The Impact of Business Risks on IT Projects

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Preface

The final part of the graduate program of the discipline Business Mathematics and Informatics consists of doing an internship at an institute or company. The objective of this internship is to solve a real world problem by means of the knowledge gained during the preceding years of the study, emphasizing the three components of the BMI study: economics, mathematics and informatics.

My internship was for a department that focuses on operational risk management. In this department a lot of effort is put into recognizing the key indicators that determine the risk an (IT) project is exposed to. This knowledge is used to determine which risk-mitigating measures can or must be taken. Much less is known however on the impact of these risks, especially the ones that include unforeseen events that influence the result of the project. These risks are called business risks, and it is on this type of risk that the objective of this internship focuses: to investigate the impact of business risks on IT projects.

In this document we will describe how we researched this question, along with the results, conclusions and recommendations of our research. Please do not hesitate to contact me at *asn270@few.vu.nl* in case of any questions.

Furthermore, I would like to express my sincere gratitude to my supervisors, Laurenz Eveleens, Rob Peters, Chris Verhoef and the contact at the organization for providing the opportunity to do this internship, as well as their assistance during the research and their help in writing this report.

Executive summary

This report contains a description of the research performed as a part of my internship. This research was concerned with the risks involved in IT projects, and focused on the question:

What is the impact of business risk on the value proposition of IT projects?

In order to answer the research question on the impact of business risk on the value proposition of IT projects, an analysis was made of a projects portfolio. This analysis was made using a simulations program created for this purpose. The input for this simulation consisted of specific project information that was taken from project business cases. This information concerned, among others, the project duration, project type, probability of failure and estimations on the costs and gains of the projects, completed with an expert's opinion whether the estimations were overestimated, underestimated or fairly estimated.

Using the information above, the costs and gains were simulated resulting in a simulated project or portfolio NPV. We compared these simulated portfolio NPVs to what was predicted to draw conclusions on the impact of both IT and business risks. From the analysis we drew the following conclusions:

- The entire portfolio: An analysis of the entire portfolio showed that a cumulative 50 million euro NPV, which was predicted in the business cases, was only realized in less than 1% of all simulations. Furthermore, the simulations showed that in merely 10% of all runs a positive portfolio NPV was realized, with a mean of −47 million euros.

- Mandatory and discretionary projects: Using the simulations we also discovered a large difference between the mandatory projects and the discretionary projects. For the discretionary projects the difference between the predicted NPV and what was simulated is rather large, the mandatory projects on the other hand are predicted rather well on average. Part of the difference between these types of projects can probably be attributed to the level of competition between the types of projects.

- Commercially strategical project: Also the commercially strategical projects were considered in detail. These are the types of project for which the difference between the simulated and predicted NPV is largest. A predicted cumulative NPV of 70 million euros was only realized in less than 5% of all simulations, and a negative cumulative NPV is no exception. The average NPV in the simulations was 20 million euros.

- IT risks and business risks: In the analysis of the portfolio, we also consider the impact of the types of risks separately. This analysis shows that the difference between the predicted and simulated NPV is mostly a result of business risks. Mitigating the business risks shows better results than mitigating the IT risks.

- Project failure: The simulations show that a large part of the deviation in NPV is a result of project failure. Reducing the probability of failure is very efficient in increasing the simulated NPV.

Based on the results of our simulations we recommend that much effort should be applied to making sure that expected gains are met. Project failure prevention, a part of IT risk mitigation, is shown to be a highly effective endeavor as well. The simulations show that much can be gained from improved business risk mitigation and project failure prevention. We believe that as a first step in the analysis of a project portfolio these outcomes provide valuable information. Not just having an idea on the best guess of a portfolio's NPV, but also having some notion of the best and worst case scenarios is very useful in the decision making process.

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1 Introduction

Over the past decades information technology (IT) has become more and more important to business and our daily lives. Information is readily available at any moment, in enormous amounts, and communication is almost purely electronic. For the most part, paper filing cabinets in offices have been replaced by large databases full of information, accessible from multiple locations at any moment. IT has risen to be one of the most important factors in communication and the way information is available to us.

This rise of IT has had its share of effect on the way business is conducted. Not a single business decision can be made without considering the effects it will have on the business' IT, because in today's companies IT is everywhere. Information technology can provide new business opportunities that would otherwise be unfeasible.

With IT being such an integral part of everyday business in companies, it is important to make the proper decisions regarding IT. A large part of these decisions in practice is the approval or denial of project proposals. The decision maker is provided with information about the nature of these projects, its predicted costs and gains, and the risks involved. When the whole concept of the project is appealing, the project is approved and will be launched sometime thereafter. According to the organization, project proposals are more than three times the amount of money available for project development, meaning that on average only one in every three projects can be approved.

Decision makers that find themselves in such a position have the opportunity to only pick the best projects to be developed. But which projects are most promising is not a decision easily made. Even with complete information on the project it is hard to determine which ones should be approved and which ones should be denied. During the course of the project unforeseen events might occur that can cause the result of the project to differ from what was initially expected. To help in this decision making process we will provide a way to present the available information in a structured manner to get a grasp on the project's expected revenue, along with its uncertainties and risks and their impact on the project's result.

1.1 Problem description

This section will discuss the decision making process in more detail and show how our investigation relates to this process. When managers want a project to be approved they submit a project proposal to one or more decision makers. This project proposal, often called the *business case*, describes the project, including its reasons, its value to the organization and other important aspects of the project. The managers realize that in order for the decision maker to approve the project they need to make the project look appealing, or convince the decision maker the project absolutely has to be done. So either the project is *mandatory* for some reason (e.g. external obligations), or the *economic indicators* of the project appeal to the decision maker: it creates value for the company.

Some part of the annual IT budget goes to mandatory projects. These are the projects that have to be done. This can be for two different reasons. The first is because it is an obligation to one or more external factors, these projects are considered mandatory. The second reason for a project to be mandatory is for *continuity* reasons. An example of this is when a running system needs an update because the current version is no longer supported by its manufacturer.

When a project is not mandatory, there has to be another reason why it should be approved. In our research, we distinguish two types of discretionary projects, the commercially strategical projects and the maintenance projects. Examples of these two project types are the launch of a promising new product, and maintenance on a running system. These projects are not chosen for their necessity but because they can be interesting to the company. Managers aim to create an appealing project proposal, one that shows that the project creates value for the company. How much and how soon these projects create value can be indicated by using *economic indicators*, such as:

- Net Present Value (NPV): an indication of the net value of the project, valued in terms of today's money.
- PayBack Period (PBP): this indicator gives information on when we can expect to earn back the initial investment, which tells us something about the risks in general.
- Internal Rate of Return (IRR): an indication for the risk measure of the project.
- Return on Investment (ROI): indicates the initial investment compared to the predicted return.

When these indicators are promising the project can be approved. The first three of these were used in the business cases that we studied.

The projects that are approved will be launched after some time, but even though a project is approved based on its economic indicators or because it is mandatory, it is still possible that unforeseen occurrences delay the project, increase its costs or sometimes even cause it to fail. There are project characteristics that are known to be an early indicator of possible future problems in a project. One example of this is the total costs of the project. When the total costs of a project are high, then often the size and/or the complexity of the system to be built are high, making the risk of its failure higher than normal. There are several of these characteristics, and together they determine the aggregated risk for a project. This aggregated risk is called the *risk exposure*, and the project managers will often use available resources to mitigate the total risk exposure. Based on the risk analysis, a sound decision can be made on which risks should be mitigated to produce optimal results using available resources.

The project characteristics mentioned above can be divided into two types of risks. These two types of risks are *IT risks*, referring to the risks of events occurring during the development phase of the project. And *business risks*, which are the risks of events that cause the result of the project to be less than was initially predicted. The risks in the IT domain can result in increasing costs of a project, whereas business risks will result in uncertainty in the gains that a project will produce.

Even though a lot of effort goes into the mitigation of IT risks and business risks, there will always be some level of residual risk, in both the IT domain, and the business domain. On the impact of IT risks existing literature can be found. Consider for example [16], where Verhoef provides handles to assess certain risks in IT development with the use of benchmark formulas created from IT project data. Business risk however, is somewhat of an uncharted territory. We are interested in these types of risks and their impact on IT projects. In other words, our objective is:

What is the impact of business risk on the value proposition of IT projects?

In order to do this we will study a large number of business cases. Using these business cases we can form an idea of the project decision making process and the information the decision makers are provided with to base their investment decisions on. We will then use this knowledge, completed with the experience of an expert on the realization of the costs and gains, to show how the *predicted value* of the projects is influenced by the project risks to produce an often different *actual value*.

The difference between the predicted value and the actual value can be a result of the uncertainties in the gains, costs, or a combination of both. As mentioned before, uncertainties in gains can be subscribed to business risks and uncertainties in costs to IT risks. This notion on the risks and their effects can be used to draw conclusions from simulated project results.

Next to simulated results at the project level, we will also use simulations to produce results for multiple projects at once, at the *project portfolio level*. Firstly, this will provide the decision makers with insights to draw conclusions on the impact of business risk on portfolio level, and it will also allow the decision maker an insight in the possible range of outcomes based on the predictions given in the various business cases.

Next to the research question that we investigate in this report, we will also consider other important, similar issues, such as the relation between the impact of different types of risks. This will allow us to draw conclusions and provide recommendations about the project decision making process and project management.

1.2 Overview

In Section 2 we will start with some background information that is useful for understanding the setting of our investigation, this includes a description of the concept of operational risk management, project management and business cases. Next, in Section 3, we will discuss the existing literature on the subject of IT project development, and in Section 4 we will describe the data that was made available to us, and how that data was used to create a useful data set. Section 5 describes the program that was created to simulate the project execution. In Section 6 we will present the results of the simulations, and in Section 7 we will interpret them and synthesize conclusions and recommendations. The report is concluded with a list of references.

2 Background information

Before we address our approach to answer the research question it is useful to provide some background information about the setting of our investigation. This information was used for assessing the business cases we received and interpreting the information contained in these business cases. We will discuss the concept of operational risk management, and show how our research relates to this area. In the final subsection we discuss project management and business cases.

2.1 Operational Risk Management

The assignment is set in the organization within a department that focuses on operational risk management. Operational risk is defined as "the risk of loss resulting from inadequate or failed internal processes, people and systems, or from external events". Most important in risk management is identifying and defining the risks the firm is faced with and dealing with these risks by assessing them and taking measures to minimize their impact and probability of occurrence, called *risk mitigation*.

To assess the operational risk of a company we must analyze the size and scope of the potential losses, along with their rate of occurrence. When we are aware of all possible risks and their probabilities and impact, we know the total operational risk exposure of the company. The higher the risk exposure, the higher the potential losses, and therefore the higher the organization's financial buffer must be to be prepared for possible losses. Any amount of money that has to be reserved is an amount the organization cannot use so the organization will want to keep this risk exposure a a minimum. The best way to do this is by having an extensive knowledge on the risks the company deals with: risk management. In short, the reasons for operational risk management are:

- Creating an overview of all operational risks: Having an overview of the risks that the company is exposed to is useful in maintaining a clear view on the operational risks and creating awareness among project managers.
- Decreasing costs of operational damage: In any case, if we want to mitigate operational risks we want to focus our available resources on mitigating the most important risks (the ones with the highest impact and probability of occurrence). In order to do this we need to have an as complete as possible overview of all operational risks involved.
- Maintaining a lower financial buffer: Having an accurate view on the total operational risk exposure to the company helps to keep the needed financial buffer as low as possible
- Protecting the reputation of the company: Failing processes and incidents are not good for the reputation of any company. Knowing the operational risks and being able to mitigate them timely aids in keeping these to a minimum, and along with it the damage to the company's reputation.

As mentioned before, the potential operational risk factors to a project are carefully monitored in this organization. These are the risks we are interested in and more specifically, the impact they can have on a project's result.

2.2 Projects

In the process of project approval or denial a number of factors are considered. First, when a project is considered to be legitimately mandatory, then it should always be carried out, possibly in an adjusted form. For the projects that are not mandatory, other factors determine whether or not the project should be approved or not. The economic indicators summarize important characteristics of the project. The NPV is a measure for the value that is created by the project. The PBP gives a notion on the time it takes for the project's investment to be earned back, and the IRR gives information on how risk sensitive the project is. In order for a discretionary project to be approved these indicators will have to be sufficiently positive. Another important factor in project decisions is the level of risk involved in the project. It is important to have a thorough knowledge on the level of risk involved in a project, so it becomes clear to the decision makers what level of risk and what types of risk the project is exposed to. The justification for the project, the economic indicators, the risk analysis, and all other important information on the project are discussed in a document, called the *business case*. The business case is submitted to the decision makers (executives) and the investment decision is based on this document.

In practice, the decision of approval or denial of the project is made considerably more difficult due to the politics involved in the collection of project proposals, two examples of this are:

Because project managers are appreciated and sometimes rewarded for managing to keep their project within budget, they tend to overestimate the costs involved, thereby safeguarding that they don't overrun the budget. However, when they overestimate the costs, they have to do the same for the gains of the project to make sure that the project still gets a positive NPV and an acceptable PBP. This highly endangers the value of the information in the project proposals, which is the only information the executives have to base their investment decisions on.

Another imaginable scenario is that the project manager overestimates the gains, and underestimates the costs, to create a more appealing project proposal. Also in that case, the information the executives have to base their decision on is politically biased.

Needless to say it is important for the company to have a maximum reliability of the information in the project proposals. If the information is not reliable the wrong projects may be selected, so that other, possibly more profitable, projects are rejected. This has a negative effect on the value that is created by the project portfolio.

When discussing project management, a distinction can be made between product based and process based project management. When projects are managed according to the Prince2 principles, a process based project management methodology, the focus is on the processes that constitute a project. The business case is then not only used to base the investment decision on, it also provides a guideline for the management of the project.

Business Case

Whether an investment decision truly is the best decision strongly depends on the quality of the business case it was based on. Business cases are written to justify an investment proposal, the justification can either be a positive NPV or some other value to the organization. Based on the business cases, management can set priorities regarding allocating the available resources to the projects with the highest value proposition. When a project is managed according to the Prince2 principle the business case provides a means for proper project management, for example by making a risk assessment and proposing a project team. They check if there is sufficient capacity available to assure that the benefits can be delivered, and they show the interdependencies between several projects or business units that have to be taken into account. To this end, ideally a business case should contain the following information [14]:

Strategic fit: In the first section of the business case the justification for the project is discussed, and it is argued how the project fits into the overall business strategy of the company.

Objectives: The second section of the business case deals with why the project needs to be done, and the most important benefits that can be expected from the project are discussed. This section is concluded with a subsection on the critical success factors of the project. These factors can be used to measure the success of the project, and are thus very useful for evaluations during the course of the project.

Options appraisal: In this section an analysis of several options for implementing the project is included. A cost/gain analysis is included along with a description of the intangible benefits for all options. According to this analysis the best option is chosen.

Commercial aspects: The arrangements are made with possible external influences in the project. For example the contract terms with an outsourcing company.

Affordability: The affordability of the project is discussed, the link is made between a total cost analysis of the project and the available budget for the project if it is approved.

Achievability: In this section the project outline is described. The key milestones of the project are considered, along with the interdependencies with other projects and a risk analysis.

Source information: Finally, the required documentation is included along with for example the high level requirements and the business strategy.

This business case provides a solid foundation for an investment decision. Another purpose of the business case is to provide a framework for the development of the project.

Above we discussed the importance of the business case to provide sound information to base investment decisions on. We showed some of the information contained in the business cases used by our organization. Part of the business cases involves an assessment of the risks involved in the project. This thesis was done within the context of the department that makes these assessments.

3 Literature

In this section we will first discuss the literature on investments, explaining in more detail the notion of NPV and the other economic indicators. After that we will focus more on the specific IT investments literature that was also important in the development of the simulation model. The information in this section will then be applied to the data in Section 4, where we clean the raw data so that we have a workable data set to base our simulations on.

3.1 Investments

Understanding the time value of money is crucial in quantifying the value of any investment. The time value of money is a concept of finance that is used in financial analysis and begins with the understanding that 100 euros today does not have the same value as 100 euros tomorrow. Suppose we have the choice to either receive 100 euros right now (option 1), or receive 100 euros 5 years from now (option 2). If we receive the money right away we can take the money to the bank and receive 5 years of interest more than if we choose to receive the money 5 years from today. This means that at an interest rate of 6% option 1 is worth roughly 33% more than option 2. So receiving 100 euros today roughly equals receiving 133 euros 5 years from now. In the same way, we can say that receiving 100 euros in 5 years, is worth roughly the same as receiving 75 euros today, with an interest rate of 6%. Analogous to the previous example we can calculate the present value of any future cash flow if we know how much more money can be earned by receiving it today. It is the answer to the question: what amount of money do we have to put on the bank today to have 100 euros 5 years from today at an interest rate of 6%? The answer is:

$$X \cdot (1+r)^5 = 100$$

leading to:

$$X = \frac{100}{(1+r)^5} = \frac{100}{1.06^5} = 74.73$$

In this way, we can express a future cash flow (FV) in t years in its present value (PV):

$$\mathrm{PV} = \frac{\mathrm{FV}}{(1+r)^t}$$

The r in this formula is also called the discount rate and is based on the other investment possibilities and risks of the investment. By using this r, the value of the investment is compared to the other investment possibilities and this way the outcome represents the net value of the project expressed in present day money: the Net Present Value. In other words the Net Present Value of an investment is the future stream of benefits and costs converted into equivalent value today. The discount rate we use will have much influence on the calculated NPV. Therefore we must very carefully choose this rate and it must reflect all risks involved in undertaking this investment. A commonly used measure is the Weighted Average Cost of Capital. The WACC is an index representing the expected return on all of a company's investments, so if an NPV is negative, the project does not meet the company's requirements for a beneficial project. Consider the following example of the calculation of the NPV of a project:

Example 1
Consider this investment:

- Initial investment of \$2 million
- Will be operational for 5 years
- Benefits are \$450.000 per year
- Retirement will make an additional \$700.000 at the end of year 5
- The WACC is 10%

$$\text{NPV} = -2000000 + \frac{450000}{1.1} + \frac{450000}{1.1^2} + \frac{450000}{1.1^3} + \frac{450000}{1.1^4} + \frac{1150000}{1.1^5} = 140.499$$

The NPV of the investment is considerably lower than considering merely the cash flows. For a Weighted Average Cost of Capital of 10% the NPV is \$140,499. The higher the WACC, the lower the NPV, until eventually it becomes negative. For instance, for a WACC of 12% the NPV decreases to \$20,000, and a WACC = 13% returns a negative NPV. As mentioned before, if the NPV of a project is negative, the investment will cost more than it will deliver. The Internal Rate of Return is the discount rate for which the NPV becomes zero, which in this case would be between 12% and 13%, to be more exact: IRR = 12.34%.

Another economic indicator that was mentioned in the introduction is the Payback Period. This is the amount of time that must pass before the gains of the project will have made up for the initial investment. For Example 1, this would be after 4 years and 6 months. If the Payback Period is too long, the investment is less attractive and combined with a low NPV, the choice can be made not to opt for this investment.

The three economic indicators that were mentioned in this section, the NPV, the PBP and the IRR are all calculated in the business cases to partially base the investment decision on.

3.2 IT investments

In the following subsection we discuss the literature on a more specific type of investment, the information technology investment. To do this, let us first discuss the concept function point. The function point is a unit of measurement to express the amount of functionality an information system provides to a user [16]. It is language independent and it can be used for all kinds of estimations and benchmarking for IT investments. The method of measuring the size of an information system and expressing it in a number of function points is called Function Point Analysis, and its methods are kept up to date by FPA user groups like the International Function Point Users Group.

Knowing the function point size of a project can be very useful. Using data from numerous companies and projects the relation between key performance indicators of projects was studied. This resulted in several so called *benchmark formulas*. These formulas can be used to calculate a project's characteristic from another. For example, if we know the number of function points of a project we can use a benchmark formula to calculate the expected total cost of development, or the lifetime of the system, or the chance of project failure.

In [16] Verhoef presents a number of benchmark formulas to estimate key performance indicators of IT projects. For our research, we will use a number of these formulas from that paper:

Project duration: Given the function point size of a project it is possible to make an estimation of the project duration. In his paper Verhoef summarizes a lot of known benchmarks from the literature. Among the benchmarks is a formula that describes the relation between project duration and function point size:

$$f^{0.39} = d$$

In this formula f stands for the total number of function points, and d for duration of the project in months. So a medium sized project of a 1000 function will take 14.7 months to develop according to the formula. The power of 0.39 varies depending on the industry, and it has much influence on the outcome of the formula, so before the use of this formula it needs to be carefully considered.

Software lifetime: If we are interested in the gains that can be expected from a system, we want to know something about the software lifetime. As it turns out the function point size of a project also relates to the software lifetime. Using the previous formula we can calculate the project duration d from the function point size, and just like the duration can be derived from the function point size f, the software lifetime y can be derived from the project duration d, using the following formula:

$$y = d^{0.641}$$

Suppose we take the 1000 function points project from the former example, the expected software lifetime of that project is 5.6 years.

Risk of failure: With an increase in size of a project, the chance of failure of the project increases as well. How high this chance of failure is, can be determined with the following formula:

$$cf = 0.4805538 \cdot (1 - exp(-0.007488905 \cdot f^{0.587375}))$$

From this formula we can derive that, based on the function point size, the chance of failure for a 1000 function point project is 17%. Because we don't have data from the actual company, we have chosen this formula to calculate the probability of failure. The formula is derived from Caper Jones' database for MIS systems, which are in line with the systems being built at the organization. Even though actual data from the organization on project failure would be more accurate, we believe that the calculated probabilities of failure are useful for the purpose of our research.

Total costs: Another important benchmark formula to our research was one that describes the relation between the function point size of the project and the total costs of development. The larger the function point size of the project, the higher the development costs. In [9] Jones shows a table containing data on several project sizes 100, 1000 and 10000 function points. Among this data is the average cost per function point for these three sizes. A 100 function point project will cost $352.46 per function point, meaning a total cost of $35.246. For 1000 function points this is $1035.46, making a total cost of $1,035,460 and the largest type, a 10,000 function point project will cost $28,519,000, with $2851.90 per function point. In [10], Kampstra and Verhoef show that it is possible to fit a curve through these three points so we can calculate the total costs based on the function point size, and, more interestingly to our research, vice versa.
The relation between the number of function points and the total costs c is

$$f = e^{-2.6027701+0.6877308*log(c)}$$

. A graph of this relation is shown in Figure 1.
Although these formulas are not reliable enough to entirely base investment decisions on they can be very useful for providing extra information to the decision makers in the decision making process. As mentioned before, in our research they have proven to be very useful. This will be discussed in the following section, about the data and how we applied the literature to create a useful data set.

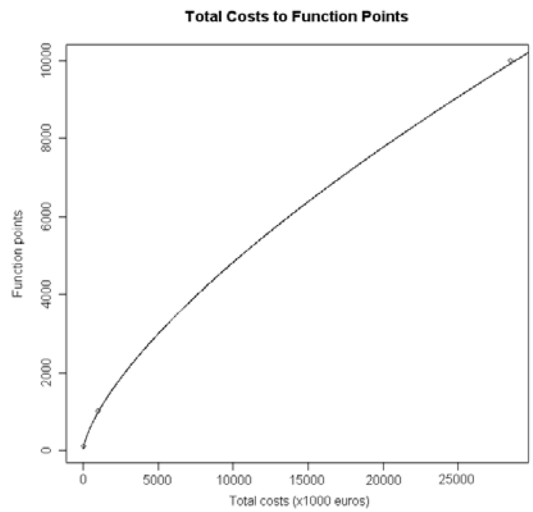

Figure 1: Relation between the total costs and the function point size.

4 Data

To assess the impact of business risks on the value of IT projects, we need to have information on the characteristics and expectations of those IT projects. This information can be found in the business cases that were made available to us. We used this information to form a data set of projects, and used it to link what was expected to what was realized. This section will describe the information that was found in these business cases, and show how we used the literature that was discussed in the previous section, to create a useful data set.

For the research the organization has provided us with the monthly budget requests of projects in the year 2005. These monthly requests include entries for new projects and projects that have arrived in stages for which new budget has to be requested. These entries can be one of four possible types: Business Cases, Project Initiation Documents (PID), Next Stage Reports (NSR) and Exception Reports. A project proposal is submitted in the form of a business case. For a few large projects we encountered a PID, an even more detailed description of a project. When a project is launched and arrives at a new stage a NSR is submitted and when additional budget is required for a phase this is requested via an exception report.

A business case starts with a management's summary of the project, in which the justification for the project is discussed along with its results and possible consequences of not doing the project. After that the predicted results of the projects (monetary and non-monetary) together with the risks of the project are discussed and the risks of the project. The business case entry in the budget request is concluded with the most important part to our research, a financial summary. It contains an overview of the costs, gains, a calculation of the NPV, PBP and IRR and an overview of the estimated number of hours of work involved.

The Project Initiation Document entries are the most extensive documents in the budget requests. Most important information on the projects can easily be found here and the cost and gains analysis is very extensive. It is clear that much effort has gone into writing the document and for only a few, important, large projects a PID is included. This entry also contains a financial summary.

A next stage report is a summarized entry in the budget requests that roughly contains the information from the business case, updated to the current situation whenever necessary. The next stage report also includes a financial summary.

An Exception Report simply deals with the difference between the last approved budget and the new requested budget. It lacks a financial summary and therefore contains insufficient information to include these into our research. These reports were omitted from the project database. This concerned some 10 projects.

From the first three types of budget request entries we were able to derive the following information:

- **Name:** Obviously, the name of the project is included and sometimes the department it belongs to.

- **Type:** From the context in the project input in the budget requests, it can be derived whether the project is mandatory or not (discretionary). If the project is mandatory, this can be to comply to external factors or for continuity purposes. The discretionary projects are either commercially strategical proposals or system maintenance proposals and it is in these groups where we the most fierce competition between projects. With more projects than funding potential, project managers will tend to try to make their projects seem more appealing by being overly optimistic on the expected results.

- **Pure IT/IT enabled:** Some of the projects may be based entirely on IT effort, for example a project that merely entails the development of a new transaction system. Other projects on the other hand can be IT enabled, they contain IT effort for some part, but also non-IT effort. We will make a distinction between both types of projects.

- **Initial investment/annual costs:** In the budget requests, the initial investment and annual costs are mentioned clearly. They belong to the most important parts of the information in the budget requests.

- **Annual gains:** Like the investment and annual costs, the annual gains are an important piece of information about the project proposal.

- **Project duration:** For many projects, the project duration can be derived from the information in the budget requests.

- **Hours of work:** The hours of work involved in the project give us, next to the total costs, a rough indication of the size of the project.

- **Net Present Value:** The Net Present Value can be derived from the data we already obtained, but it can also be directly taken from the budget request entries.

This information on the projects will be used in the simulations. We have the predicted costs, gains and we know the predicted NPV. These budget request entries already give important information on the projects. However, to simulate the project execution we need more information about the realization of the projects. The most useful extra piece of information is the function point size of the project. To determine the function point sizes for all projects in the data set we used the total hours of work involved in the project. For the total hours of work we considered IT effort only, which was clearly indicated in the financial summary. Next, we multiplied the total number of IT hours by an hourly fee of 112.50 euros, that we found in some of the business cases, to derive the *total cost of development* of the project. We then used this total cost of development in a benchmark formula to derive the function point sizes of the projects. Now that we know the function point size we can use the benchmark formula on project failure (cf) to determine the *probability of failure* for each project in the data set. Consider the following subsection for a summary of the data set.

4.1 Creating the data set

After studying the 2005 budget requests, we found 85 project entries that had sufficient information to include them in our research, some of which from projects with multiple entries. Instead of using all these projects in our research, including the double and triple entries, we decided to delete the multiple entries from the project data set, to form a good representation of the 2005 project portfolio. For projects with multiple entries we used the first entry by default, since we are most interested in the project information that was available during the decision phase. After deleting the multiple entries the project data set contained 68 projects.

The data set was completed with the expert's information on the realization of the gains and costs compared to the estimated values. They were either defined as *overestimated*, *underestimated* or a *fair estimate*. Based on this definition of the estimates, the parameters of the distribution of the gains and the costs will be determined, as we will discuss in more detail in the next section.

Finally, for each project in the data set the NPV was recalculated with year 1 as 2004. In the financial summaries in the budget requests, the NPVs were calculated with year 1 ranging from 2004 to 2006. To make the NPVs of the projects comparable, they were all recalculated in the same way.

4.2 Data set summary

Using the data in the budget requests, completed with expert's knowledge, and applying the benchmark formulas we created a data set of 68 projects. In this data set, 23 were mandatory projects, 9 due to external factors, 14 due to continuity reasons. The other 45 were discretionary, with 18 commercially strategical projects, and 27 maintenance projects. In our research we distinguished between purely IT projects that were based merely on IT effort, and projects that were merely IT enabled. Of the first type we found 41 projects, and of the second 28 projects. For each of the projects we calculated the project's function point size, ranging from 70 function points for the smallest project, and 5000 function points for the larger ones (see Figure 2). The annual costs and gains of the projects were found in the budget requests from 2004 to 2007 and 2004 to 2010 respectively, and the NPVs of those projects ranged from a negative NPV of 20 million euros to a positive NPV of 30 million euros.

Using this data set we will simulate the projects, and use the results from these simulations to analyze the impact of the risks, both in the IT and the business domain. How we accomplished this will be discussed in the next section.

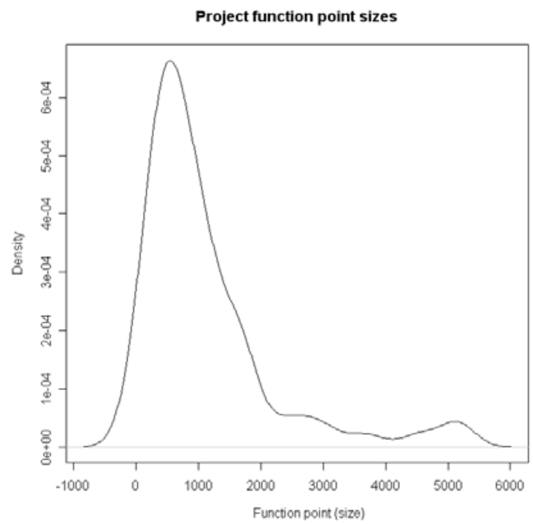

Figure 2: Distribution of function point sizes in project portfolio.

5 Simulation Model

To assess the risk impact we want to know the probability of occurrence and the potential losses. Because the potential losses due to these risks may occur once in every 20 times considering at one project execution does not suffice. More interesting is what happens if we run the same project again, and again, and again. If we do this a large number of times, we can get some idea of what can happen, and how often this happens.

Of course, in real life, a project can only be done once. But using simulations, we can run the same project any number of times. We can then use the information from all of the simulation runs of that project to analyze how the risks relate with each other and what happens if we change any of the settings. Subsequently, we can use the information from all projects and combine it to get a grasp on the risks on portfolio level.

In this section we will describe the model we used to simulate the projects, along with a description of the simulation program itself. We will start with an explanation of some of the underlying assumptions, regarding the costs and gains. After that the program in general and the simulation settings will be discussed.

The simulation program that was used was developed using a free software environment for statistical computing and graphics, called R. For more information on R consider [7].

5.1 The cost and gain distributions

The provided data gave us a lot of insight into the expectations of the projects. Especially from the information in the budget requests we managed to get a better view on the decision process and the way the projects are expected to perform. However, we did not have any specific data on the realization of the projects, which can provide useful insights into the value of that information. Of course, the predictions tell us what can be expected and we know that the realization will most probably be somewhere in the order of degree of that estimation, but how far are these estimations usually off? On this we had to make certain assumptions, which will be explained in this section.

In the financial summary at the end of most budget request entries we encountered, there was a clear overview of the total development costs of the project. In the simulations, we will need to simulate a realization based on those estimates. In the simulations, this realization of the costs and gains will be randomly drawn from a probability distribution. For these simulations, the parameters of the costs and gains distributions are determined by the best guess (to be found in the financial summaries), and the information provided by the organization: whether it was an over-, under- or fair estimation.

If the estimate in the budget request was found to be an overestimation of the true value the true value is probably *lower*. Similarly, an underestimation of the costs or gains implies a *higher* than predicted actual value. A fair estimate means the realization can turn out to be either lower or higher, and for the purpose of our simulation we choose to make those probabilities equal.

Suppose we consider a cost estimate in the financial summary of a project proposal, and we know from the information from the organization that this is an overestimation of the true value. This means that the true value will presumably be lower than the best estimate. The question is however, how much higher or lower will it turn out to be, and, more generally, what will the probability distribution look like? A probability distribution very useful for this type of situation is the *triangular distribution.* The triangular distribution is defined by its lower limit a, mode c and upper limit b, and is therefore very useful when not much else if nothing more is known about the probability distribution. As can be seen in Figure 3, the probability is highest for c and gradually decreases towards a and b. This fits our model properly, we assume that the manager will provide a best estimate (with a high probability of occurence), and some best and worst case scenario (with a low probability of occurence). An important advantage of the triangular distribution is that it is easily understandable; the minimum, maximum and mode are well-known expressions making it easier to use in practice.

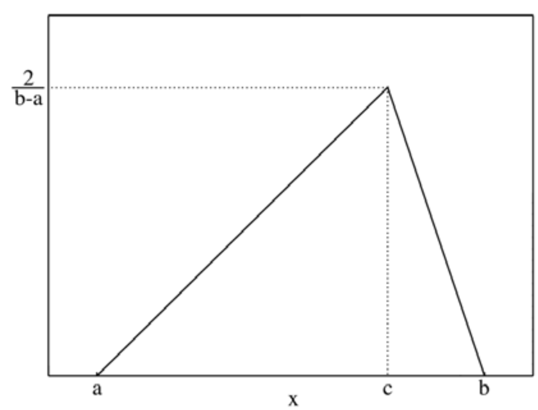

Figure 3: The triangular distribution.

5.1.1 Overestimation

Now suppose we consider an expected cost of 100 euros in the financial summary, and the extra information tells us, using knowledge from the *actual execution* of the project, that was an overestimation. To determine the parameters of the triangular distribution we must determine the minimum, the mode and the maximum. We choose the mode to be equal to the best guess before the project, meaning exactly the estimation. Since the probability of the costs turning out *higher* than the estimation is very low, we say that the maximum (b) is also equal to the best estimate. As for the minimum (a), we have to consider the amount of uncertainty in the estimations of the costs. Since these are in general more easily determined for the costs than for the gains we say the minimum is 60% of the cost estimate. For an overestimation of the gains we say the minimum is 40% of the estimate. Note that these are figures that were considered to be reasonable for this specific case. For any situation the minimum and maximum of these distributions can be adjusted. Applying the aforementioned minima leaves the following distributions of our costs and gains in case they were overestimated (See Figure 4). This same principle will be applied to any cost or gain overestimation in the data set.

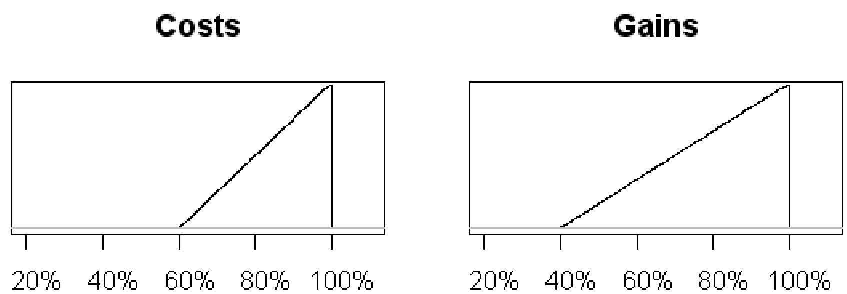

Figure 4: Costs and gains overestimation.

Note that the application of this program for our research differs from its use in practice in the fact that for our research we have exact knowledge on the actual realization of the projects. Using this knowledge we can say that the costs were overestimated, and that therefore the actual costs must have been lower, resulting in the aforementioned triangular distribution. However, when this program is used in the assessment of a portfolio *before* execution the users of the simulation program will have to resort to a best estimate, and a worst and best case scenario (c, a and b). This will result in a cost and gain distribution that can differ greatly in shape from the graphs shown in this subsection.

5.1.2 Underestimation

When we know an estimate is too low, when it is an underestimation, we know that the actual value will probably be *higher*. Therefore, the lowest possible value is the estimation itself, and so is the mode. Similarly for the maximum, we say for the costs it is 40% higher, and for the gains it is 60% higher. Again, this is due to the higher uncertainty in predicting gains than there is in predicting costs. This gives the following graphs for the cost and gain underestimation (See Figure 5):

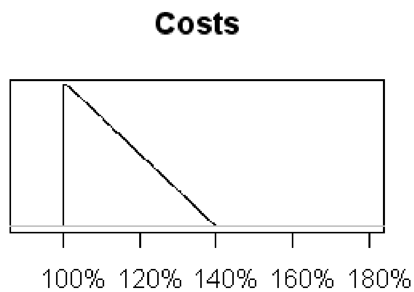

Figure 5: Costs and gains underestimation.

5.1.3 Fair estimation

Finally there is a third possibility when we know the estimation is about right. We have already established that this means that the probability of the realization turning out lower or higher is equally high, but how much higher or lower it can be is yet to be determined. In our model, a fair estimation is rather close to the actual value, the variance is smaller than for the ovr- or underestimation. This was in accordance with the information we received from the organization. We will say that the mode is, again, equal to the estimation, and that for the costs the minimum and maximum are both 10% off and for the gains this is 20%. This gives the following triangular distribution for a fair estimation (See Figure 6):

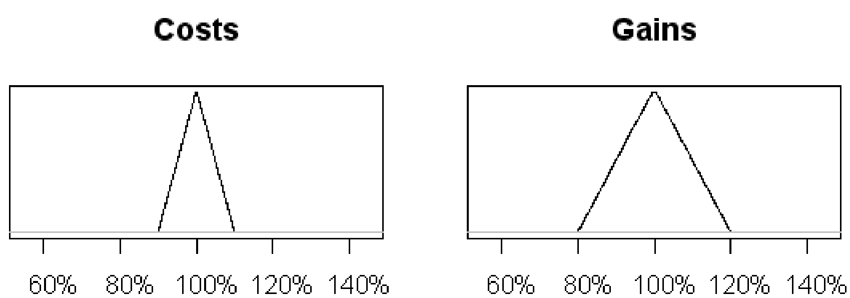

Figure 6: Costs and gains fair estimation.

5.2 The simulation settings

Before we elaborate on the simulation program, we must first explain the settings that were used to produce our results. Some of these settings refer to the way the projects are simulated and can be adjusted to properly fit the circumstances, others provide additional possibilities to analyze the results.

- Minimum and maximum triangular distribution: For both the costs and the gains it is possible to adjust the minimum and maximum of the triangular distribution for the over-, under- and fair estimation. This feature can be used to adjust the distributions to properly fit the circumstances under which the projects are developed, as well as to provide a means to investigate the impact of uncertainty in either of these domains.

- Failure loss ratio: When a project fails, this oftentimes occurs after numerous attempts have been made to save the project. These attempts cost resources and therefore it is very well possible that when a project fails, the total costs are not equal to the initial estimate but are, for example, 50% higher. A failure loss ratio of 2.0 means that the simulated total costs are 200% of the estimated costs when the project fails. For the simulation described in Section 6 we have used a failure loss ratio of 1.5.

- Fixed gains, fixed costs: It is possible to fix the costs or the gains of a project at their estimated value. When the costs or gains are fixed, they are no longer drawn from a probability distribution, but are simply what they were estimated to be. This way, the effect of the risks in either of these domains can be easily isolated and analyzed.

- Failure chance calibration: In some cases, the estimated failure probability can be higher or lower than is predicted by our benchmark formula. A calibration constant provides a means to adjust the failure probability to the situation. A constant of 75% decreases the probability of failure of all simulated projects by 25%. Another way this setting can be used is in the analysis of failure on the NPV of a project (portfolio). For the simulations we have used a calibration constant of 100%

5.3 The simulation program

Using the settings that we have discussed before, the simulations are run. One iteration in the simulation of a single project consists of several steps, using the information in the data set about that project. Suppose that in the business case we found a gains prognosis of $500,000 per year for 4 years, and a cost estimation of $1,000,000 for the first year and $250,000 for the second, and we know from the extra information that the gains were overestimated, and the costs were underestimated. Based on this information, the gains and costs are drawn from their triangular distributions as described above. Before the NPV can be calculated, according to the probability of failure of the project, some of the projects are marked as *failed*. If a project has a 20% chance of failing, then *on average* 2 in every 10 runs, the project is marked as failed. If this is the case the gains are set to 0, and the costs are multiplied by the *failure loss ratio*. Finally, the NPV is calculated. This completes one run of the project simulation. Now that this iteration is finished, the NPV is stored, and another iteration starts. This process is repeated n times, resulting in an array of n possible project NPVs.

As for the portfolio simulation, one portfolio iteration consists of one iteration for every project in the portfolio. These NPVs are then added together, and stored, after which another iteration starts. After n iterations, the result is an array with n possible portfolio NPVs.

With these settings and data from the business cases, we are now able to simulate the portfolio. This allows us to gain insight in the impact the risks have on the value of the portfolio NPV. In particular we can illustrate the impact of the business risks on the portfolio NPV. This risk, contained mainly in the uncertainty of the gains, can then be compared with the impact of the IT risk. These are modeled via the uncertainty in costs and project failure. In the next section we will discus the results from the simulation runs.

6 Results

To answer our research question on the impact of business risk on the value proposition of IT projects, we will use the simulation program that was described in the previous section along with the data set containing information on the projects in the portfolio. We will first run the simulations for the entire project portfolio. After that, we will split the portfolio into segments and alter the settings in the simulation program to analyze it in more depth.

For all simulations, the following default settings were used, unless mentioned specifically. The default settings are: underestimations of the costs are triangularly distributed between 100% and 140% of the predicted costs, for the gains this is between 100% and 160%, overestimations of the costs are triangularly distributed between 60% and 100% of the predicted costs. An overestimation of the gains results in a realization between 40% and 100%. Fair estimations for the costs means a realization between 90% and 110% of the estimation, and for the gains between 80% and 120%. The failure loss ratio is 150%, this means that a project that fails returns no gains, and makes 1.5 times the simulated costs. Furthermore the failure calibration constant is taken to be 100%, this means that no changes to the used formula are taken into account.

6.1 The Entire Portfolio

To form an idea of the realized NPV of the project portfolio compared to what was predicted beforehand, we first used the entire data set in the simulations. Doing one thousand runs of the simulations, with default settings, resulted in the density plot depicted in Figure 7.

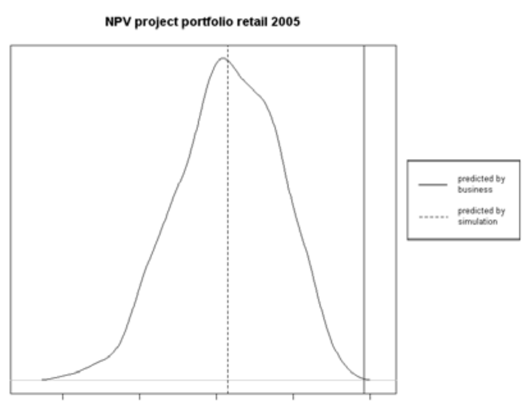

Figure 7: Density plot of the entire Project Portfolio.

The vertical lines in the graph represent the mean (average) simulated NPV (dashed line) and the predicted NPV (solid line). As indicated, a total NPV of nearly $50 Million was predicted, but in the simulations, using the information from the organization on what actually happened with those projects, shows that on average the projects cost more than they deliver. Consider the following graph (Figure 8) for a cumulative distribution of the NPVs: in merely 10% of all simulation runs a positive NPV is realized. And in less than 1% a higher NPV is realized than was predicted.

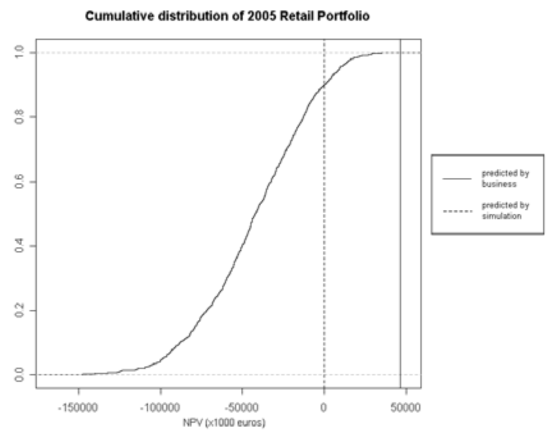

Figure 8: Cumulative distribution of the entire Project Portfolio.

These outcomes show the relevance of carrying out simulations before deciding on projects. Although we should keep in mind the simulation is founded on rather rough assumptions, the results were confirmed by the organization. Based on this simulation, the executives may have chosen different projects for the portfolio or taken measures to mitigate risks for key projects. The simulations also allow for zooming in on which risks are most promising to mitigate, and for which types of projects these risks are most prominent. We will answer this question by splitting the data set into mandatory and discretionary projects and run the simulation for those two subsets of the portfolio. This will show whichever of these subsets shows the largest difference between expectation and realization.

6.2 Mandatory and discretionary projects

In the data set four types of projects where distinguished: external obligations projects, continuity projects, commercially strategical projects and maintenance projects, or type 1, 2, 3 and 4. For types 1 and 2 projects (external obligations and continuity) a positive NPV is not a decision criterium, since they are done simply because they have to be done, as opposed to projects of types 3 and 4 (commercially strategical and maintenance). So it is in those latter two categories, for the discretionary projects, where managers will sometimes boost their business cases to get their projects approved. We will simulate both types (mandatory (1 and 2) and discretionary (3 and 4)), using the default settings, to analyze the effect on the difference between predicted NPV and realized NPV.

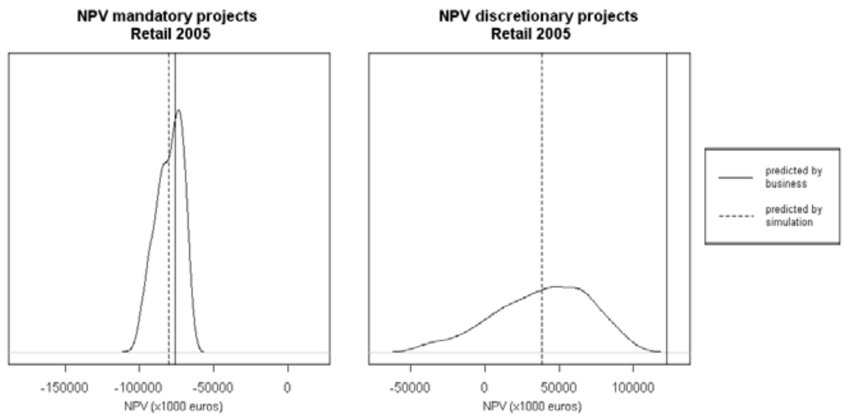

Figure 9: Density plot mandatory and discretionary projects.

Analyzing the resulting graph (Figure 9) it is immediately clear that the mandatory projects not only have a much smaller standard deviation (9072.7 for mandatory projects and 32646.3 for discretionary projects), but also a much smaller difference between the predicted NPV and the average simulated NPV. As was already hinted before, a large part of this difference can be contributed to the difference in the way the project proposals are considered. The mandatory project proposals are taken at face value, they don't have to impress, and the project managers can make an honest estimate of the gains and costs involved. The discretionary projects proposals on the other hand, as mentioned before, do have to appeal to the decision makers and therefore will sometimes be portrayed too positively, resulting in projects that, on average, deliver much less than is predicted. This was confirmed by the organization.

6.3 Portfolio divided into categories

So now we know that the largest difference in the predicted NPV and realized NPV comes from the discretionary projects. To further analyze this difference, we will divide the portfolio into categories to investigate which of the four categories accounts for most of the gap (see Figure 10). These figures were created using default simulation settings.

As can be expected by considering the previous density plot, the projects from categories 1 and 2 show a much smaller difference between the predicted value and the realized value than the projects from the last two categories do, especially for the commercially strategical projects. The question, again, is, where does this difference come from? Is it because the costs are much higher

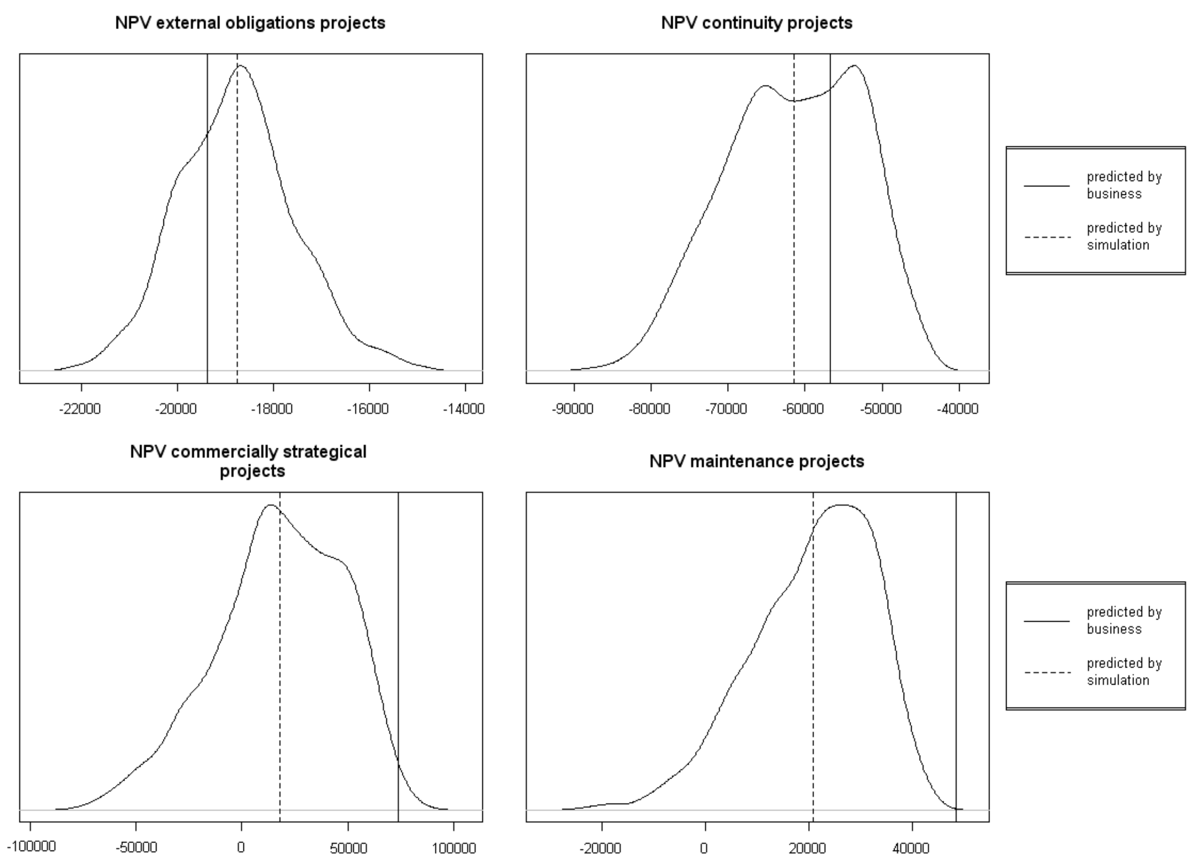

Figure 10: Density plots portfolio per category.

than expected, or did the result of the project simply disappoint? In other words, do the risks from the business domain, or from the IT domain dominate, and how do these relate to each other? To answer this question we will examine the commercially strategical projects more closely, because these projects show the highest risk impact. We will further analyze the category 3 projects by manipulating the settings in the simulations program. By doing this we can isolate the risk types to clearly investigate the impact they have. We will do this in the following section.

Isolating the risks

As mentioned before, we will focus on category 3 (commercially strategical) projects for the remainder of this section. This is because the impact of the risks is most clear for these types of projects. To show the impact of the risks we can isolate the risks by changing the settings of the simulations. For example, if we want to know what the effect is of project failure, we can decrease the probability of failure in the simulations to analyze its effect on the expected NPV. The first analysis we will make in this subsection is on the effect of cost uncertainty. Below we will show two graphs, in the first we depict the results of a simulation of the commercially strategical projects with stochastic costs and gains and default settings. In the second the simulation results for the same project portfolio are depicted, except for fixed instead of stochastic costs. The comparison between the two graphs illustrates the effect of uncertainty in the costs (a result of risks in the IT-domain). Consider Figure 11 for the simulation results.

The first graph shows the result for the default settings, the next graph shows the result for which the costs are fixed. The difference between the graphs tells us that when the costs are exactly as predicted, the mean NPV in the simulations *decreases*, meaning that the costs *increase*. In other words, the costs for commercially strategical projects are on average *overestimated*. This was also confirmed by the organization. The difference however is quite small, which tells us that reducing the risks concerning the costs has little effect. This means that the IT risks (that deal with the costs) are, on average, predicted rather well. Further effort put into the mitigation of IT risks for this portfolio would have made little difference, this effort might perhaps be better applied elsewhere.

The risks that can cause the gains of the projects to be less than predicted are called the business risks. To form an idea of the order of magnitude of these risks we will simulate the commercially strategical projects again, and this time we fix the gains, resulting in Figure 12. The first is, again, simulated using default settings, the second with default settings except for the fixed gains:

This graph shows exactly the opposite, when we fix the gains, the NPV *increases*, which means that the gains also *increase* when they are fixed, which tells us that, on average, the gains are *overestimated*. Also, the difference between the graphs is larger than for the costs. This tells us that there is more to be gained from an improved gains prediction and business risk assessment,

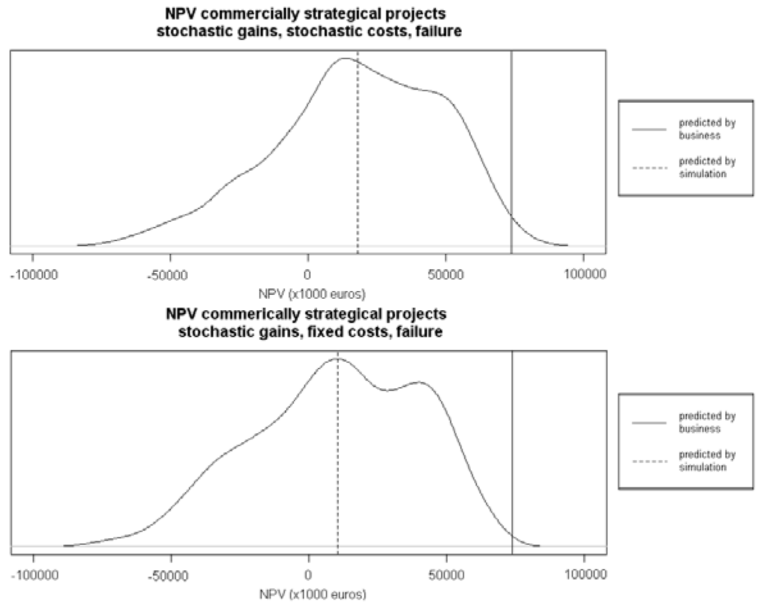

Figure 11: Comparison between stochastic and fixed costs for commercially strategical projects.

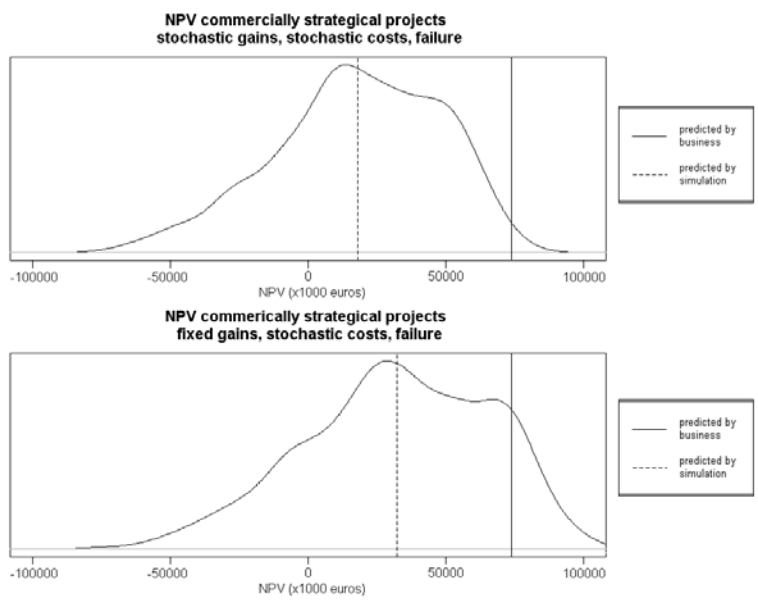

Figure 12: Comparison between stochastic and fixed gains for commercially strategical projects.

than to focus on costs in this portfolio.

Another way to show the uncertainty and deviation in costs and gains individually is to display them separately in a graph. The following graph (Figure 13) displays the simulated costs and gains of all projects in the data set, the dashed line is again the simulation average and the solid line the predicted costs/gains by the business. This graph matches what we saw in the previous figures, on average the costs are predicted quite accurately, and the gains are on average overestimated.

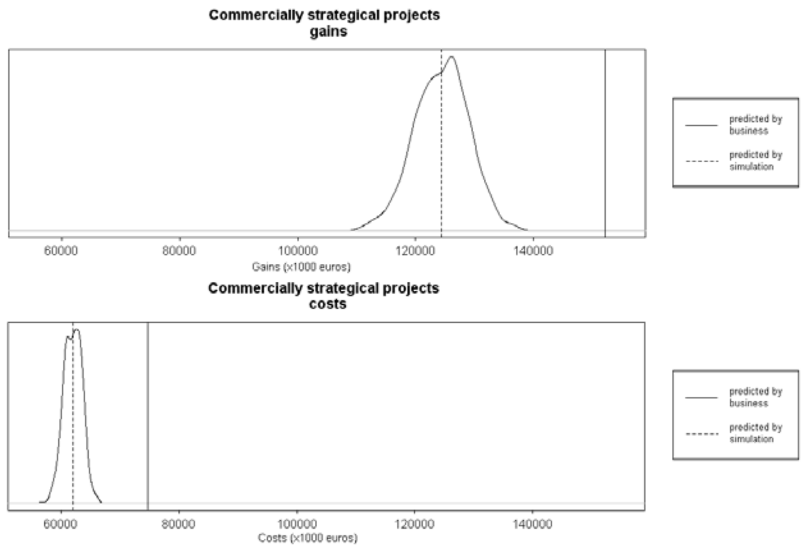

Figure 13: The costs and gains separately of the commercially strategical projects.

As for the influence of the probability of failure, we want to investigate the effect this has on the NPV of the project portfolio. To show this influence graphically, the simulations were first run with default settings. Next, the probability of failure was decreased by 25% using the failure calibration constant. After that it was decreased by 50%, and once again with a decreased probability of failure of 75%. The results are displayed in Figure 14.

The graph shows that a decrease in probability of failure has a positive effect not only on the portfolio's NPV, but also on the deviation of the NPVs. In other words as the failure chance goes down, so does the deviation of the NPV of the portfolio.

This illustrates that within this portfolio risk mitigation effort should be focused foremost on making projects more successful. Of course the outcomes of the simulation are largely influenced by the assumptions and the use of the benchmark formula for project failure. To increase the simulations' usefulness these assumptions should be carefully considered.

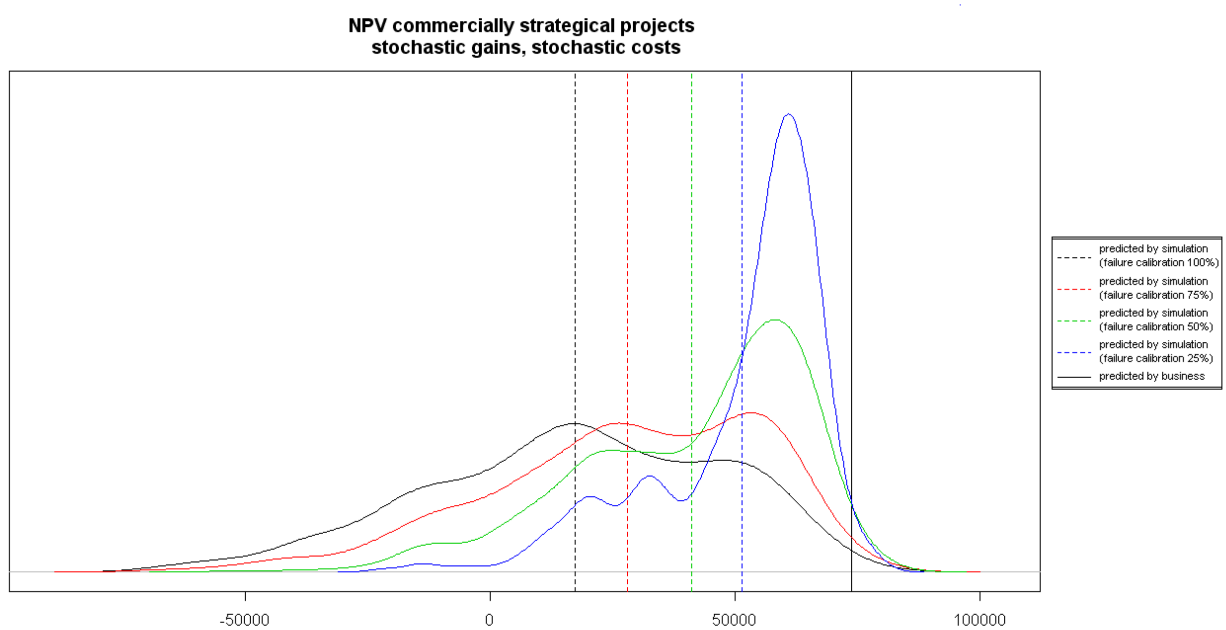

Figure 14: Decreasing failure probability for commercially strategical projects.

7 Conclusions en Recommendations

To answer the research question on the impact of business risk on the value proposition of IT projects, an analysis was made of the entire portfolio. This was done using a simulations program created for this purpose.

The input for this simulation consisted of specific project information that was taken from the project business cases. This information concerned, among others, the project duration, project type, and estimations on the costs and gains of the projects, completed with information from experts at the organization whether the estimations were probably too high (overestimation), too low (underestimation) or rather well (fair estimation). The projects were also divided into four categories: external obligations projects, continuity projects, commercially strategical projects and maintenance projects. The first two are considered mandatory projects and the last two are discretionary projects.

In the simulations, the information on the estimates was used to randomly draw simulated costs or gains from a probability distribution. For the costs this was either between 100% and 140% (underestimation), 60% and 100% (overestimation) or 90% and 110% (fair estimation). For the gains this was between 100% and 160%, between 40% and 100% or between 80% and 120% respectively. The reason these intervals were chosen to be larger for gains was due to the larger level of uncertainty in project gains than in costs.

During the simulations, for each run these gains and costs were randomly drawn from the distributions, resulting in a simulated discounted total costs and discounted total gains (using a discount rate of 12%). As a next step, the probability of failure was calculated from an industry benchmark. Each simulated project fails with a probability equal to that probability of failure. The projects that fail produce no gains (total gains are set to 0), and produce more costs than predicted (indicated by the failure loss ratio). The failure loss ratio used in these simulations is 1.5, meaning that projects that fail produce no gains, and make 50% more costs. Next, the total costs and gains are used to calculate the NPV, and another run is initiated. After n runs, the result is an array of n possible project NPVs.

As for the simulation of the project portfolio, each run of the simulations consists of one run for each project. The NPVs of these projects are added together, after which another simulation run is initiated. The result is an array of n possible portfolio NPVs. Now the simulation can be run to make an analysis of the project portfolio and to answer the research question.

The first analysis gave an impression of the combined impact of both risk types, shown by the difference between what is predicted and what was realized in the simulations. After that, we divided the data set into segments per project type to analyze this difference for each type of project individually. A further analysis of these project types showed the relation between the different types of risks and the effect of the probability of failure.

According to our simulation results, the commercially strategical projects and the maintenance projects show the largest difference between what is expected and what is realized. The other two project types, the external obligations projects and the continuity projects are predicted rather well on average. The difference between the performance of mandatory and discretionary projects can be explained by the fact that there is a high level of competition between the discretionary projects causing the project managers to provide an overly positive project proposal. For the mandatory projects, the need is smaller to boost the project proposals which creates a more realistic prediction of the NPV.

An analysis of the commercially strategical projects showed that the large difference between the predicted and simulated NPVs is due to the high level of uncertainty in the prediction of the gains that a project will generate. In comparison to this, the project costs are predicted rather well on average, with a much smaller average deviation from the estimates. So even though much effort goes into the mitigation and management of especially the IT risks in advance of a project, much more can be gained by enhancing the gains prediction and making sure predicted gains are actually met.

The effect of project failure was also analyzed in the final phase of this report. It showed that a decrease in the projects' probability of failure has a large positive effect on the portfolio's NPV, and causes a decrease in the deviation from the predicted NPV. Therefore, the prevention of project failure is an efficient measure as well.

The simulation program proved to be a useful tool to provide insight into the financial impact that various risk factors can have on the NPV of any project. This can then be translated to the portfolio level to show where portfolio management should focus on. Of course, the underlying assumptions that were made determined the outcome of these simulations. We believe however that as a first step in the analysis of a project portfolio these outcomes provide valuable information. The organization was also convinced this analysis of a project portfolio by means of simulation can provide useful extra information in the decision making process and project management. Further refinement of the simulation settings to best fit a specific situation can improve the results of the simulations further. Not just having an idea on the best guess of a portfolio's NPV, but also having some notion of the best and worst case scenarios is very useful in the decision making process.

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