be compared.

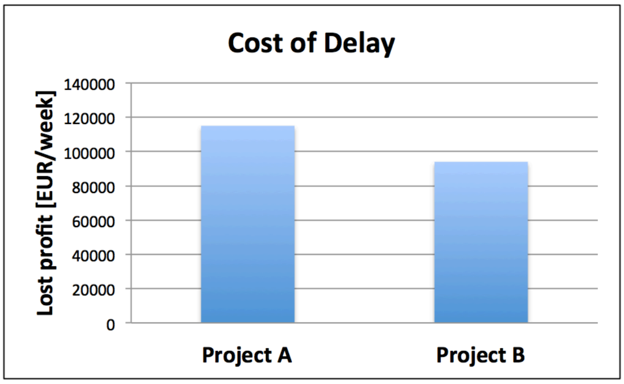


Figure 22 The CoD for two projects presented in a bar chart.

Solution 2B – Graphs

Another way to present the outcome of the model could in form of graphs. The graphs of the sales curves for the two scenarios for different projects could also be compared with each other in one separate document. In this document the decision point could be the same for all project and shows the sales curves for the projects from that point and onwards, see figure 23.

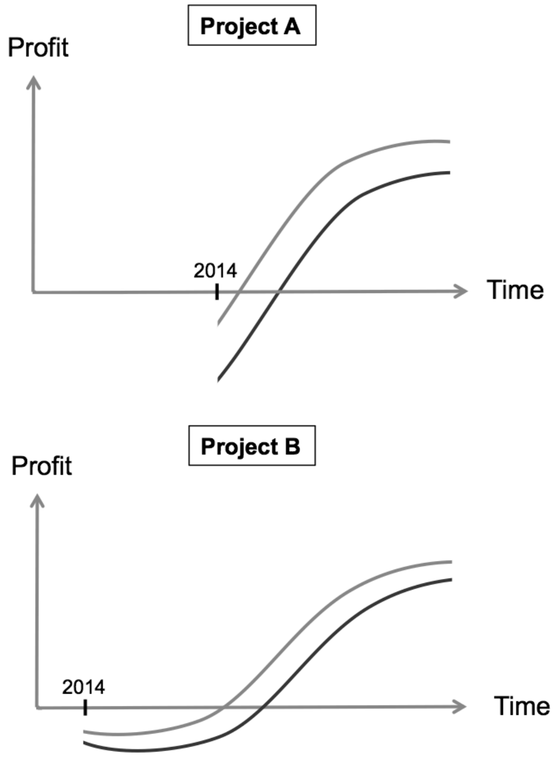


Figure 23 The sales curves for two projects from the decision point 2014. The blue sales curve corresponds to Scenario 1 and the red sales curve to Scenario 2.

Solution 3B – Capacity utilisation

In order to visualise the capacity utilisation needed for six certain projects that are planned to be worked with simultaneously a graph can be used. The principle of a graph that can be used for this purpose (not to scale) is shown in figure 24. Data from the Business Case in form of how much time that will be spent on different activities will be needed to create this graph. By calculating how much capacity is needed in percentage of the total capacity the value can be marked with a cross on the graph. In this way the queue size of product development projects that this will result in will be obtained.

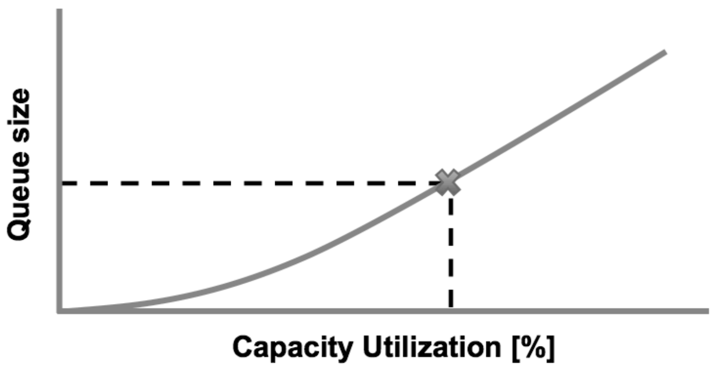


Figure 24 The capacity utilisation needed to work with six certain projects simultaneously is marked with a cross to obtain the size of the queue of projects that this will result in.

Solution 4B – Numbers
Another way to visualise the outcome of the calculation model could be to present it in numbers, in other words the CoD for the current product development project.

Solution 5B - Tables
For the solutions where data is taken from the Business Case to calculate the CoD the total profit for Scenario 1 and 2 for each year over a ten-year period can be shown in a table, see figure 25. In this way partial calculations will be visualised.

Year	Cash flow [EUR]	
	Scenario 1	Scenario 2
1	-100	-100
2	-100	-100
3	100	-100
4	200	100
5	300	200
6	400	300
7	500	400
8	500	500
9	500	500
10	500	500
Accumulated profit:	2800	2200

Figure 25 The annual cash flow for a project over a ten-year period presented in a table.

5.1.2 Combining sub-solutions into concepts

By combining the different sub-solutions in the Morphological matrix (see table 3), with synergy in mind, five different concepts were created. The result is shown in table 4.

Table 4 The concept created based on the Morphological matrix.

		Concept				
Function		1	2	3	4	5
A	Calculation of the CoD	Sensitivity analysis of the Business Case with respect to development time	Equation using the most important variables	Equation using the most important variables	Long product life	Calculation of the integral for the two sales curves
B	Visualisation of outcome	Capacity utilisation	Bar charts	Graphs	Bar charts	Graphs
		Numbers	Numbers	Numbers	Numbers	Numbers
		Tables		Tables		

5.2 Evaluation and selection of concepts

The concepts described in the previous section were evaluated together with Göran Lindsten and Paulo Andolfi at SKF and also by using two different concept selection matrices: elimination matrix and Pugh selection matrix. The requirements and wishes stated in the list of specifications (see Section 4.3) were used to create the two different concept selection matrices, which for the concepts were marked how well they fulfilled these.

The result of the elimination matrix is shown in table 5. In order for the concepts to continue in the concept selection process they had to fulfil all the requirements, which two of the five concepts did, Concept 2 and 3. Both of these concepts were based on the solution *Equation using the most important variables*, but how the outcome would be visualised differed.

Table 5 The elimination matrix used to eliminate the generated concepts.

Requirements	Concept 1	2	3	4	5
Input					
Few variables	-	+	+	+	-
Accurate enough to base decisions on	-	+	+	-	+
Output					
Generate the outcome CoD	+	+	+	+	+
Enable comparison between different projects	+	+	+	+	+
Usability					
Easy to use	-	+	+	+	-
Easy to understand the outcome	-	+	+	+	-
Not require software that is not commonly used	+	+	+	+	+
Total score:	-1	7	7	6	1

The next phase of the concept selection process was to evaluate how well the two remaining concepts fulfilled the wishes, where a Pugh selection matrix was used. The result is shown in table 6. Concept 2 did not fulfil any of the wishes but Concept 3 fulfilled at least one of them.

Table 6 The Pugh Selection Matrix used to eliminate the remaining concepts.

Wishes	Concept 2	Concept 3
Output		
Visualise capacity utilisation	-	-
Generate the outcome in trade-off parameters	-	-
Visualise partial calculations	-	+
Total score:	-3	0

Based on Göran Lindsten and Paulo Andolfi's preferences and the result of the concept selection matrices, Concept 3 was chosen as the final concept to develop further. This final concept calculates the CoD with an equation using the most important variables and visualise the outcome in form of graphs, numbers, and tables. By using this type of calculation model data from the Business Case can be used and be put into the model automatically.

5.3 Prototyping

The concept was designed in Excel in an iterative process similar to a design-build-test cycle that Wheelwright & Clark (1992) suggests should be used in order to avoid functional gaps in the development object. During the iterative process the model was refined based on deficiencies that appeared during the development. This included testing different levels of detail of the calculations to find the right balance between accuracy and simplicity. The process resulted in the final design of the model, which is presented in the next section.

5.4 Final calculation model

This chapter first introduces the structure of the calculation model. Second, a description of how the model is designed to calculate the CoD is presented. This part is divided into four sections in order to describe how the model is designed depending on what the reason for the delay is and also how to calculate the Cost of preventing delay, meaning adding extra resources to the project to avoid a delay. Finally, the part on how the comparison of the projects' CoD will be performed and how the concept was tested are described.

5.4.1 The structure of the model

It was decided to create the calculation model in an Excel spread sheet. The reason for this choice of software was that it is relative simple and includes the required functions needed for the model. The software is also widely used within the organisation, which means that it will be possible for anyone to use the model.

In order to fulfil the requirement that says that the model has to be accurate enough to base decisions on, it was decided to connect the final model to the Business Case in order to use the data for the current project over a ten-year period. To make the development of the calculation model and the description of this as easy to understand as possible a simplified Business Case has been used within this project. Figure 26 shows the principle of the Business Case.

Project start year: 0

		Year			
		0	**1**	**...**	**10**
Cash flow [EUR]	Sales volume [pcs]:	0	100	...	1000
	Sales price [EUR]:	0	300	...	300
	Product cost per unit [EUR]:	0	200	...	200
	Gross profit [EUR]:	0	10000	...	100000
	Project cost [EUR/h]:	100	100	...	0
	Time on project [h]:	1000	100	...	0
	Total project cost [EUR]:	100000	10000	...	0
	Accumulated profit [EUR]:	-100000	0	...	100000

Figure 26 The simplified Business Case used when creating the model of CoD.

The simplified Business Case calculates the expected profit over a ten-year period, just as the real one. The simplified Business Case takes the listed variables in figure 26 into account. The yellow fields are the ones that the user will have to type in manually and the white field are the ones showing the result of the calculations based on the figures in the yellow fields. These calculations are shown in Equation 4-6.

$$Gross\ profit = Sales\ volume \times (Sales\ price - Product\ cost\ per\ unit) \quad \text{Equation 4}$$

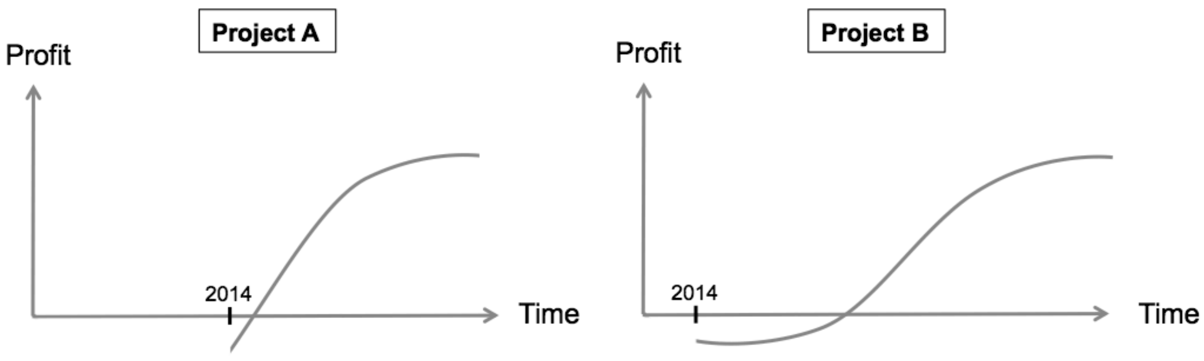
$$Total\ project\ cost = Project\ cost \times Time\ on\ project \quad \text{Equation 5}$$

$$Accumulated\ profit = Gross\ profit - Total\ project\ cost \quad \text{Equation 6}$$

Note that the final model that will be put into use will be connected to the real Business Case for each individual project, which means that the figures in the yellow fields will be retrieved automatically.

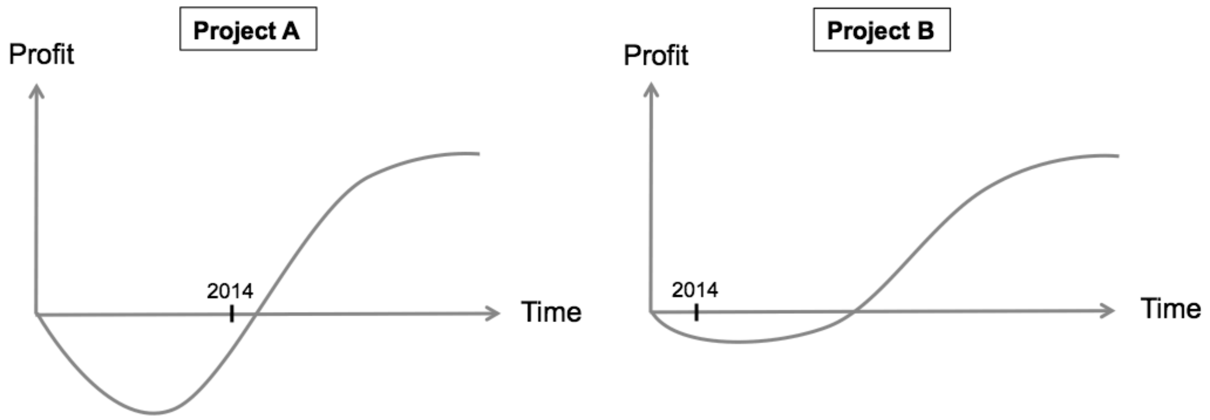
For each project the user will type in the decision point when calculating the CoD or the Cost of preventing delay. The decision point will be typed in as the numbers of weeks that the project has proceed so far. The decision point will be used to subtract the project costs for these weeks from the total profit. These costs are sunk costs meaning that these are irreversible outflows and cannot be affected in any way (Ulrich & Eppinger, 2012). Focus should rather be on the return on the remaining investment of the project.

To argue for the principle of sunk costs two examples are made. At the first example, look at the two sales curves for Project A and B in figure 27-a and 27-b, which project looks most profitable? You probable say Project A where little project costs is needed before launching the project in comparison to Project B. At the second example, look at the sales curves for Project A and B in figure 28-a and 28-b, which project looks most profitable based on these two sales curves? This time you probably say Project B where less project costs are needed in order to launch the project and reach up to a similar sales volume. This is true in cases where one is looking at the sales curves from the point where the projects were started. In cases where the profit for certain projects are compared against each other during the projects life cycle, the time and money already spent on the projects should not be taken into account, as in the first example shown in figure 27-a and 27-b.



(a) **(b)**

Figure 27 Sales curve for project A (a) and project B (b).



(a) **(b)**

Figure 28 Sales curve for project A (a) and project B (b).

What the delay cost consist of depends on which of the following three main reasons the delay is caused by: more time is needed, a feature is added to the product, or the project is put on hold. How the model is designed for each of these three reasons is described in the following sections, followed by the design of the model to calculate the Cost of preventing delay.

5.4.2 The model of CoD – More time needed

The most common reason for why a project is being delayed is that the project simply takes longer time than planned. In this case the CoD consists of the cost for working on the project during the delay. For this model the user will specify the number of weeks that the project will be delayed, see figure 29. The model calculates how the profit will change over a certain period of time due to the delay. This certain time period that the calculation covers consists of ten years plus the delay. One example of this is shown in figure 30, which visualises how the cash flow is shifted one year forward due to a one-year delay, the extra project cost is market in red. As the products basically have infinite product life the same time period of sales will be calculated for both scenarios, because the product will have the same annual sales volume long after this time period. This means that in this example the cash flow for Scenario 2 with one-year delay will be calculated over eleven years but Scenario 1 will be calculated over ten years.

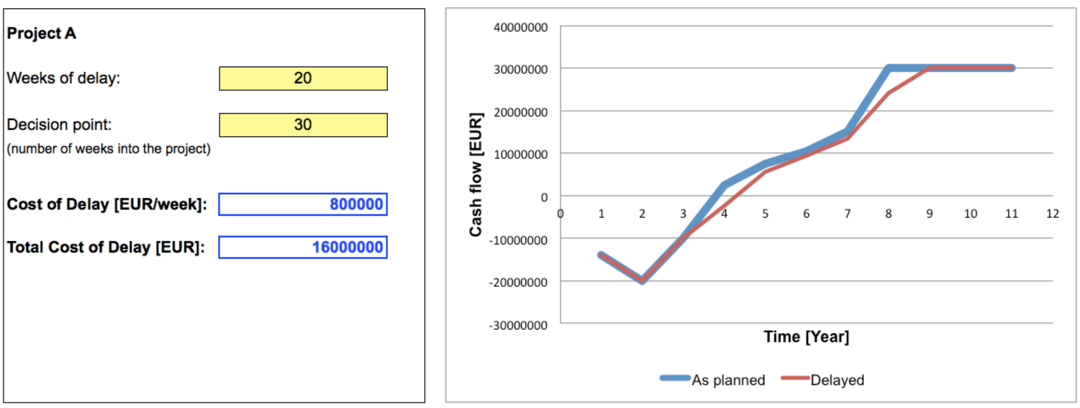


Figure 29 The user will specify the number of weeks of delay and the decision point, which will generate the CoD for the project. The changed cash flow will also be presented in a graph.

Year	Cash flow [EUR]	
	As planned	Delayed
0	Project cost	Project cost
1	Project cost	Project cost
2	Project cost + Revenue	Project cost
3	Project cost + Revenue	Project cost + Revenue
4	Revenue	Project cost + Revenue
5	Revenue	Revenue
6	Revenue	Revenue
7	Revenue	Revenue
8	Revenue	Revenue
9	Revenue	Revenue
10	Revenue	Revenue
11		Revenue

Figure 30 The cash flow displacement for one-year project delay caused by that more time is needed to work with the project.

The difference in profit for Scenario 1 and 2 is the lost profit and equal to the CoD. To get a more manageable value the CoD is divided by the number of weeks of delay to get the CoD per week, which is suitable to use when comparing the CoD for different projects. The output of the model will be shown in form of both CoD per week and total CoD, see figure 29. The coordinates from the table (year, cash flow) will be plotted in a graph for both scenarios, see figure 29. How the cash flow will differ between the two scenarios due to a delay will in this way be visualised. How the model is designed in Excel is seen in Appendix XIV.

The CoD for one project will only have to be calculated ones as the CoD are more or less constant given that no radical changes are made in the Business Case. If radical changes are made in the Business Case the CoD for the project has to be recalculated.

5.4.3 The model of CoD – Modifying a feature on the product

One other reason for why a project is being delayed can be that there is a need to modify a feature on the product. Decisions to do this in the middle of a project might be due to a misunderstanding of the customer needs or a discovered valuable feature on a new competing product.

The principle for the model to calculate the CoD when deciding to modify a feature on the product is the same as for the previous case but with the different that the user will type in the changed project data in addition to weeks of delay and decision point, see figure 31. The changed project data will be typed in as the percentage change in sales volume per year, sales price per unit, and product cost per unit.

Project A	
Weeks of delay:	30
Decision point: (number of weeks into the project)	30
Change in sales volume [% per year]:	7
Change in sales price per unit [%]:	0,1
Change in product cost per unit [%]:	0,1
Cost of Delay [EUR/week]:	100000
Total Cost of Delay [EUR]:	3000000

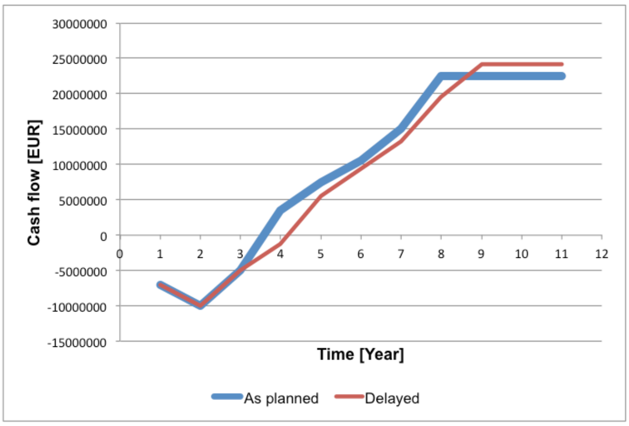


Figure 31 The user will specify the changed project data, caused by modifying a feature, in addition to the number of weeks of delay and the decision point. The model will generate the CoD for the project and also present the changed cash flow in a graph.

The changed profit due to a one-year delay, caused by modifying a feature, over an eleven-year period is shown in figure 32. The project cost marked in red is the costs for working with the project one extra year and Revenue A is based on the first planned project data and Revenue B is based on the changed project data. The CoD will in this case consist of project cost but hopefully in the end be added up by a larger sales volume or a higher sales price, however, this is in many cases difficult to achieve. The model will just as in the previous case present the changed cash flow due to a delay in a graph, see figure 31. How the model is designed in Excel is seen in Appendix XV.

Year	Cash flow [EUR]	
	As planned	Delayed
0	Project cost	Project cost
1	Project cost	Project cost
2	Project cost + Revenue A	Project cost
3	Project cost + Revenue A	Project cost + Revenue B
4	Revenue A	Project cost + Revenue B
5	Revenue A	Revenue B
6	Revenue A	Revenue B
7	Revenue A	Revenue B
8	Revenue A	Revenue B
9	Revenue A	Revenue B
10	Revenue A	Revenue B
11		Revenue B

Figure 32 The cash flow displacement for one-year project delay caused by modifying a feature on the product.

5.4.4 The model of CoD – Project on hold

A third reason for why a project is being delayed can be that the project is put on hold in order to allocate the resources on other projects instead. The cost of putting a project on hold can be compared to WIP. The simplest way to calculate the cost of WIP is to assign a standard cost to the percentage completion of the goods (Accounting Tools, 2013). The analogue way to calculate the cost of DIP would be to calculate the internal rate of return on the reprocessed work during the time the project is put on hold, see Equation 7. At SKF the annual internal rate of return is 15 percent. In order to draw the attention to the cost of putting projects on hold, only the project costs will be taken into account in the calculation model for this situation. These project costs has been limited to the ones needed until the project is launched to the market. The project cost shiftings for putting a project on hold for one year is shown in figure 33 and the plotted cost curves are shown in figure 34. How the model is designed in Excel is seen in Appendix XVI.

$$On\ hold\ cost = 0{,}15 \times Project\ cost\ of\ reprocessed\ work \times Year\ on\ hold \qquad \text{Equation 7}$$

Year	Project cost [EUR]	
	As planned	**Delayed**
0	Project cost	Project cost
1	Project cost	On hold cost
2		Project cost
3		
…	…	…
10		

Figure 33 The project cost displacement due to a project delay caused by putting the project on hold.

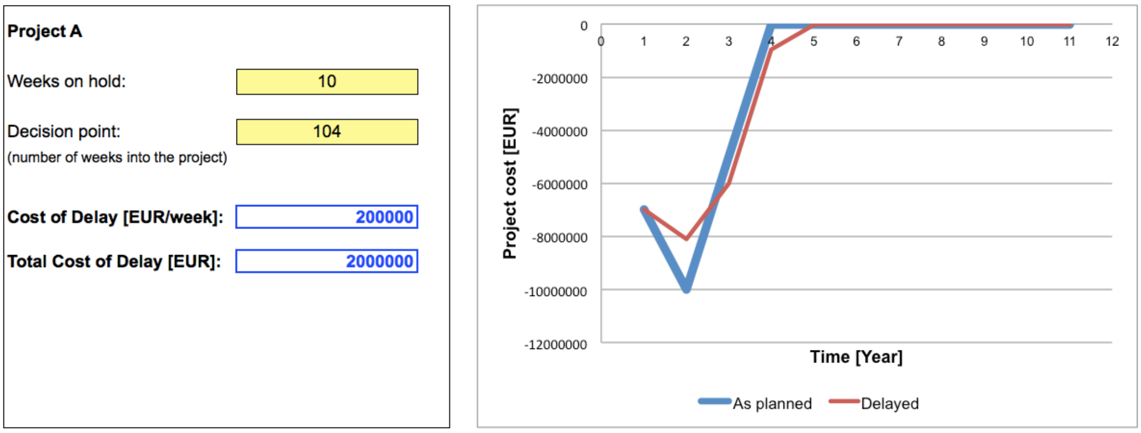


Figure 34 The user will specify the number of weeks the project will be on hold. The model will generate the CoD and present the changed cash flow in a graph.

5.4.5 The model of Cost of preventing delay

One case could be that it is anticipated that a delay will cost more money than what allocating extra resources to the project in order to avoid a delay will do. This model calculates the cost of spending more man-hours on the project during the same time as was initially planned, which the user will specify, see figure 35. The outcome will be presented as the total cost and the changed cash flow in form of a graph, see figure 35. The principle of the changed cash flow caused by adding extra resources to the project is shown figure 36. As Scenario 2 not causes a cash flow displacement the total profit will be calculated over ten years for both scenarios. The outcome of the model can be used to compare the economic consequences of this case with the outcome of delaying the project. How the model is designed in Excel is seen in Appendix XVII.

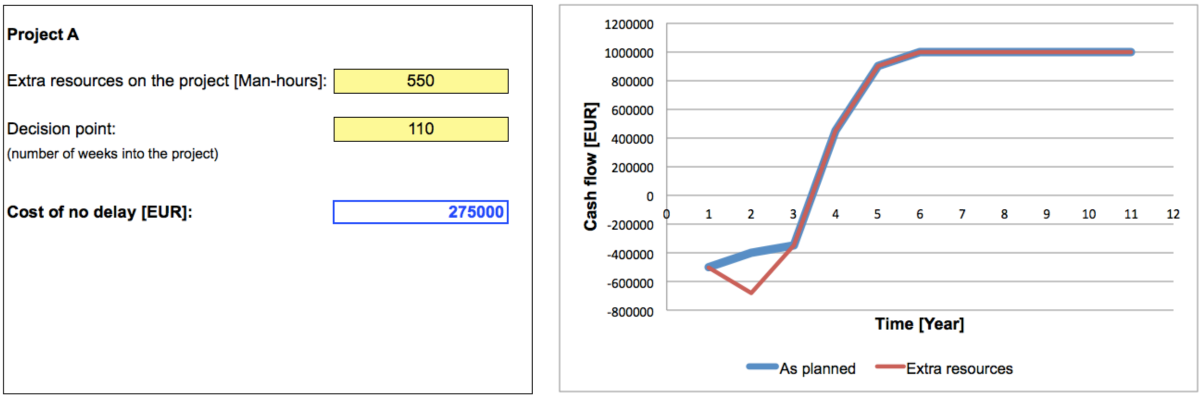


Figure 35 The user will specify the amount of extra man-hours that is planned to be added to the project. The model will generate the cost of adding these extra resources and present the changed cash flow in a graph.

Year	Cash flow [EUR]	
	As planned	Extra resources
0	Project cost	Project cost
1	Project cost	Project cost + Extra resources
2	Project cost + Revenue	Project cost + Revenue
3	Project cost + Revenue	Project cost + Revenue
4	Revenue	Revenue
5	Revenue	Revenue
6	Revenue	Revenue
7	Revenue	Revenue
8	Revenue	Revenue
9	Revenue	Revenue
10	Revenue	Revenue

Figure 36 The principle of the changed cash flow due to adding extra resources to the project to avoid a delay.

5.4.6 Comparison between projects

To be able to compare the CoD for different projects in an easy way one sheet-tab has been created in Excel where the graphs showing the sales curves for the projects are gathered together with the projects' CoD per week. The user will type in the decision point from where the sales curves will show, see figure 37. In this way the sunk costs are not taken into account.

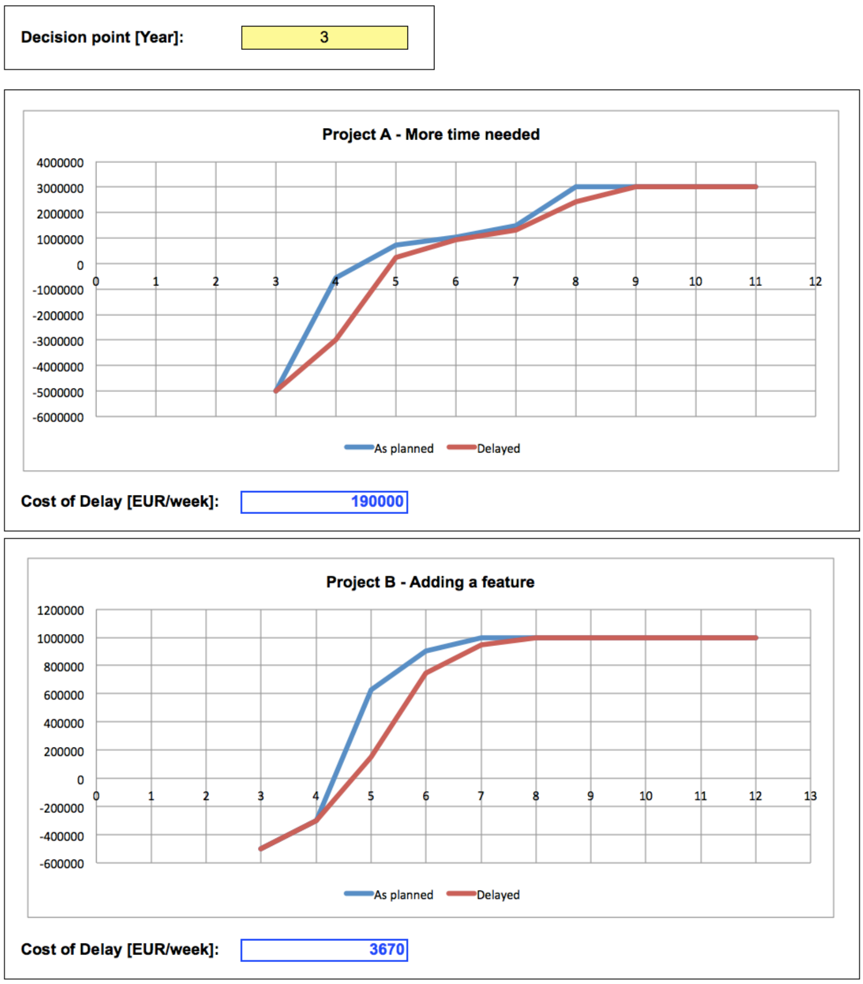


Figure 37 The graphs displaying the sales curves for both scenarios for different projects will be gathered in one sheet-tab for easy overview.

5.5 Concept testing

In order to verify the working mode of the final calculation model an already launched product development project was used. The relevant data from the project's Business Case were inserted in the model to calculate the CoD for the project. The output of the model was analysed whether it would have been a realistic result if the project had a delayed launch.

By making manually calculations to verify the working mode of the model it was found that that the outcome of the model is realistic. It was also discovered that for projects where a long project development time is planned it would be appropriate to extend the time period with a number of extra years in order to include enough sales data when full sales volume is reached.

6. Analysis and discussion

This chapter covers an analysis and discussion of the overall thesis work. This includes findings of the literature and the empirical study, the conceptual work, the final calculation model and how well it fulfils the specifications.

6.1 Literature study

The main purpose of performing the literature study was to investigate different theories about how to calculate the CoD of product development projects. A lot of theory was found related to prioritising product development projects but only a few authors have written theories related to the CoD or similar principles. The main literature that has been used in this project is written by Donald G. Reinertsen, the oldest literature used is written by him together with Preston G. Smith in 1998 named *Developing Products in Half the Time, New Rules, New Tools.* The literature suggests a method to calculate the CoD through a sensitivity analysis with respect to market introduction date one the baseline model for the product development project. The fact that the literature is 16 years old has been reflected upon, however, the same way on how to manage the financial part of product development projects is used today, as when the literature was written why their proposed method is still relevant. Reinertsen brings up parts of this method in his later literature *The Principles of Product Development Flow, Second Generation Lean Product Development* written 2009, which also shows that he still think this method is of great use.

6.2 Empirical study

The empirical study was divided into two parts, where one was to study how the prioritisation of projects is performed at SKF today and the other one to study how other companies prioritise projects. It was decided to separate these two studies from each other as they differ in both size and purpose. The first mentioned study was the most extensive one with the purpose to get a deeper understanding of the overall problem. The latter one was not as extensive as the first one, the purpose with this study was to investigate how widespread the use of the principle of CoD is. An analysis and discussion of both studies are presented in the following sections.

6.2.1 Study of how the prioritisation of projects is performed at SKF today

By interviewing employees at different departments at SKF a deeper knowledge were obtained about how the work is structured today, their thoughts around the problem of prioritising projects, and the developers' opinions of how they would prefer to work with the model of CoD. The SKF employees showed a great interest around the subject of prioritising projects, some of their opinions were shared while some were in conflict. Some shared opinions were that the organisation has a tendency to work with too many projects at the same time and that it is difficult to acquire resources dedicated to the projects. This, together with many other opinions revealed that there is a need of a more consistent way of prioritising product development projects.

6.2.2 Study of how other companies prioritise projects

How the companies within this study prioritise product development projects turned out to be similar to how they perform this at SKF. All companies answered that they use specific project parameters to compare the projects with each other. The most common parameters seemed to be strategic reasons, economic risk, and sales potential. However, one difference was that in some cases resources in terms of personal competence were not the main restriction but money it self. This difference mainly depends on what industry the company operates in.

Regarding the question if the companies are taking the CoD of projects into consideration when prioritising projects in the daily work the general answer were that they do take the CoD into consideration but it did not seem like anyone had a systematic way to do this. The companies that have the possibility to use external resources used this as a solution to avoid delays. One company answered that they have no delays, the reason for this is that it would be to costly to delay a project within that industry that the company operates in.

6.3 Conceptual work

During the conceptual work parts of different methods were combined to make the model of CoD fit the organisation it will be used in. Methods that parts were taken from were partly from the ones suggested by theory but also some of the generated methods from the brainstorming sessions.

However, there was one solution that was not used to calculate the CoD, that was *Calculation of the integral for the two sales curves*. The reason for why this concept was eliminated was that it would have been unnecessarily complicated. Also, the outcome would not have been that accurate as trend lines are used to calculate the integral instead of the actual sales curves. The objective of the thesis is to develop a model that is easy to use and easy to understand the outcome of it, which this solution does not fulfil.

Among the solutions for how to visualise the outcome there were two solutions not used, which were *Bar charts* and *Capacity utilisation*. The bar charts could have been a substitute to the graphs as they both visualises the CoD. However, the graphs provide more information in terms of the CoD in relation to time, while the bar charts only shows the CoD, why graphs was chosen over bar charts. The solution that visualises the capacity utilisation may have been useful in order to plan which projects to work with simultaneously. The reason for why this solution was not included in the final calculation model was that it would have required more detailed data about the different project operations than what the Business Case provides. The procedure needed to collect this type of data would have been too complicated to do in the daily work.

There are a number of different aspects that could have been taking into consideration during the conceptual work. All different aspects might having influence on the CoD that came to mind were discussed whether these should be taken into account or not. The following sections present the ones that were decided to not take into account, with an explanation why these were not considered as important aspects in the model.

6.3.1 Influence on sales of existing products

When a new product has negative influence on the sales of an existing product it is called cannibalising (Smith & Reinertsen, 1998, p.76-77). When calculating the CoD for a project where the product planned to be launched is forecasted to have negative influence on an existing product this might affect the CoD. As the sales of the old product will decrease when introducing the new product the sum of total lost sales due to a product introduction delay will not be as large as if the new product has no influence on existing products.

One other case could be that the new product is forecasted to have positive influence on an existing product. In this case the CoD might be even larger due to lost sales of the old product as well. However, it is difficult to forecast to what extent the new product will affect the old one why this phenomenon has not been taken into consideration in the calculation model.

6.3.2 New product on the market

In cases where the product is a new product on the market an introduction delay might lead to that competitors have time to introduce a competing product before and takes market shares. As it is difficult to forecast if there are any competitors that are about to introduce similar products in the near future, the lost market shares that this scenario might result in is not taken into account in the calculation model.

6.3.3 Technological obsolescence

Delaying a project might lead to a number of different risks. These risks includes that the knowledge gained might become out-dated, the technology gets obsolete, or that the market change. These risks are difficult to forecast and to assign a cost why these are not taken into consideration in the model of CoD.

6.3.4 Investments

The eventual investments that are needed for the product development projects are not included in the calculations of the expected profit during the projects life-cycle. This is due to the requirement that the model should be as simple as possible. However, it is of course possible to include the investments in the final model that will be connected to the Business Case where investments and depreciations are included.

6.3.5 Project costs

The project costs for different departments and activities might differ in reality, these costs are not distinguished in the model, instead an average project cost is used. One of the delimitations for the model was that it is only going to take the variables that have the largest influence into account to make the use of the model as simple as possible. This is why an average project cost is used, as the differences in costs between the departments are small enough to not have a significant influence on the CoD.

6.4 Final Calculation Model

The first part of this section presents an analyse and discussion of the final calculation model in terms of the structure of it and how it would have looked like if the CoD was based on net present value. Further, how the model can be used to plan the most profitable way of working will be discussed. Finally, an analysis of how well the model fulfils the specifications is presented.

6.4.1 The structure of the model

When developing the final calculation model it was decided to create a simplified Business Case to make it as easy as possible to explain the principle of the model. The figures in the Business Case and calculation model of CoD are not related to the real ones and in order to put attention to the projects costs these are scaled. The reason for this is that the products have such long product lives, when using real scale the project costs are difficult to distinguish in the diagram. When introducing the model that will be put into use, the model should be recreated in the same document as the Business Case so that it retrieves the actual figures automatically.

It was decided to make a pedagogical example in this report to argue for why sunk costs should not be taken into account in the calculation of CoD. This decision was made because it was anticipated that it might be mixed opinions whether these costs should be included in the calculations or not. This prediction turned out to be correct as the knowledge about sunk cost varied among the audience of the presentation of the project.

It was decided to calculate the cost of putting a project on hold as the internal rate of rerun on the reprocessed work during the time the project is on hold. The decision that this would be a realistic measurement was made together with the supervisor at SKF. It was also decided to only take the project costs into account in the calculation model when putting a project on hold. The reason for why this decision was made was because the awareness of that putting a project on hold actually cost money is not that widespread.

It is important to notice that the model of CoD should not be the only tool to prioritise projects. The CoD is only one parameter to take into consideration within decision-making when prioritising product development projects and should be seen as a complement to the parameters used today.

6.4.2 Calculating the CoD using net present value (NPV) instead of present value

It was discussed if it would be appropriate to calculate the total profit for Scenario 1 and 2 over ten years for both scenarios. The conclusion was made that it would be unfair to take a shorter time period of sales into account in the calculation of the total profit for Scenario 2 as the sales of the product will not stop after ten years, but continue long after that. The sales volume that will be added after ten years for Scenario 2 is set equal to the weekly sales volume during the tenth year as it is assumed that a steady sales volume has been reached at that stage.

The developed model calculates the present value (PV) for each year, see the left column of table 7. If the model instead would calculate the net present value (NPV) each year, visualised in the right column of table 7, the sales curve would look different, see figure 38. If the model would base the calculation of CoD of the NPV each year the total profit could have been calculated over ten years for both scenarios. This due to that the sales curves slope instead of continuing in a straight line when full sales volume is reached, which means that sales loss caused by the delay during the earlier part of the time axis would not be recovered by the sales later on the time axis for the delayed scenario.

Table 7 A visualisation of how the outcome differ between the two approaches to calculate the CoD. The column to the left are based on present value and the column to the right net present value.

Year	Present Value [MEUR]		Net Present Value [EUR]	
	As planned	Delayed	As planned	Delayed
0	-10	-10	-10	-10
1	-10	-10	-9	-9
2	10	-10	8	-8
3	20	10	13	7
4	30	20	17	11
5	30	30	15	15
6	30	30	13	13
7	30	30	11	11
8	30	30	10	10
9	30	30	9	9
10	30	30	7	7
Total profit:	220	180	84	56
Cost of Delay [EUR]/week]:		**40**		**28**

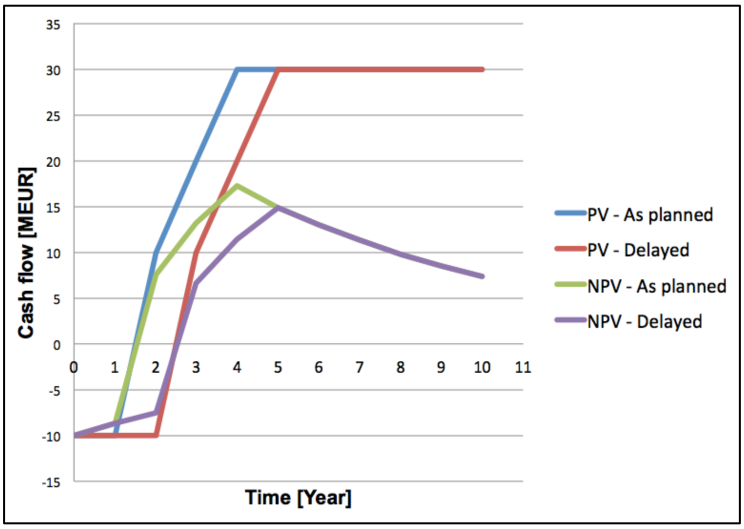


Figure 38 The sales curves for Scenario 1 and 2 based on present value (blue and red curve) and net present value (green and purple curve).

The theory about how to calculate the CoD for projects with long product life suggests to multiplying the delay period by peak sales (see Section 2.4.2) and takes thereby not the extra project cost into account. For this calculation model it has been decided only to take the extra project cost and not take the lost sales into consideration in the calculation model as this eventually will be recovered.

6.4.3 One project or several projects at a time

Related to the research question whether it is most profitable to work with one project at the time or with several projects in parallel the consequences for different scenarios can be discussed based on the outcome of the different calculation models. Consider the following example. In the first scenario the developers work with two projects simultaneously, Project A and B, with equal resource allocation, see figure 39. Project A will be launched as planned as long as the resource allocation does not change. Project B on the other hand will be delayed if the resource allocation stays the same and thus cause a CoD. To verify if it would be more profitable to allocate all the resources on Project B to avoid a delay the cost of putting Project A on hold is calculated.

	Project	Resource allocation	Cost
Scenario 1	A	50%	As planned
	B	50%	Cost of delay
Scenario 2	A	0%	On hold cost
	B	100%	Cost of preventing delay

Figure 39 The principle costs for the two scenarios with different resource allocation.

The total cost for each scenario is of course dependent on the projects' characteristics and size, but generally the on hold cost is relative low in relation to CoD as this cost is in the form of the internal rate of return on the reprocessed work and lost sales (see Section 5.4.4), while the CoD usually is in form of actual project cost and lost sales (see Section 5.4.2 and 5.4.3). Let us say that the on hold cost is 1/10 of the CoD in this case, see figure 40. The Cost of preventing delay is equal to the cost of working as planned on Project A and are generally slightly lower than the CoD as this case not result in any lost sale (see Section 5.4.5). Let us say that the Cost of preventing delay is 8/10 of the CoD in this case. The total cost for Scenario 1 would in this case be twice as high as for Scenario 2, see figure 40, which means that it would be more profitable to work with one project at the time than with two in parallel in this case.

	Project	Resource allocation	Cost	Total cost
Scenario 1	A	50%	As planned = 8	18
	B	50%	Cost of delay = 10	
Scenario 2	A	0%	On hold cost = 1	9
	B	100%	Cost of preventing delay = 8	

Figure 40 The principle total cost for the two scenarios.

However, there are aspects that it not taken into consideration in this case. As projects often vary in intensity during different periods working with one project at the time can be inefficient when the project has low intensity. When working with several projects in parallel the developers can alternate between the projects depending on which project that has high intensity at the moment (James & Lowell, 2002). However, working with several projects in parallel leads to a larger number and longer setup times (Ulla Sebestyén, 2006). This leads to both increased lead times and cycle times, which results in a lower profit and project delays. It is important to notice that other project parameters used today when prioritising projects such as strategic fit and business risk are not taken into consideration in this example. This is due to that it lies outside this project's scope, why this example only discusses how to prioritise based on the CoD.

6.4.4 Fulfilment of specifications

Before starting the conceptual work a list of specifications was created. The list was based on the initiator's requirements and the end-users' preferences on the calculation model of CoD. The requirements for the input of the model are that it should use few variables but at the same time be accurate enough to base decisions on. As the final calculation model uses variables from a simplified Business Case as few variables as possible are used. The model calculates the changed profit over ten years plus the delay, which will generate an outcome accurate enough to base decisions on as the products has long product lives, which means that the CoD is in form of extra project cost during the delay. This means that the final model fulfils these two requirements.

One requirement for the output of the model is that it has to generate the outcome CoD, which the final model does in form of CoD per week. One other requirement is that the output of the model has to enable comparison between different projects, which the end result enables in a separate sheet-tab in Excel where the graphs and CoD for the different projects are shown (see Section 5.4.6).

The requirements for the usability of the model is that it has to be easy to use and easy to understand the outcome, and that the model should not require software that is not commonly used. When calculating the CoD for a project the user will only have to type in the number of weeks of delay and the number of weeks into the project that has proceeded and the model will generate the CoD (see figure 29). The fields where the user will type in the data will be marked in yellow, as in the Business Case and other Excel models that the employees are used with. The model is created in Excel, which is one of the most commonly used software within the company, this means that anyone can use the model at their own computer.

6.5 Future work

The method used to test the final concept involved applying the model on a real product development project in order to verify the working mode of it. One complementing approach before implementing the model would be to analyse the usability of the model by letting product developers try to use the model.

7. Conclusions

This chapter presents what conclusions that have been drawn that answers the research questions stated in the beginning of the report, which have been used to fulfil the purpose of the thesis.

1. Why should the product development department base their decisions on CoD when prioritising projects?

There are several problems related to managing multiple projects (Engwall & Jerbrant, 2003). One important problem is that it tends to provoke discussions among project managers regarding which projects to prioritise, this in turn leads to that re-allocation of resources becomes common. One reason to why these problems appear is that the project parameters used to prioritise product development projects today are rather speculative. Using a more consistent parameter based on economic facts when prioritising projects will ease the process of taking joint decisions.

The empirical study showed that one common opinion is that the organisation is much slower than the competition when it comes to give the customer answers to their requests. Using the CoD that is an economic substantiated parameter when taking decisions could help speed up this process.

Another common opinion among the employees at SKF was that the organisation has a tendency to work with too many projects at the same time, which leads to that it is difficult to get everything done properly. By basing prioritisation decisions on which projects would be most profitable to work with, the ones with lower profitability could be terminated.

One important aspect is that a project that is being delayed does not only cause a CoD for this specific project, it also affects the upcoming projects as resources are bond to the delayed project. This means that a project delay also impedes the progress of other projects.

2. What economic factor has the largest influence on the CoD?

The economic factor that has the largest influence on the CoD is the one that constitute the main part of the total project profit and that also are related to time. There are two variables that this applies to, sales volume and time on project, see figure 41. However, as the products basically have infinite product lives the lost sales caused by a delay will later be recovered. The total project cost is dependent on project cost per time unit, which is constant, and time on project. A delay that leads to that more time is spent on the project leads to larger project costs and is thus the factor that has the largest influence on the CoD.

Cash flow [EUR]		Year		
		1	…	10
	Sales volume [pcs]:	0	…	10000
	Sales price [EUR]:	0	…	300
	Product cost per unit [EUR]:	0	…	200
	Gross profit [EUR]:	0	…	1000000
	Project cost [EUR/h]:	100	…	0
	Time on project [h]:	10000	…	0
	Total project cost [EUR]:	1000000	…	0
	Accumulated profit [EUR]:	-1000000	…	1000000

Figure 41 The economic variable having the largest influence on the CoD marked in red in the figure.

3. How should the model be designed to be user friendly and how should the outcome of the model be presented to be as understandable as possible?

The most important aspect regarding the design of the model is that it has to be clear where the user will type in data manually and where the outcome will be displayed. The Business Case used at SKF have indications in form of yellow fields for where the user is supposed to type in data and the outcome is marked with blue text and a blue frame, why the same principle have been used for the model of CoD, see figure 42.

Project A	
Weeks of delay:	6
Decision point: (number of weeks into the project)	30
Cost of Delay [EUR/week]:	**833000**
Total Cost of Delay [EUR]:	**5000000**

Figure 42 The fields where the user is supposed to type in data are marked in yellow and the outcome is marked in blue text and a blue frame.

The annual cash flow for the initial planned scenario and the delayed scenario will be presented in a table, in this way the partial calculations of the CoD will be visualised. The sale curves for the two scenarios will also be presented in a graph. The graph will make it easier for the user to overview the cost that a delay would cause and to relate this to the total project profit over ten years.

4. Which is the most profitable way of working, with one project at the time or with several projects in parallel?

Depending on the on-going projects' characteristics different project constellations differs in profitability. If one of the on-going projects is a radical innovation where time-to-market is important not to lose market shares (see Section 2.3.3), or if it is a larger project with high expected profit, it might be more profitable to only work with this project and put the other on hold. However, it is in most cases difficult to have use of all capacity on one specific project, which might lead to that part of the personnel gets underemployed (Ulla Sebestyén, 2006).

The difference between working with one project at the time and working with several projects at the time is rather extreme. If the question instead would be which is the most profitable way of working, with three projects at the time or with six projects in parallel for example, the projects' characteristics and size more or less determinant for the profitability. By instead calculating the CoD for the on-going projects and use this parameter to sequencing the work (see Section 2.2.4), the most profitable way of planning the work can be scheduled.

5. How does other companies prioritise product development projects?

The approach the participating companies in the study have when prioritising product development projects is similar to the ones that SKF has. The most common mentioned parameters used when prioritising projects were strategic reasons, economic risk, and sales potential. In what settings the prioritisations are made varied from informal to formal meetings.

How the different companies takes CoD for projects into account differed between them, the main reason for the differences is that the companies are of various sizes and in different industries. Smaller companies providing less expensive products uses external resources to avoid delays, while larger companies providing more expensive products avoid delays completely. However, the CoD is not used explicit within the companies to prioritise product development projects.

8. Recommendations

For the follow up version of the model of CoD it is recommended that it will follow the same principle as the proposed one in this project but that it is connected to the real Business Case in a separate sheet-tab. This way it is possible to retrieve the necessary data automatically, which will ease the use of the model.

When the calculations of CoD has been performed for a number of product development projects, the output can be used both to prioritise which projects to allocate resources on as well as to schedule how to sequence the work (see Section 2.2.4). By sequencing the work when a number of projects share a certain resource, in terms of an operation, the most profitable order of carrying out this operation will be planned.

The model should also be implemented at the R&D department to calculate the CoD for Research, Technology and Development (RTD) projects. The model should in that case be modified in terms of what variables the total profit of the RTD projects are depending on. As one RTD project often is used for a number of product development projects, where this number in many cases is unknown, it is difficult to calculate the total profit of a RTD project. A recommendation is to develop a method to calculate the average profit for each project to be able calculate the CoD.

References

Accounting Tools, (2013) *Work-In-Process Inventory* [Online] Available at <http://www.accountingtools.com/dictionary-work-in-process-inv> [Accessed: 10 July 2014]

Boardmansauser, (2006) *From TRL to SRL: The Concept of Systems Readiness Levels,* [Online] Available at <www.boardmansauser.com/downloads/ 2005SauserRamirezVermaGoveCSER.pdf > [Accessed: 23 July 2014]

Bryman, A., & Bell, E., (2011) *Business Research Methods*, Oxford University Press, New York, USA

Engwall, M. & Jerbrant, A., (2002) *The resource allocation syndrome: the prime challenge of multi-project management?*, International Journal of Project Management 21 2003 403-409, Stockholm, Sweden

James, S. P., & Lowell, D. D., (2002) *Managing Multiple Projects - Planning, Scheduling, and Allocating Resources for Competitive Advantage,* Marcel Dekker AG, Basel, Switzerland

Lean for Change, (2012) *Cost of Delay* [Online] Available at http://leanagilechange.com/leanagilewiki/index.php?title=Cost_of_Delay [Accessed: 24 July 2014]

NASA, (2012) *Technology Readiness Level* [Online] Available at <www.nasa.gov/content/technology-readiness-level/> [Accessed: 23 July 2014]

Pahl, G., & Beitz, W., (1995) Engineering design*, A systematic approach*, Springer-Verlag London, Great Britain

Pugh, S., (1990) *Total design, Integrated methods for successful product engineering*, Addison-Wesley Publishing Company, Wokingham, UK

Reinertsen, D. G., (2009) *The Principles of Product Development Flow, Second Generation Lean Product Development,* Celeritas Publishing, California, USA

Sebestyén, U., (2006) *Multiprojektledning, skapa puls i produktutveckling med lean tänkande,* Parmatur Handelsbolag, Books-on-Demand, Visby, Sweden

Shah, J. J., (1998) "Experimental Investigation of Progressive Idea Generation Techniques in Engineering Design", Proceedings of ASME DETC 1998, Paper Number DTM-5676, Atlanta, Georgia, USA

SKF, (2014) *Historia* [Online] Available at <http://www.skf.com/se/our-company/skf-historia/index.html> [Accessed: 20 April 2014]

Smith, P. G., & Reinertsen, D. G., (1998) *Developing Products in Half the Time, New Rules, New Tools,* Van Nostrand Reinhold, A division of international Thomson Publishing Inc., USA

The Newredo blog, (2013) *Product Backlog Tools – How to prioritise using the cost of delay* [Online] Available at < http://www.newredo.com/2013/11/22/product-backlog-tools-how-to-prioritise-using-the-cost-of-delay/> [Accessed: 24 July 2014]

Ulrich, K.T., & Eppinger, S.D., (2012) *Product Design and Development*, McGraw-Hill, New York, USA

Wheelwright, S. C., & Clark, K. B., (1992) *Revolutionizing Product Development, Quantum Leaps in Speed, Efficiency, and Quality*, The Free Press A Division of Simon & Schuster Inc., New York, New York, USA

Zwicky, F., (1969) *Discovery, Invention, Research – Through the Morphological Approach*, The Macmillian Company, Toronto, USA

Appendix I: Interview guide - Product Development

Background

Can you please tell me a little bit about your self and your background?
(Education, work experience, for how long have you been working at this department, main job assignments, responsibilities)

How the work is structured today

Do you follow some sort of formal process when working with the product development projects today?

Do you usually follow this process?

What do you think about this process?

Do you follow some sort of decision-making process when you prioritise projects?

Would you consider this way of prioritising projects to be favourable?

What product development activities have the largest capacity utilization?

Which variables are taken into consideration when prioritising projects?

Do you reflect on your prioritisations, for example after a project is ended? If yes, do you document these reflections in some way?

About the projects

You have three types of projects: emergency, fixed date, and First-In-First-Out. Which of these would you consider as the most usual one?

Is it usual that trade-offs has to be made between different parameters within a project? In that case, which are the most common trade-offs?

How long are the products' life cycles in general?

The model of Cost of Delay

Do the Product Development department and the Finance department interact with each other today? If yes, how does this interaction look like?

How aware are you about how different variables affect the cost of a project?

How do you prefer the result of the model of Cost of Delay to be presented?

What calculations would you like to include in the model of Cost of Delay?

Do you have any other comments or opinions about prioritising projects?

Appendix II: Interview guide - Product Engineering

How the work is structured today

Do you follow some sort of formal process when working with designing variants of bearings?

Approximately, how many projects do you usually work with at a time?

Do you follow some sort of decision-making process when you prioritise projects?

About the projects

You have three types of projects: emergency, fixed date, and First-In-First-Out. Which of these would you consider as the most usual one?

What parameters are taken into consideration when prioritising projects?

Is it usual that trade-offs has to be made between different parameters within a project? In that case, which are the most common trade-offs?

Interaction with the Product Development department

Do the Product Engineering department and the Product Development department interact with each other today? If yes, how does this interaction look like?

How does changes in the prioritisation of product development projects affect your work?

Do you have any other comments or opinions about prioritising projects?

Appendix III: Interview guide - Business Development

Background

Can you please tell me a little bit about your self and your background?
(Education, work experience, for how long have you been working at this department, main job assignments, responsibilities)

How your work is structured today and questions about the projects

Do you work in project form at this department? If yes, approximately how many projects are you working on at a time?

Do you consider this way of working to be favourable? Please explain.

Is it usual that trade-offs has to be made between different parameters within a project? (E.g. product performance, market introduction date, product unit cost) In that case, do you negotiate about these parameters together with the customer?

Which are the most common trade-offs?

Do you see a difference between projects regarding the importance of time to market, depending on if the customer is an OEM or if it is an aftermarket customer?

How long are the products' life cycles in general?

Interactions between different departments

Do the Business Development department and the Product Development department interact with each other today? If yes, how does this interaction look like?

How does changes in the prioritisation of product development projects affect your work?

Do the Business Development department and the Sales department interact with each other today? If yes, how does this interaction look like?

Do the Business Development department and the Market department interact with each other today? If yes, how does this interaction look like?

Do you perform market forecasts for different projects or do you get that type of information from another department?

Do you have any other comments or opinions about prioritising projects?

Appendix IV: Interview guide - Sales

Background

Can you please tell me a little bit about your self and your background?
(Education, work experience, for how long have you been working at this department, main job assignments, responsibilities)

How your work is structured today and questions about the projects

Do you work in project form at this department? If yes, approximately how many projects are you working on at a time?

Do you consider this way of working to be favourable? Please explain.

Do you perform market forecasts for new products? If yes, how du you perform these?

Do you calculate market size and market share for upcoming products? If yes, how du you perform these calculations?

Do you forecast the importance of time to market for different products? If yes, how do you perform these calculations?

If a project is being delayed, how do you calculate how this will affect the market share?

Is it usual that trade-offs has to be made between different parameters within a project? In that case, do you negotiate about these parameters together with the customer?

Which are the most common trade-offs?

Interaction with the Product Development Department

Do the Sales department and the Product Development department interact with each other today? If yes, how does this interaction look like?

How does changes in the prioritisation of product development projects affect your work?

Do you have any other comments or opinions about prioritising projects?

Appendix V: Interview guide - Technical Sales

Background

Can you please tell me a little bit about your self and your background?
(Education, work experience, for how long have you been working at this department, main job assignments, responsibilities)

How your work is structured today and questions about the projects

Do you work in project form at this department? If yes, approximately how many projects are you working on at a time?

Do you perform market forecasts for new products? If yes, how du you perform these?

Is it usual that trade-offs has to be made between different parameters within a project? In that case, do you negotiate about these parameters together with the customer?

Which are the most common trade-offs?

How long are the products' life cycles in general?

Interaction with the Product Development Department

Do the Technical Sales department and the Product Development department interact with each other today? If yes, how does this interaction look like?

How does changes in the prioritisation of product development projects affect your work?

Do you have any other comments or opinions about prioritising projects?

Appendix VI: Interview guide - Market

Background

Can you please tell me a little bit about your self and your background?
(Education, work experience, for how long have you been working at this department, main job assignments, responsibilities)

How your work is structured today and questions about the projects

Do you work in project form here in the department? If yes, approximately how many projects are you working on at a time?

Do you consider this way of working to be favourable? Please explain.
Anser du att detta sätt att arbeta på är gynnsamt? Var vänlig att förklara.

Do you perform market forecasts for new products? If yes, how du you perform these?

Do you calculate market size and market share for upcoming products? **If yes**, how du you perform these calculations?

Do you forecast the importance of time to market for different products? If yes, how do you perform these calculations?

If a project is being delayed, how do you calculate how this will affect the market share?

Is it usual that trade-offs has to be made between different parameters within a project? In that case, do you negotiate about these parameters together with the customer?

Which are the most common trade-offs?

Interactions between different departments

Do the Market department and the Product Development department interact with each other today? If yes, how does this interaction look like?

How does changes in the prioritisation of product development projects affect your work

Do you have any other comments or opinions about prioritising projects?

Appendix VII: Answers from Company A

A – Company A
P – Pernilla Lydén

P: Hur prioriterar ni produktutvecklingsprojekt i det dagliga arbetet när det kommer till att fördela gemensamma resurser bland projekten? Följer ni någon form av formell process när ni prioriterar produktutvecklingsprojekt idag?
A: Komplex organisation, vi är 5000 anställda inom produktutveckling. Först har vi en förutveckling (t.ex. forskning) som kan bli produkter, då prioriterar vi enligt strategiska skäl, nya material, vart vill vi vara om X antal år, ganska tydlig process, enligt form av pengar. Sedan arbetas det med kunderbjudanden, plan för 5 år framåt, vi vet vad vi ska erbjuda (kan dock ändra sig), tydlig process, strategisk planering ihop med marknad, vilka produkterbjudande (det här är ej produktutveckling). Sedan har vi produktutveckling, inom 3 år vill vi lansera det här tillsammans med design, vi tittar ej på resursperspektivet (i form av ”personlig kompetens”) utan vad har vi råd med. Vi har ca 7-8 miljarder om året som vi får välja att placera ut inom aktiviteterna (förutveckling, nuvarande erbjudanden, nya erbjudanden).

P: Tar ni kostnaden för förseningar av projekt i beaktning när ni prioriterar projekt i det dagliga arbetet?
A: Vi har inga förseningar, inser vi att ett projekt inte kommer att vara lönsamt (innan marknadsföring och tillverkning av det har startat) lägger vi ned det. Eventuellt byter använder vi oss av nuvarande komponenter istället i nya erbjudanden.

Appendix VIII: Answers from Company B

B – Company B
P – Pernilla Lydén

P: Hur prioriterar ni produktutvecklingsprojekt i det dagliga arbetet när det kommer till att fördela gemensamma resurser bland projekten?
B: Vårat företag jobbar ofta på uppdrag av kunder och valet av att delta i ett utvecklingsprogram är ett strategiskt val som baseras på lönsamhet. Det ses som en affär bland andra affärer. Kostnaderna för produktutveckling bedöms och påverkar affären eftersom kostnaden tas tidigt i livscykel av produkten. I uppskattningen görs riskanalyser och bedömningar av förseningar och kostnadsöverdrag. De projekt som startas ska vi bemanna med gemensamma resurser för att undvika förseningar och brist på kompetens/kapacitet. Resurser som stöttar alla produktutvecklingsprojekt, allokera till respektive projekt efter kompetensprofil och svårighet på jobb. Vi har under dem senaste åren försökt undvika att hamna i prioriteringsproblem genom att styra projekten på kostnader och låta linjeorganisationen som försörjer projekten planera och skaffa resurser enligt dem behov som projekten har. Denna planering sker månadsvis och sträcker sig 2 år fram i tiden. Egen personal med hög kompetens tar lång tid att bygga upp medan generell kunskap går att skaffa med konsulter som går relativt snabbt att få i arbete. Om vi får stabila planer så klarar vi av att använda resurser på ett sätt som inte skapar behov av prioritering. Om vi ändå (vilket händer) skulle behöva resurser på samma ställe samtidigt sker denna förhandling mellan dem som ansvarar för projekten och om detta inte går eskaleras frågan vidare till Head of Engineering and Technology vår tekniske chef som stöttar VD att fatta beslut om vilket projekt som är mest kritiskt. Beslutsunderlaget är en kombination av konsekvens för kund, ekonomisk påverkan, förseningar och resursbehov osv. Oftast kommer vi överens innan frågan tas av ledningen. Denna prioritering lyfts upp på en tavla (Visual system) där alla korta brister hanteras. Långsiktiga brister hanteras i den månatliga planeringen. Detta sätt att hantera projektbehov som sällan är stabila eller förutsägbara bygger på att det finns en tillräcklig flexibilitet att öka och minska tillgängliga resurser. Vi jobbar därför med att hela tiden värdera vilken kompetens vi ska bygga upp, vilken vi ska köpa och hur detta ska gå till. Att minska ledtiden för upprampning och nedrampning av resurser är också en fråga som vi jobbar med.

P: Tar ni kostnaden för förseningar av projekt i beaktning när ni prioriterar projekt i det dagliga arbetet?
B: Vi tar kostnader för försening i beaktande. Enligt modellen ovan blir det viktigt att inte bara titta på ekonomiska konsekvenser utan också risk för ökade resursbehov. Man kan gardera sig med en ekonomisk riskhantering och på så sätt prognostisera företagets resultat bättre i relation till tekniska risker och komplexitet. Det man ofta missar är att dessa pengar (när något händer) ska omsättas i erfarna ingenjörer och kapacitet i maskiner. Denna del av riskerna behöver också hanteras och beaktas. Totalt blir det en fråga om att väga ekonomisk risk/kostnad/försening mot förmågan att göra jobbet. Finns t.ex. ledig kapacitet längre fram? Detta spelar så klart stor roll när prioritering ska göras. Frågeställningen blir snabbt komplex. Man måste hela tiden försäkra sig om att den konsekvens som vi planerar emot är en korrekt bedömning av läget.

Appendix IX: Answers from Company C

C – Company C
P – Pernilla Lydén

P: Hur prioriterar ni produktutvecklingsprojekt i det dagliga arbetet när det kommer till att fördela gemensamma resurser bland projekten? Följer ni någon form av formell process när ni prioriterar produktutvecklingsprojekt idag?
C: Vi har ett ledningsgruppsforum en gång per vecka där vi stämmer av projekt samt linjeuppdrag, där sker prioriteringar vid behov alternativt om vi skall tillsätt extern resurs för att hålla tiden. På daglig basis så kör vi morgonmöten för dagsplanering.

P: Tar ni kostnaden för förseningar av projekt i beaktning när ni prioriterar projekt i det dagliga arbetet?
C: Vi har inte kostnadssatt förseningar på ett systematiskt sätt men när projekten är inne i slutfaser så blir kostnadskonsekvenser väldigt tydliga, i tidig fas har vi ingen metod för beräkning av kostnader på grund av försening.

Appendix X: Answers from Company D

D – Company D
P – Pernilla Lydén

P: Vad har du för erfarenhet av hur olika företag prioriterar produktutvecklingsprojekt i det dagliga arbetet när det kommer till att fördela gemensamma resurser bland projekten?
D: Den generella bilden är att det ser helt olika ut i olika företag. Även om många företag vid en första anblick ser ut att ha ett system för detta baserat på olika mätetal kan det i praktiken gå till på helt andra sätt. Informella diskussioner, politik och annat kan ha större påverkan. Mycket beror också på vilken typ av projekt det är så även inom samma företag kan det se olika ut och variera från projekt till projekt. I en portfölj av projekt kan vissa projekt drivas av strategiska skäl, andra av ekonomiska skäl också vidare.

P: Har du erfarenhet av att företagen tar kostnaden för förseningar av projekt i beaktning då de prioriterar projekt i det dagliga arbetet?
D: Intressant och viktigt mått, men personligen anser jag att det enbart skall användas för att prioritera inom ett enskilt projekt, d.v.s. vid jämförelse mellan olika alternativ i ett enskilt projekt. För att prioritera mellan projekt tycker jag att man skall mäta det man vill ha och inte det man inte vill ha. För att citera Taguchi – If you want quality don´t measure lack of quality”. Personligen känner jag inte till något företag som använder det som viktigaste måttet för att prioritera mellan projekt.

Appendix XI: Answers from Company E

E – Company E
P – Pernilla Lydén

P: Hur prioriterar ni produktutvecklingsprojekt i det dagliga arbetet när det kommer till att fördela gemensamma resurser bland projekten?
E: Jag skulle säga vi prioriterar främst efter vilken 1) försäljningspotential vi bedömer varje projekt har och 2) hur mycket arbete som kvarstår innan vi kan lansera 3) sannolikheten att vi stöter på nya problem innan vi hinner i mål och hur omfattande dessa problem kan tänkas vara 4) vilka investeringar kan komma att krävas (formverktyg och dylikt), vilken unit cost som kan bli realistisk och hur denna förhåller sig till priset våra kunder kan tänkas vara beredda att betala för produkten.

P: Tar ni kostnaden för förseningar av projekt i beaktning när ni prioriterar projekt i det dagliga arbetet?
E: Kostanden vid försening består för oss främst i uppskjuten/missad försäljning av den nya produkten. Och det kan man väl säga att vi tar i beaktande i och med punkt 1. Det stora problemet är väl att det alltid finns en stor osäkerhetsfaktor när man produktutvecklar. Det är svårt att veta omfattningen på eventuella problem man har framför sig på vägen till målet innan problemen hunnit uppenbara sig. Hade man vetat exakt hur vägen med alla hinder man måste ta sig igenom innan lansering såg ut för varje projekt hade man nog kunnat prioritera betydligt smartare. Det är ju dessvärre omöjligt att förutse de flesta problemen innan man jobbat på en bit och faktiskt stött på dem. Ju mer erfarenhet man får desto bättre känsla kan man dock få för att t.ex. koncept A kommer nog bli krångligt att realisera pga. område X, koncept B har inte lika häftig potential men kommer nog vara lättare att ta till marknaden snabbare eftersom man har en hyfsad bild över hur varje komponent kan tillverkas etc. Sen får man försöka väga dessa faktorer mot varandra och göra en prioritering och hoppas man bedömt rätt.

Appendix XII: Answers from Company F

F – Company F
P – Pernilla Lydén

P: Hur prioriterar ni produktutvecklingsprojekt i det dagliga arbetet när det kommer till att fördela gemensamma resurser bland projekten?
F: Det vi tar hänsyn till är flera olika saker:

- Värdet av projektet när det kommer fram till marknad, NPV relaterat
- Hur stor chans det har att lyckas (här har man en standard modell som ger samma sannolikhet till alla projekt som ligger inom samma fas i innovationstratten)
- Hur det sett ut hittills inom projektet (andelen gröna, gula och röda ljus som indikerar hur projektet gått gentemot projektplanen, där tid är en parameter, kostnad mot plan en annan)
- Andelen koncept mot andelen utvärderingsprojekt mot andelen utvecklingsprojekt mot andelen lanseringsprojekt
- Förändringar på marknaden där vi måste svara mot vad konkurrenterna just lanserat

P: Tar ni kostnaden för förseningar av projekt i beaktning när ni prioriterar projekt i det dagliga arbetet?
F: Ja, som en faktor av många, men bara med hänsyn taget till tiden i sig, inte till kostnaden för att vara försenad. Det är ju, enligt mitt tycke, ett överstyrt system när man både skall hålla sig till budget OCH tid. För om man ligger efter i tid måste man vanligtvis sätta till extra resurser (läs *pengar*) för att kunna leverera i tid. Undersökningar har visat att det för vissa kritiska projekt med stort förväntat värde är så mycket viktigare att hålla tiden för lanseringen, det så kallade lanseringsfönstret, än att hålla kostnaden för projektet i sig. För andra mera inkrementella projekt är det kanske mer viktigt att kunna lansera till en låg kostnad

Appendix XIII: Answers from Company G

G – Product Developer Manager
P – Pernilla Lydén

P: Hur prioriterar ni produktutvecklingsprojekt i det dagliga arbetet när det kommer till att fördela gemensamma resurser bland projekten?
G: Inom divisionerna (Fordon, Industri och Textil) är det respektive divisionsledning som prioriterar mellan projekten. Är det mindre frågor reder vi ofta ut det direkt. Är det resurser utanför divisionsgränserna (d.v.s. gemensamma resurser) görs prioriteringen tillsammans. Ofta gör vi en enklare konsekvensanalys. Dock tror jag att vi ofta prioriterar tid före kostnad. Vi har även ett möte (kallat portfölj råd) cirka 2 gånger per månad där större prioriteringar kan göras. Deltagare här är divisionsledning, marknadsledning, CEO, CTO.

P: Tar ni kostnaden för förseningar av projekt i beaktning när ni prioriterar projekt i det dagliga arbetet?
G: Ofta ser vi det ur ett kundperspektiv, där kundens önskemål och krav värderas högt.

Appendix XIV: The model of CoD – More time needed

Project A

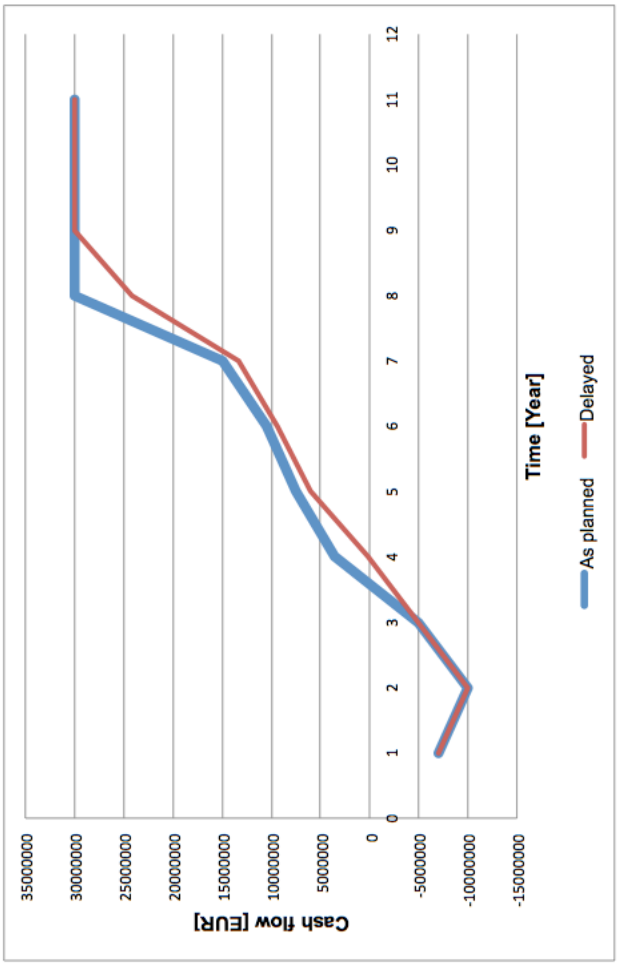
Weeks of delay: 20

Decision point: 30
(number of weeks into the project)

Year	Cash flow [EUR] As planned	Cash flow [EUR] Delayed
1	-7000000	-7000000
2	-10000000	-10000000
3	-5000000	-5000000
4	3500000	231000
5	7490000	5960000
6	10500000	9340000
7	15000000	13300000
8	30000000	24200000
9	30000000	30000000
10	30000000	30000000
11	30000000	30000000
12		11500000
Accumulated profit:	139000000	125000000

Cost of Delay [EUR/week]: 700000

Total Cost of Delay [EUR]: 14000000



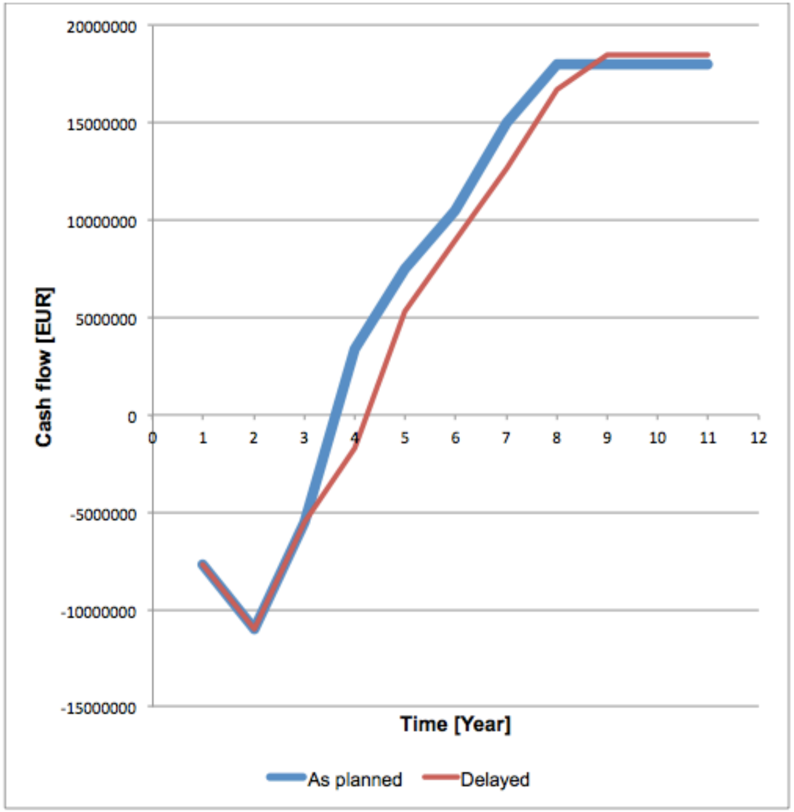
Appendix XV: The model of CoD – Modifying a feature on the product

Project A

Weeks of delay:	30
Decision point: (number of weeks into the project)	30
Change in sales volume [% per year]:	5
Change in sales price per unit [%]:	0
Change in product cost per unit [%]:	1

Year	Cash flow [EUR]	
	As planned	Delayed
1	-7700000	-7700000
2	-11000000	-11000000
3	-5500000	-5500000
4	3400000	-1700000
5	7490000	5280000
6	10500000	8990000
7	15000000	12700000
8	18000000	16700000
9	18000000	18500000
10	18000000	18500000
11	18000000	18500000
12		10700000
Accumulated profit:	88600000	88400000

Cost of Delay [EUR/week]:	**6670**
Total Cost of Delay [EUR]:	**200000**



Appendix XVI: The model of CoD – Project on hold

Project A

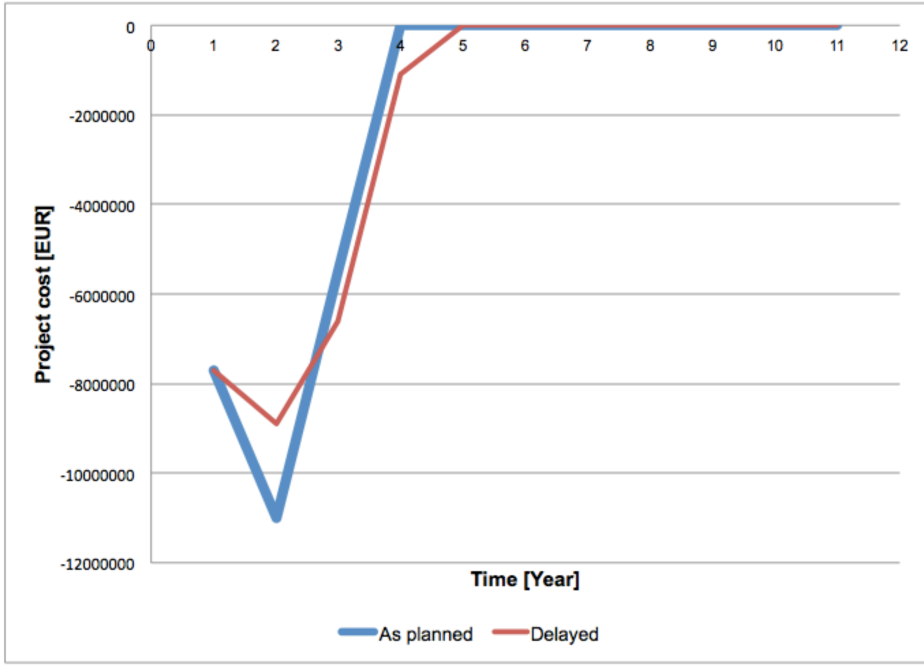
Weeks on hold: 10

Decision point: 104
(number of weeks into the project)

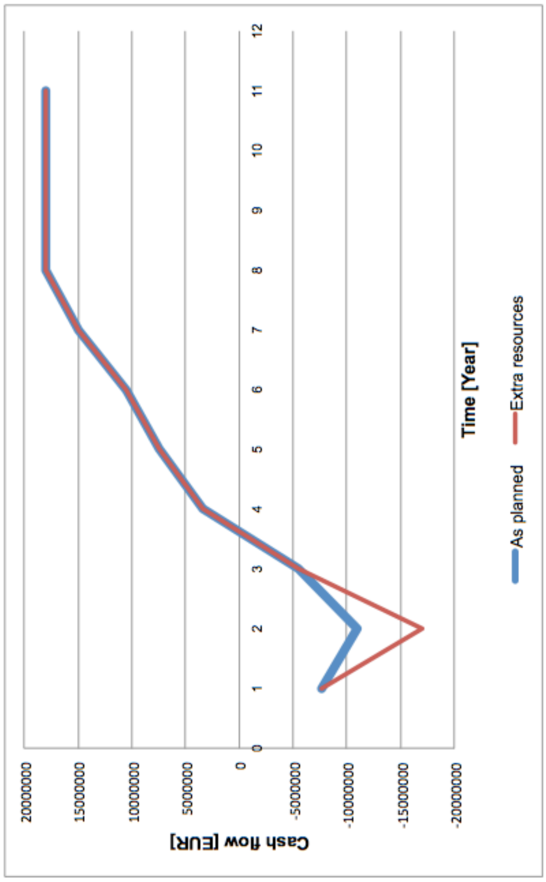
Year	Project cost [EUR]	
	As planned	Delayed
1	-7700000	-7700000
2	-11000000	-8900000
3	-5500000	-6600000
4	0	-1100000
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
Accumulated cost [EUR]:	-5500000	-7700000

Cost of Delay [EUR/week]: 220000

Total Cost of Delay [EUR]: 2200000



Appendix XVII: The model of Cost of preventing delay



Project A

Extra resources on the project [Man-hours]: 5000

Decision point: 110
(number of weeks into the project)

Year	Cash flow [EUR]	
	As planned	Extra resources
1	-7700000	-7700000
2	-11000000	-17000000
3	-5500000	-5500000
4	3400000	3400000
5	7490000	7490000
6	10500000	10500000
7	15000000	15000000
8	18000000	18000000
9	18000000	18000000
10	18000000	18000000
11	18000000	18000000
Accumulated profit:	104000000	104000000

Cost of no delay [EUR]: 5500000