



Preface

Business Mathematics and Informatics is a study that combines three fields: Economics, Mathematics, and Computer Science.

It is focused on the application of business, mathematical, and information technological methods to describe and/or to improve business processes. This study both pays attention to the scientific aspects as well as the business aspects of the courses. Many courses are combinations of theory and practice. The student gets the opportunity to use scientific knowledge in various projects. In the end he/she has to do an internship. The internship is usually performed in a company in order to introduce the student to business life.

For my graduation I chose to do my internship in the company *Andersen*¹ in Amstelveen. I had two main reasons for my choice:

- First, I was wondering how it was to join a big and (international) well-known company;
 - Second, I was really interested in the research they offered me: ‘Quantification of Operational Risks’.
- During my internship my statistical knowledge was refreshed and I gained experience in designing and implementing a risk quantification model. In the end I got some interesting conclusions. Now I would like to present the results of my research in this essay.

I would like to thank ir. C.A. Messemackers van de Graaff and ir. M. Siezen from Andersen for offering me this research and for giving me the opportunity to learn about risk quantification. I really appreciated the time that ir. M. Siezen made for me to share his ideas and knowledge during this research. He helped me a lot to get insight in the subject.

From the Free University I would like to thank Prof. G. Koole for being my second reader and for advising me drs. S. Bhulai being my supervisor during my internship. Without his advices, help and especially his critics I would not have been able to do this research and to write my thesis in a proper way! I would also like to thank prof. F. Boshuizen for telling me his experiences in financial risks quantification. His information helped me to get ideas for operational risks quantification.

Finally, I would like to thank M. Schouten from Schiphol Group for the input values in the risk quantification model. Without these input values it would have been very hard to test the credibility of the model.

And last, but certainly not least, I would like to thank all my colleagues from Risk Consulting within Andersen for giving me such a great time during my internship. Especially ir. J. Hurkens, for explaining me so much about Visual Basic, which I needed for the construction of the model.

¹Words in italic type style will be described in more details in the next sections.



Summary

The subject of this research is ‘*Quantitative Risk Modeling*’. Risk Quantification is a well-known phenomenon in the financial market that concerns measurements of portfolio risks. The method to quantify financial risks is called ‘*Value-at-Risk*’ (*VaR*). *VaR* is a measure of potential loss from an unlikely event in a normal (everyday) market environment. We would like to get the same results for operational risks. The identification of (operational) risks is a part of Risk Management. How can we express these operational risks in values in order to give a good impression of the effects on the company?

The goal of this research is to quantify risks that could help management in decision-making. Decision-making is based on a company’s net profit. To help management in their decision-making we should express the risks in money. In this research we based the risk values on the elements of the net profit. We quantified the risks by estimating the impact of the risk on the elements of the net profit.

The product of this research is a risk quantification model. Our risk quantification model is a user-friendly model, which means that it should not only be useable for modeling experts. People who do not know much about modeling should be able to use the model as well. The model is constructed in Excel with Visual Basic. The idea is to turn input values into certain output values. The input values are received by expert knowledge. Experts have to indicate the impacts of the risks on the elements of the net profit in values. Statistical knowledge and a simulation technique called the Monte Carlo Simulation turn these input values into output values. Output values are examined with the help of statistical methods, which result in risk values. Our way of operational risk quantification is a combination of expert knowledge, statistical methods and the Monte Carlo Simulation.

We designed a risk quantification model for the operational risks that are identified in the utility services of Schiphol Group (Schiphol Utility Services). Before the model was constructed we went to Schiphol Utility Services to get information about the calculation of their net profit. After this information we started to design our model. When the model was finished we went to Schiphol Utility Services again to ask for the input values. Because of lack of time, we just managed to quantify one risk: Competition. However, this information did lead to interesting results.

This thesis not only presents the risk values, but also describes the whole course of the research. It starts with an introduction of *Andersen* and *Schiphol Group* and a *summary of the approach* in Section 1. The *steps of the approach* are described in more details in Section 2. The section should provide the reader of more information about the different *subjects, methods and techniques* we used for this research. Section 3 describes the results of the application of the approach in practice. Finally, Section 4 finishes this thesis with some results of our research for ‘*Quantitative Risk Modeling*’.



Contents

PREFACE	I
SUMMARY	II
CONTENTS	III
1 INTRODUCTION	1
1.1 GENERAL	1
1.2 ANDERSEN	2
1.2.1 <i>Once upon a time</i>	2
1.2.2 <i>Industries and Segments</i>	2
1.2.3 <i>Risk Consulting</i>	3
1.2.4 <i>Office</i>	4
1.3 SCHIPHOL GROUP	5
1.3.1 <i>The profile</i>	5
1.3.2 <i>The departments</i>	5
1.3.3 <i>Schiphol Support Services (SSS) and Schiphol Utility Services (SUS)</i>	6
1.3.4 <i>Office</i>	8
1.4 THE APPROACH	9
1.4.1 <i>General</i>	9
1.4.2 <i>The Methodology</i>	9
2 THE REVIEW OF THE METHODOLOGY	11
2.1 PROCESSES	13
2.1.1 <i>Definition</i>	13
2.1.2 <i>Process Modeling</i>	13
2.2 NET PROFIT	14
2.2.1 <i>Profit and Loss Account</i>	14
2.2.2 <i>Variables</i>	14
2.2.3 <i>Correlations</i>	15
2.3 RISK	17
2.3.1 <i>Definition</i>	17
2.3.2 <i>Risk Analysis</i>	17
2.4 EXPERT KNOWLEDGE	19
2.4.1 <i>Risk-Variable Relations</i>	19
2.4.2 <i>Input Values</i>	19
2.5 THE BASICS OF STATISTICS	20
2.5.1 <i>Statistics</i>	20
2.5.2 <i>Probability Distributions and Distribution Functions</i>	20
2.5.3 <i>Examples</i>	21
2.5.4 <i>Mean and Standard Deviation</i>	23
2.5.5 <i>Tests</i>	24
2.5.6 <i>Confidence Intervals</i>	25
2.5.7 <i>Quantile Values</i>	26



2.6	SIMULATION	27
2.6.1	<i>Definition</i>	27
2.6.2	<i>Monte Carlo Simulation</i>	27
2.6.3	<i>@RISK</i>	28
3	PART I: DESIGNING THE RISK QUANTIFICATION MODEL.....	29
3.1	STEP 1: GETTING INSIGHT IN THE <i>PROCESSES</i>	30
3.2	STEP 2: STUDYING THE <i>PROFIT AND LOSS ACCOUNT</i>	30
3.3	STEP 3: DEFINING THE <i>VARIABLES</i>	31
3.4	STEP 4: DEFINING THE <i>RISKS</i>	34
3.5	STEP 5: INDICATING THE <i>RISK-VARIABLE RELATIONS</i>	35
3.6	STEP 6: ASSIGNING <i>PROBABILITY DISTRIBUTIONS</i>	38
3.7	STEP 7: DESIGNING THE <i>SIMULATION MODEL</i>	40
4	PART II: ANALYZING THE RISK QUANTIFICATION MODEL.....	44
4.1	STEP 8: ANALYZING THE RESULTS OF THE SIMULATION	44
4.1.1	<i>Standard Deviations as Result</i>	44
4.1.2	<i>Test as Result</i>	45
4.1.3	<i>Quantile Values as Result</i>	47
4.2	DIFFICULTIES	49
5	REFERENCE LIST	50
	APPENDICES.....	52
I.	ENTERPRISE-WIDE RISK MANAGEMENT.....	53
I.1.	RISK MANAGEMENT	53
I.2.	ENTERPRISE WIDE RISK MANAGEMENT	53
II.	STEPS FOR EWRM	55
II.1.	STEP 1.....	55
II.2.	STEP 2.....	55
II.3.	STEP 3.....	56
II.4.	STEP 4.....	57
II.5.	STEP 5.....	58
II.6.	STEP 6.....	59
II.7.	STEP 7.....	59
II.8.	STEP 8.....	59
III.	LEVEL OF PROCESSES	60
IV.	DATA ANALYSIS.....	61
V.	DESCRIPTION OF THE RISKS IN SCHIPHOL UTILITY SERVICES.....	64



1 Introduction

1.1 General

Andersen is a business service provider and is active in the field of accountancy, finance, tax, legal advice, and consultancy. Within accountancy there is a division called *Risk Consulting* that is managing risks² from strategic to process levels. One of the services that Risk Consulting offers is advising firms about *Enterprise-Wide Risk Management (EWRM)* to improve a firm's *Risk Management* capabilities. The Software Engineer Institute [1] described Risk Management as a methodology with processes, methods, and tools for managing risks in a company. It supports decision-making by first assessing continuously what could go wrong (risks). Then strategies are determined to deal with those risks. DeLoach [2] describes EWRM as a new way of risk management. EWRM is broader and identifies the full range of risks and opportunities. A more detailed description of Risk Management and EWRM is given in Appendix I 'Enterprise-Wide Risk Management'.

Risk Consulting has a methodology to support business advice in the field of EWRM. The methodology is described in Appendix II 'Steps for EWRM'. A part of the methodology is risk measurement in which risks are measured. These measurement results are expressed in the severity, likelihood, and financial impacts of the risks. The level of this risk measurement is restricted to an expression of the identified risks in words, which is called a qualitative expression. The expression of risks in values (money) is called a quantitative expression. A quantitative expression of risks is a more objective result of risk measurement than a qualitative expression.

Andersen wants to provide its clients with a more precise and detailed service of risk measurement. Therefore they are looking for methodologies to quantify risks. With these methodologies Andersen wants to improve the estimation of its clients risk profiles. This results in a better look into the future of their clients. Strategic decisions can be taken (earlier) and can decline/prevent unwanted situations. A combination of statistics, modeling, and financial management can provide a research for quantification of operational risks. The question of this research is:

'How can risks be expressed in money that could help managers in decision-making?'

Managers are mostly interested in a company's net profit. That is why we used the net profit to quantify the risks. The result is an expression of the risks in money that is related to a company's net profit. Our research resulted in a methodology to quantify risks.

The methodology of our research is used in a department of Schiphol Group. This department is called Schiphol Support Services. Within this department we looked at the risks of their utility services (Schiphol Utility Services). Then we designed a model to indicate the effects of their risks on the net profit. This model was able to indicate the impacts of the risks in money.

²From now on, when we talk about risk we mean operational risk, unless mentioned differently



1.2 Andersen

Andersen offered this research for quantitative risk modeling. This section gives some general information about one of the biggest accountancy firms.

1.2.1 Once upon a time...

In 1913 a university professor started a company, named (after him) Arthur Andersen, by training some of his students to become professional accountants. The company invented its own methodologies in order to give service in improving financial services. Nowadays, Arthur Andersen has grown and not only provides services in accountancy, but also in the field of finance, tax, legal advice, and consultancy. It has 390 offices scattered amid 84 different countries and it consists of more than 85000 people. It is not called Arthur Andersen anymore, but Andersen.

1.2.2 Industries and Segments

Andersen is divided into the following industries and segments:

Industries

<i>P&S</i>	<i>RE</i>	<i>GS</i>	<i>E&U</i>	<i>TMC</i>	<i>FSI</i>
Products & Services	Real Estate	Government Services	Energy & Utilities	Technology, Media & Communication	Financial Services & Insurance

Segments



Figure 1.1 Organization structure of Andersen

The division in which we did this research belongs to the segment Assurance & Business Advisory (ABA). ABA provides services that are focused on business risks and the quality of processes and controls underlying financial reporting and management assertions. It manages risks with the goal to improve and to protect a company's goals. ABA consists of four divisions:

- Financial Assurance Services (FAS)
- Business Process Outsourcing (BPO)
- Transaction Support Group (TSG)
- Risk Consulting (RC)

We performed our research for Risk Consulting.



1.2.3 Risk Consulting

Risk Consulting in Andersen manages business risks from strategic to process levels. The risk consultants help their clients to understand where risks lie and how to address them. Together with their clients, risk consultants assess risks that can disrupt their clients business. They also help their clients to take the necessary steps to protect and enhance shareholder value.

Risk Consulting consists of three product groups:

- Enterprise and Operational Risk Services (EORS);
- eBusiness and Technology Risk Services (e-BTRS);
- Fraud and Integrity Risk Services (FIRS).

The research was proposed by and performed for EORS.

The Risk Consulting organization scheme is structured along two groups:

- First, we have the Risk Consulting product groups (EORS, e-BTRS, and FIRS). The product groups are responsible for the quality of the products and services rendered.
- Second, we have the industry groups (P&S, RE, GS, E&U, TMC, and FSI). The industry groups are primarily responsible for the sales.

The organization scheme is as follows:

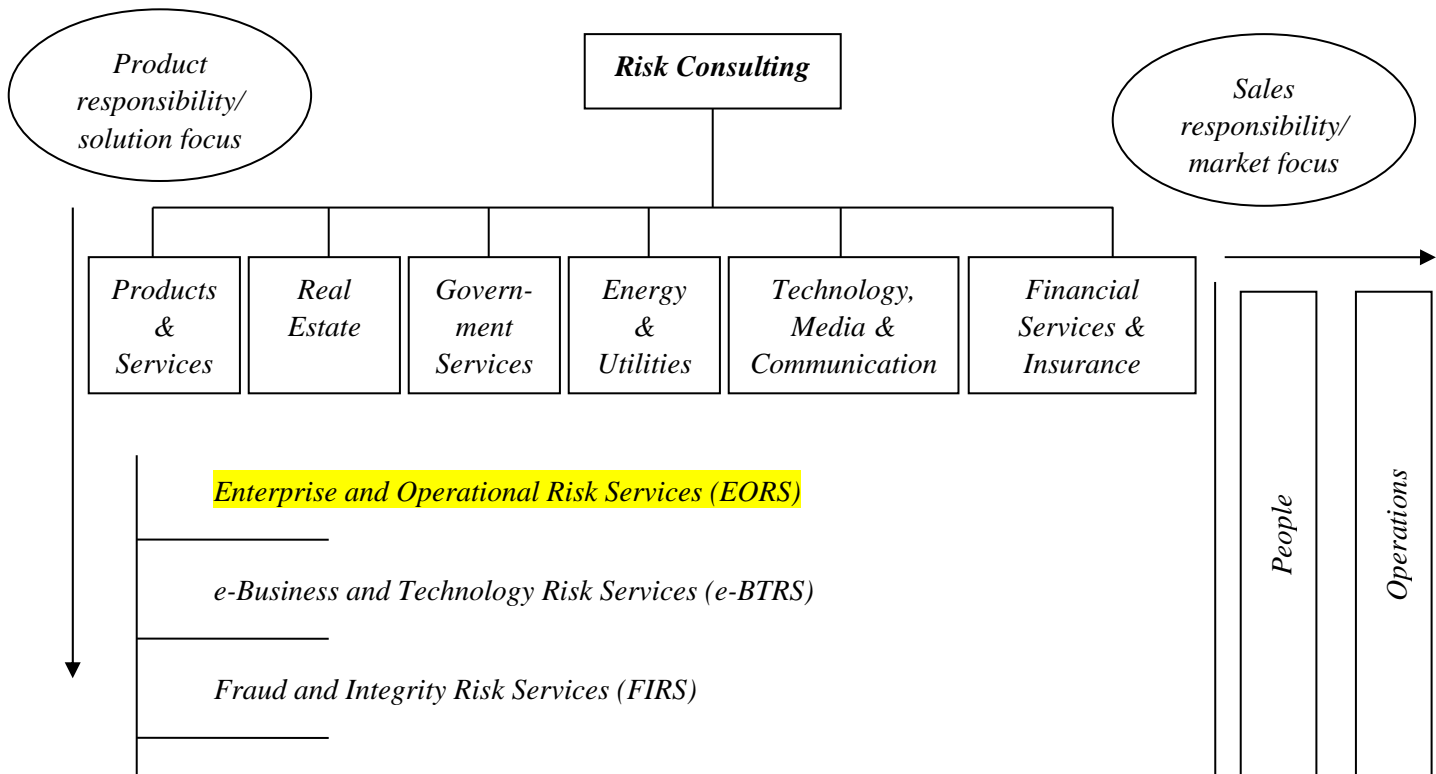


Figure 1.2 Organization Scheme for Risk Consulting



1.2.4 Office

The internship took place in the office located in Amstelveen:

Andersen

Prof. W.H. Keesomlaan 8

1183 DJ Amstelveen

The Netherlands



1.3 Schiphol Group

Schiphol Group is one of the clients of Andersen. We designed a risk quantification model based on the information of one of the departments of Schiphol Group. This section gives an introduction of this airport firm.

1.3.1 The profile

Schiphol Group is a firm that creates and develops activities in and around airports. The activities are delivered by AirportCities. The services of AirportCities can be divided into two main groups:

1. A multi-functional interchange of air-, rail- and road transport;
2. Shopping, hotel and catering (business meeting facilities), information and communication technology, and relaxation.

The clients of an AirportCity are the visitors (of the air-, rail-, and road transport) and the (inter)national companies that are settled in the area around the AirportCity.

Schiphol Group consists of several AirportCities from which Amsterdam Airport Schiphol is the most developed one. With Amsterdam Airport Schiphol as an example, Schiphol Group tries to develop its other AirportCities:

- Rotterdam Airport;
- Lelystad Airport;
- Eindhoven Airport;
- John F. Kennedy Airport (New York);
- Airport of Brisbane (Australia).

1.3.2 The departments

Schiphol Group consists of different kinds of departments that can be classified into two main groups:

- Business units of AirportCities:
 - Business Unit Passenger;
 - Business Unit Retail;
 - Business Unit Airlines.
- Other departments of Schiphol Group:
 - Other domestic airports;
 - Schiphol International;
 - Schiphol Project Management;
 - Schiphol Real Estate;
 - **Schiphol Support Services.**
 - Information & Communication Technology

We applied the result of our research within *Schiphol Support Services (SSS)*.

The departments are structured in the following way:

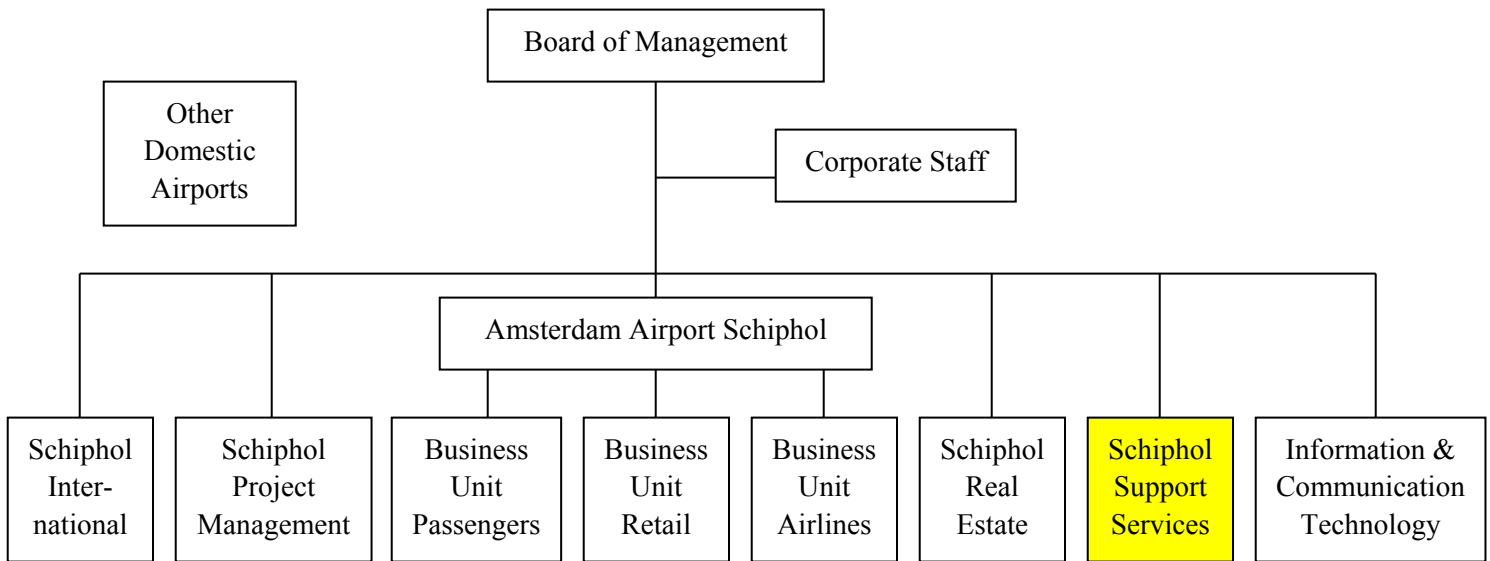


Figure 1.3 Organization Structure of Schiphol Group

1.3.3 Schiphol Support Services (SSS) and Schiphol Utility Services (SUS)

Schiphol Support Services (SSS) is the service provider and director of support products and services. Their task is to strengthen the development and extension of the AirportCity concept. Their goal is to achieve cost-savings for whole Schiphol Group by means of synergy. Schiphol Support Services consist of six departments to achieve their goal:

- Fleet Management;
- Airport Security;
- Facility Services;
- Access & Identification Center;
- Utility Services;
- Communication Services.

Within Schiphol Support Services we designed a risk quantification model for the utility services (*Schiphol Utility Services*).

Schiphol Utility Services (SUS) also consists of different departments:

- Sewage Purification;
- Control & Administration;
- Engineering & Maintenance;
- Environment & Support;
- Trade & Commerce;
- Schiphol Utility Networks.

The departments of Schiphol Support Services and Schiphol Utility Services are structured in the following way:

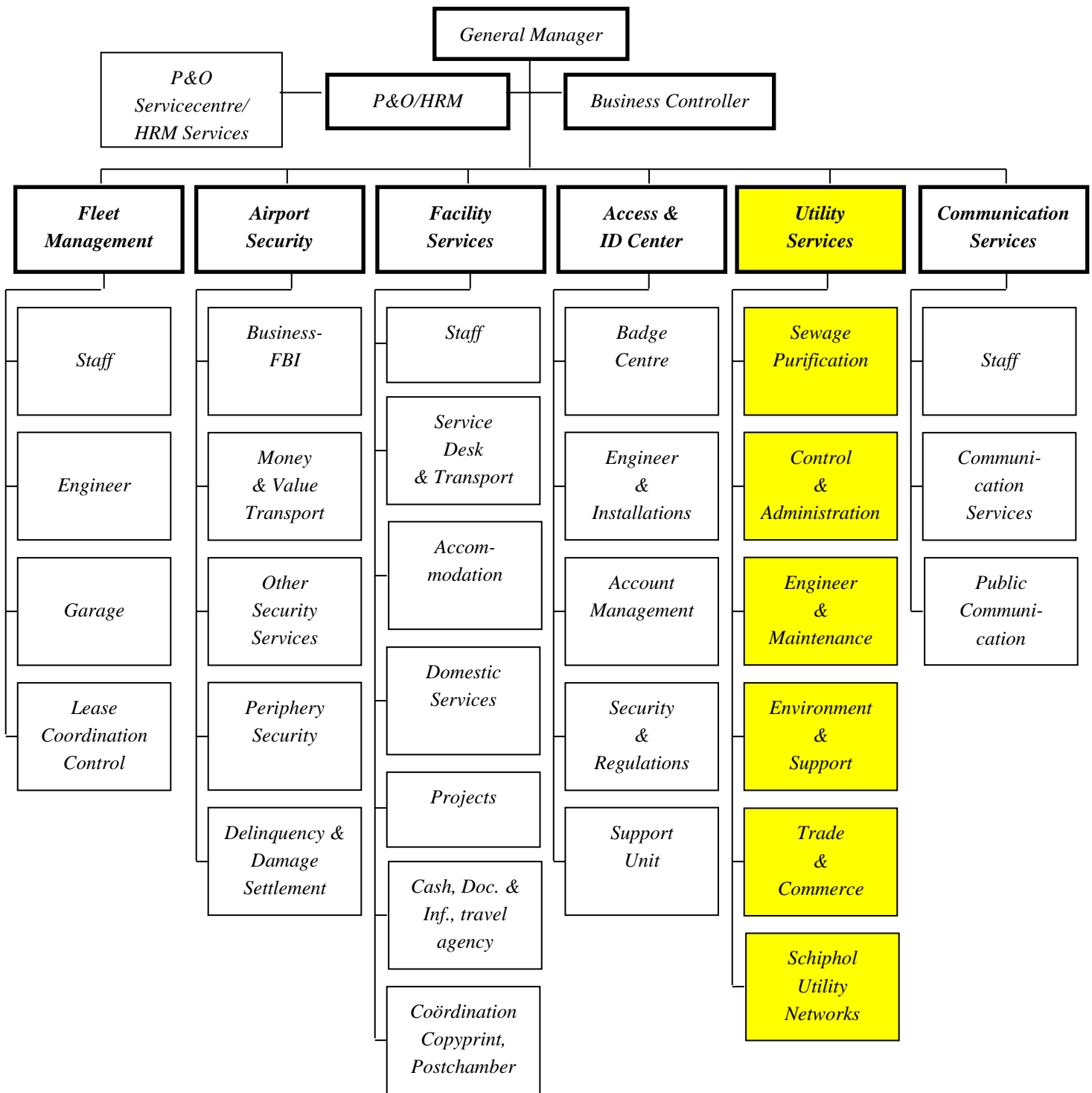


Figure 1.4 Organization Structure of Schiphol Support Services



Introduction

The products and the services of Schiphol Utility Services played an important role during our research. Knowing the products and services helped us to understand SUS and to find the necessary information to design the risk quantification model.

SUS is responsible for the delivery of three products:

- Gas;
- Water;
- Electricity.

The delivery of these products happens through the following services:

- Gas Delivery and Transport;
- Electricity Delivery and Transport;
- Water Delivery and Transport;
- Cables and Pipes Network Connections;
- Waste Products Collection;
- Cleaning;
- Green Service.

1.3.4 Office

The office of Schiphol Group is settled in:

Schiphol Group
Evert van der Beekstraat ??
???? ?? Schiphol Rijk



1.4 The Approach

This section gives a general description of our approach to quantify operational risks. We described which steps we have taken to design our risk quantification model. The steps can be considered as our methodology for ‘Quantitative Risk Modeling’.

1.4.1 General

The approach for our research can be divided into *two basic parts*:

- I. We had to *design* a model for the operational risks of a company (in Excel);
- II. We had to *analyze and validate* the behavior of this model (with @RISK) by applying it to our business case (Schiphol Utility Services).

This approach led to the answer of our research question:

‘How can risks be expressed in values that could help management in decision-making?’

Decision-making is often based on a company’s net profit. To help management in their decision-making we indicated the impacts of the risks on the net profit in values. These values are expressed in money.

1.4.2 The Methodology

The methodology consists of eight steps. The first seven steps belong to part I and the last step belongs to part II.

Part I

Step 1: Getting insight in the *processes* of a company.

By making a business model, we had to know how a company makes profit. In other words: how a company turns input into output. Processes describe the way a company turns input into output to make profit. Having information about these processes helped us to describe the output after the impacts of the risks.

Step 2: Study the *profit and loss account*.

After studying the way the company makes profit we studied the net profit itself. If we wanted to quantify the impacts of the risks on the net profit, we had to find out how the net profit was calculated. The profit and loss account presents the calculation of a company’s net profit. It consists of the descriptions of the revenues and the costs elements.

Step 3: Defining the *variables*.

Revenues and costs elements usually are calculated by certain formulas. Formulas are combinations of variables. The size of the variables will change if they are influenced by certain risks. We had to define all the variables in order to find the impact of the risks. Besides the definitions we also had to take *correlations* between the variables into account. This is because in reality variables have influences on each other that can be captured by correlation values.

Step 4: Defining the *risks* we have to quantify.

After we have described the variables of the net profit in step 3 we needed to study the risks. We had to describe clearly what it meant when a certain risk occurred. This could be explained by looking at what would happen if a risk occurred. The explanation was described by words.



Step 5: Indicating the *relations* between the risks and the variables.

We had a list of variables and a list of risks and had clear definitions of them. In step 5 we had to indicate the impacts of each risk on the variables. We had to specify if a certain risk had influence on a certain variable. Then we could describe whether the value of the variable increased or decreased if the risk increased or decreased. Just like in step 4 we were still describing in words.

Step 6: Assigning *probability distributions* to each risk-variable combination.

In step 6 we finally started to describe in values. For each relation between a variable and a risk, we assigned a probability distribution. This probability distribution indicated the variation of the variable when it was affected by the risk. The variation was described by the probability of occurrence of each possible value of the variable.

Step 7: Design the *simulation model*.

In step 7 we put the results of the six steps above in a business model in order to make calculations to quantify risks. Business models can be calculated analytically or with the help of simulation. Simulation is used for complex models. In our research we also used simulation to imitate the behavior of our model. Calculating risk values once does not give a realistic analysis of the reality. For a more reliable result, we had to make the same calculation many times. Each calculation is called a simulation run. Therefore we used the *Monte Carlo Simulation* with the help of a program in Excel (*@RISK*).

Part II

Step 8: Analyze the *results* of the simulation.

When the model was completed, we asked for input from the organization we designed this model for. This organization was Schiphol Group. Within Schiphol Group we asked input from the department Schiphol Utility Services. The model turned the input into certain output. We analyzed the output with the help of statistical theories. The results are presented in Section 4.



2 The Review of the Methodology

In Section 1.4 we introduced the eight steps of our methodology to design a risk quantification model. This section describes the subjects of the first seven steps that belong to the first part of our methodology. The last step belongs to the second part and will be described in Section 3.

First, we present the graphical view of our methodology:

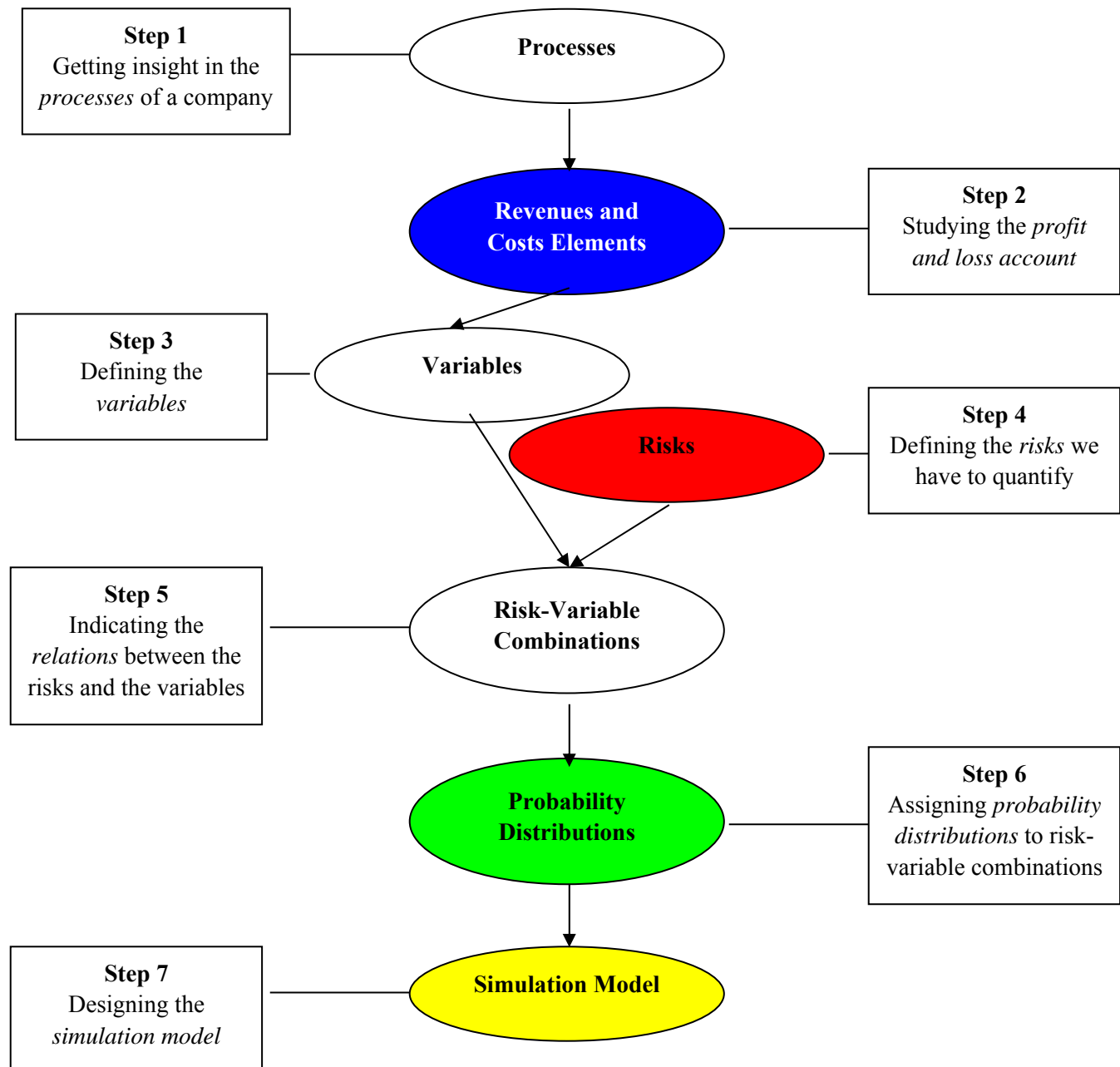


Figure 2.1 The Methodology for 'Quantitative Risk Modeling'



The Review of the Methodology

The first part of our research was to *design* a model to quantify operational risks.

We started with defining the processes of the company in the first step. *What are processes and why should we get insight in them?*

Then we studied the profit and loss account in step 2, followed by the variables in step 3. *How is the net profit calculated and why do we need to know the variables? What are correlations between variables?*

In step 4 we identified the risks. *What is the definition of risk and how is risk analysis performed?*

After knowing the variables and the risks we were indicating the risk-variable relations. *Who is able to indicate these risk-variable relations and what knowledge did we need from them?*

The risk-variable relations were specified by probability distributions. *What subjects of statistics did we use in our research and what results could we get with statistics?*

Finally, in step 7 we designed our risk quantification model. *What did we need and what did we use to design our model?*

This section not only gives answers to the questions above but also describes the theories of the subjects.



2.1 Processes

We wanted to make a quantification model for the impacts of the risks on a company's net profit. Therefore it was necessary to find out how a company makes profit. The activities of a company to make profit are described in the value chain. The value chain consists of processes that divide the activities. The levels of processes can be read in Appendix III 'Level of processes'. Knowing how a company turns input into output could help us to describe the output after the impacts of the risks.

2.1.1 Definition

Burg [4] described a process as a series of successive activities that transforms input into output. This output is supposed to create value for the organization.

A process has two criteria:

- A process transforms input into certain output;
- Every process has one goal. If there is more than one goal, then there is more than one process.

The relationship of input, process, and output is as follows:

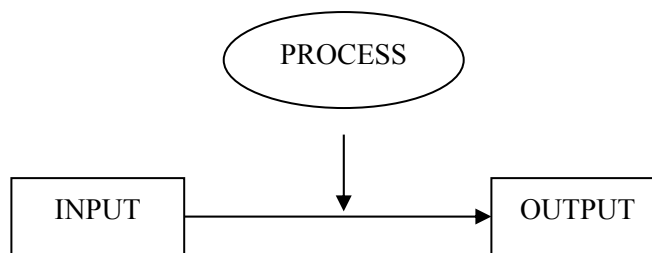


Figure 2.2 Input-Process-Output

2.1.2 Process Modeling

Process modeling is a way to gain insight into a company's processes. It gives the company information about the possible outputs of the input. The different outputs are the results of the impacts of the risks from the company.

Modeling processes is useful because process models:

- Give information about the activities in the organization. These activities will lead to value addition;
- Give an indication in the necessary preparation for a process;
- Give insight in the activities and its dependencies. Analyzing and/or simulating the process models will improve this insight;
- Give a clear picture about the responsibility of every department.



2.2 Net Profit

In our methodology we used the net profit to quantify the risks. We wanted to quantify the risks by describing the impacts of the risks on the net profit. This section describes how the net profit is calculated. The profit and loss account presents the calculation of a company’s net profit. It consists of the descriptions of the revenues and costs elements.

2.2.1 Profit and Loss Account

The net profit is calculated in the profit and loss account. This calculation is based on the *revenues* and the *costs*.

Van Asperen [5] described three important results of the profit and loss account:

The **operating result** is the balance of the *operating revenues* minus the *operating costs*.

The **financial result** is the balance of the *interest revenues* and the *interest costs*.

The **extraordinary result** is the balance of the *extraordinary revenues* and the *extraordinary costs* (= revenues and costs that cannot be considered as the operating revenues and costs).

Examples of extraordinary elements are costs of reorganizations, recovery of fundamental faults.

The results are calculated as follows:

Operating Revenues		Interest Revenues		Extraordinary Revenues	
Operating Costs	-/-	Interest Costs	-/-	Extraordinary Costs	-/-
Operating Result		Financial Result		Extraordinary Result	

The general profit and loss account is as follows:

Operating Result	
Write-offs	-/-
Operating result after write-offs	
Financial result	+/+
Result of normal business exercise before taxes	
Taxes (on result of normal business exercise)	-/-
Result (on normal business exercise) after taxes	
Extraordinary result after taxes	+/+
Result after taxes/ net profit	

Describing the impacts of the risks on the net profit meant describing the impacts of the risks on the revenues and costs elements. We made a step further and described the impacts of the risks on the variables of the revenues and costs elements. The reason is described in the next section.

2.2.2 Variables

The values of the revenues and costs elements are either received from bills or calculated by certain formulas. We defined the values that are received from bills as **Fixed Price**³ in our business model. Formulas are combinations of variables. If a variable is influenced by a certain risk then its value can change. The size of the change is called variability and has a certain value. This value can be considered as the value of the risk on that specific variable. We had to define all the variables in order to find the risk values. Variables can be found by defining the formulas of the revenues and costs elements.

³ Words in Arial represent variables in our risk quantification model.



For example, if personnel costs are calculated by the formula:

$$\text{Worked Hours} * \text{Salary per Hour}$$

Then the variables are: Worked Hours and Salary per Hour.

The essence is to find out which variable is influenced by which risk(s) and how big this impact is. The size of the impact can be found by estimating the variability of the variable. These estimations can either be based on historical data or on expert knowledge. This research was based on expert knowledge, because of the lack of measurable data.

Section 2.4 describes how we found the relations between the variables and the risks, and Section 2.5 describes more about turning expert knowledge into measurable data.

2.2.3 Correlations

In practice the variation of variables might be related to each other. It means that if one variable is decreasing for instance, another variable is influenced and will decrease as well. The other way, if one variable is decreasing then another is increasing, is also possible. This is called correlations between variables. Correlations between variables are indicated by a value between -1 and +1. In the first case, when variables vary in the same ‘direction’ (both increasing or both decreasing), we have a positive correlation value. In the second case, when variables vary in the opposite ‘direction’ (one is decreasing or increasing while the other is increasing or decreasing), we have a negative correlation value.

Imagine the variables Price of product and # sold products. In practice, it often happens that if the Price of product is decreasing, the # sold products is increasing. When a product is cheaper people will buy more. This is a case of a negative correlation value. The height of the value indicates how ‘strong’ this relationship is. A correlation value of (-) 0,7 indicates a stronger relationship than a correlation value of (-) 0,3.

Correlation values are given in a correlation matrix:

Correlation Matrix	<i>Variable 1</i>	<i>Variable 2</i>	<i>Variable 3</i>	<i>Variable 4</i>	<i>Variable 5</i>	<i>Variable 6</i>	<i>Variable 7</i>
<i>Variable 1</i>	1						
<i>Variable 2</i>	.	1					
<i>Variable 3</i>	0,7	.	1				
<i>Variable 4</i>	.	.	.	1			
<i>Variable 5</i>	.	.	.	.	1		
<i>Variable 6</i>	.	.	.	.	0,4	1	
<i>Variable 7</i>	.	.	-0,3	.	.	.	1

Figure 2.2 Correlation Matrix

A cell in the correlation matrix indicates the correlation between two variables. The cells on the diagonal matrix always have a value of 1 because that cell correlates two identical variables. Correlation values are only entered in the cells beneath the diagonal axis where we see the dots. In the correlation matrix above we see the next correlations:

- Variable 3 and Variable 1 are correlated with a correlation value of 0,7. This means that if one of the variables is increasing the other variable will increase with almost the same change (70%).



The Review of the Methodology

- Variable 6 and Variable 5 are also positively correlated. Their correlation is 'less strong' than the correlation written above, because this correlation value is just 0,3.
- Variable 7 and Variable 3 are negatively correlated. This means that if one of the variables is increasing (decreasing) the other one will decrease (increase). Their correlation value is not that high (0,3), so the variables do not influence each other very 'strongly'.



2.3 Risk

The goal of this research was to quantify risk. What is the definition of risk and why is it so important to analyze risks?

2.3.1 Definition

Risk sounds like a negative phenomenon. If you look into a dictionary for the definition of risk, you will find a definition like ‘the danger for damage or loss, the dangerous chance’. If someone says, “If you perform plan A, you will have a risk that you will end in situation B”, then situation B sounds like an unpleasant situation.

However, Deloach [2] defines risk as:

‘The distribution of possible outcomes in a firm’s performance over a given time horizon due to changes in key underlying variables’

This definition does not have a negative meaning. How should risk be defined then?

Risk can be divided into two groups:

- *Pure risk* = The risk of damage or loss, which is always negative once they occur.
- *Speculative risk* = The dispersion of possible outcomes that could lead to uncertain returns, which could have negative as well as positive effects for the company.

In this essay, when we talk about risk, we talk about speculative risk. We did not only look at the negative impacts but also at the positive impacts of risks. For the revenues it meant that we did not only look at how they would decrease as a result of the impacts of the risks, but also how they would increase. For the costs we looked at how they could increase and decrease as well.

An example:

Almost every company has competitors. **Competitors** can be defined as a risk for the company. Imagine a revenue element called **Water Delivery**. It has the following formula: $\text{Water Delivery} = \text{Price} * \text{Water Quantity}$.

The risk **Competitors** causes variability in the variable **Water Quantity**. The risk does not only cause decrease in **Water Quantity**, it can also make **Water Quantity** increase.

Besides ‘stealing’ its customers, competitors can also be seen as a motivation for the company to work harder on its performances.

2.3.2 Risk Analysis

Every company has to deal with risks. Risks might have big impacts on the company, such as loss of money or your investors/clients might lose faith in your company. Risks should be analyzed as best as possible. When there is risk involved in the situation the company is interested in, people will like to know the impact of the risk. That is why there is need for risk analysis.

The first thing a company should do is defining the risks in words (qualitative expression), in order to recognize them. It is a matter of thinking about the uncertain situations the company could have and deciding what kind of risks is related to them.

The next thing is to understand as precisely as possible from where the risks originate. If you know the sources of the risks, it will be easier to describe what will happen when this risk occurs. This will help risk managers to decide what is needed and available to measure these changes.



The Review of the Methodology

Finally, the last thing is to measure/estimate the likelihood and financial impact of the risks. The likelihood indicates the probability that a risk will occur, and the financial impact indicates the size of the risk effect. After risks are measured, risk managers will have a better idea about what kind of decisions should be made and how to formulate strategies in order to manage these risks.



2.4 Expert Knowledge

Once we knew what the variables and risks were, we could find the relationships between them. Here fore we needed expert knowledge. The expert knowledge was divided into two questions:

1. Which variables are influenced by which risks?
2. How big is this influence?

2.4.1 Risk-Variable Relations

The first question led to the risk-variable relations. For this question it was important that the experts looked at each risk separated from each other. They had to decide from each risk separately which variable(s) they could influence. The advantage of this way was that the impacts of the risks we were looking for would also be independent from each other. This led to a calculation of each risk value without influences of the other risks.

Risk-variable relations are presented in a matrix:

Variable Risk	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	Variable 6	Variable 7
Risk A	V						V
Risk B							
Risk C				V			
Risk D							
Risk E		V					

Figure 2.3 Risk-Variable Relations

A cell in the matrix indicates a risk-variable relation with a ‘V’. In the matrix above we see the next risk-variable relations:

- Risk A has impact on Variable 1 and Variable 7;
- Risk C has impact on Variable 4;
- Risk E has impact on Variable 2.

2.4.2 Input Values

Once we had an overview of the risk-variable relations we needed to ask for the most important input values. This was the expression of the impact of each risk. For each risk-variable relation we needed to assign values. These values indicated the variety of the variable as the result of the influence of the risk. This variety was indicated by a most likely value, a minimum value and a maximum value.

The most likely value was not hard to estimate. This was a matter of looking at the most common value for the variable of the past few years. The maximum and the minimum value were more difficult to determine. The expert had to estimate the biggest deviation above and below the most likely value. The estimation of these values was strictly based on the influence of one risk only.

For example, you have the variable **Price** that is influenced by the risk **Competition**. The most likely value is the most common value of the **Price**. The maximum value is the maximum deviation above the most likely value of **Price** when it is influenced by the risk **Competition**. And the minimum value is the maximum deviation below the most likely value when it is influenced by the risk **Competition**.

The next section explains how these values were used in the model.



2.5 The basics of Statistics

The product that our research delivered was a risk quantification model with the help of statistics. First of all, we turned the input values of the expert knowledge (Section 2.4.2) in *Probability Distributions*. The application of a technique called *Monte Carlo Simulation* (Section 2.6.2) turned this input into output. This output was examined with the help of *graphs, stochasts* like *standard deviation* and *expectation, tests* and *confidence intervals*. This section describes the basics of statistics, in order to understand the statistical terms and methods.

2.5.1 Statistics

Tijms [6] defined a model as a description of a real life event in order to gain insight in this event. Statistics can be seen as the way in which statisticians find suitable models for real life events. The model is a construction of actual data (of the event) combined with statistics. Actual data are usually historical data. These data are called *observations*. Statisticians analyze the observations by making different kinds of plots and calculations. This is called *data analysis*. You can read about data analysis in Appendix IV ‘Data Analysis’. Eventually, statisticians want to give a summary of the observations. This summary is presented by a *Probability Distribution*. A probability distribution describes the behavior of the observations and allows statisticians to make conclusions of their research. The behavior is expressed in the probabilities of the values that occur in the observations. These conclusions should provide the user insight in the event. With the help of the insight in the event, statisticians are able to estimate the behavior of the event.

Unfortunately, in real life it often happens that historical data are not available. They were either not collected or they are not representative anymore for the situation nowadays. With the lack of historical data, there is no other choice than to examine the behavior of an event without observations. Without observations we will use expert knowledge. The expert knowledge that we used in our research is described in Section 2.4.2. With clear descriptions and a good sense for values, this will lead to suitable probability distributions for the event.

2.5.2 Probability Distributions and Distribution Functions

A probability distribution $F(X)$ describes the behavior of an event. In statistics an event, in which you are interested, is also called a *stochast*. A stochast is often indicated by X . The description is expressed in the probabilities that values will occur. The values are summarized in one or two *parameters*. Two important parameters are the *mean* and the *standard deviation* (see Section 2.5.4). When parameters values are known we can set up the *distribution functions* of a probability distribution. According to Morgan and Henrion [9] distribution functions are given for computing the moments of the distribution in terms of its parameters. The distribution function describes the probability that X (stochast) takes on a value less than or equal to a value of x . A probability distribution is thus a general description of the behavior of an event. The general description is specified into distribution functions that consist of values for the parameters.

We can set up different distribution functions. Two of them will be frequently used in our model:

- *The probability density function $P(x)$*

The probability density function displays the values on the x -axis and the probabilities these values will occur on the y -axis.

- *The cumulative distribution function $D(x)$*

The cumulative distribution function gives the probability that X will be less than or equal to each possible value x . It is the integral function of the probability density function. The total probability mass of the values has the maximum probability of 1. And the value 0 has the minimum probability of 0.

Graphs of these functions will give a clearer picture of the probability functions. This will lead to a picture of the behavior of an event.



2.5.3 Examples

To give a picture of probability distributions and distribution functions, we describe some well-known probability distributions:

- **The Normal Distribution**

The normal distribution is described by two parameters: the location μ and scale parameter σ . Negative values are allowed in the normal distribution. This is why this distribution is theoretically inappropriate for quantities (lengths, weights, etc.).

- The general probability density function is:

$$f(x) = \frac{e^{-(x-\mu)^2/(2\sigma^2)}}{\sigma\sqrt{2\pi}}$$

- The cumulative distribution function does not have a general representation.

The graphs of the functions are as follows:

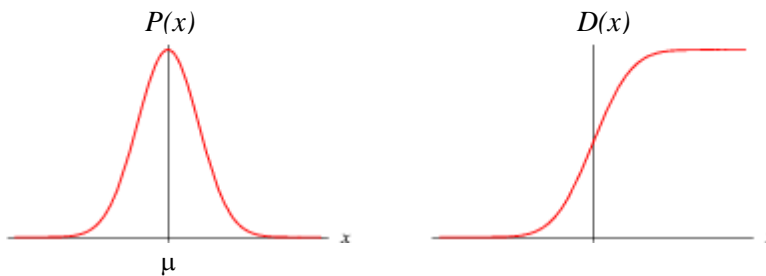


Fig.2.4 The probability density function and the cumulative distribution function of the Normal Distribution

- **The Uniform Distribution**

The uniform distribution consists of two parameters as well: **a** and **b**. Parameter **a** is called the location parameter and the combination of **b-a** is considered as the scale parameter. The uniform distribution is appropriate by a range of values that have the same probability of occurrence.

- The general probability density function is:

$$f(x) = \frac{1}{b-a}, \quad a \leq x \leq b$$

- The general cumulative distribution function is:

$$F(x) = \frac{x-a}{b-a}$$



The graphs of the functions are as follows:

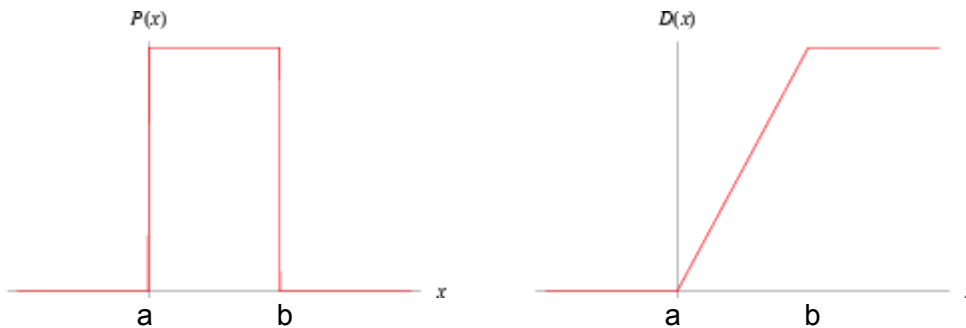


Fig.2.5 The probability density function and the cumulative distribution function of the Uniform Distribution

- **The Exponential Distribution**

The exponential distribution has one parameter λ . Events that occur randomly in time lead to exponential distributions. The parameter λ indicates the occurrence rate of the event.

- The general probability density function is:

$$f(x) = \lambda e^{-\lambda x}, \quad 0 \leq x \leq \infty$$

- The general cumulative distribution function is:

$$F(x) = 1 - e^{-\lambda x}$$

The graphs of the functions are as follows:

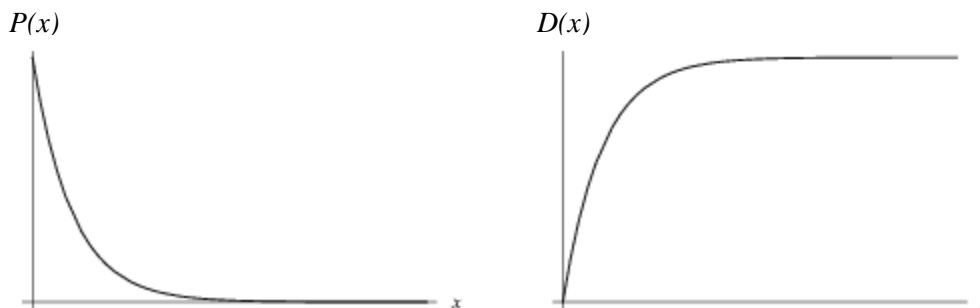


Fig.2.6 The probability density function and the cumulative distribution function of the Exponential Distribution (with $\lambda=1$)

- **The Triangular Distribution**

In the Triangular Distribution, extreme values are less likely to occur than the other values away from the extremes. It consists of three parameters: The minimum value a , the maximum value b , and the most likely value c . The distribution has the shape of a triangular, which explains the name. The triangular distribution is used when there is not enough data available and just the minimum, maximum and most likely value (which is the case in this research).



- The general probability density function is:

$$f(x) = \frac{2(x-a)}{(b-a)(c-a)}, \quad a \leq x \leq c$$

$$f(x) = \frac{2(b-x)}{(b-a)(b-c)}, \quad c \leq x \leq b$$

- The general cumulative distribution function is:

$$F(x) = \frac{1}{2} + \frac{1}{(c-a)^2} \left(\frac{1}{2}(x^2 - c^2) - a(x-c) \right); \quad a \leq x \leq c \text{ dit moet ik nog verder uitzoeken...}$$

$$= 1 + \frac{1}{(b-c)^2} \left(-\frac{1}{2}(x^2 + b^2) + bx \right); \quad c \leq x \leq b \text{ dit moet ik nog verder uitzoeken...}$$

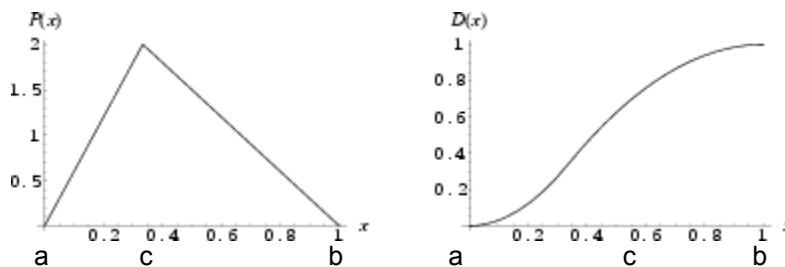


Fig.2.6 The probability density function and the cumulative distribution function of the Triangular Distribution (with $a=0$, $b=1$, and $c=0,3$)

In our model, we assigned probability distributions to each risk-variable combination. Section 2.4.1 described how these risk-variable combinations were found. Section 2.4.2 described the input values that indicate the impact of the risk on the variable. We assigned Triangular Distributions to each risk-variable combination. We made this choice because of the lack of historical data. Without historical data we could not do data analysis to find suitable probability distributions for risk-variable combinations. An easy way to describe a risk-variable combination was to describe it by the three parameter values of the Triangular Distribution.

2.5.4 Mean and Standard Deviation

Two important parameters are the *mean* and the *standard deviation*. The mean is the average value of the data set. The standard deviation is the average difference of the values with the mean.

In formulas:

Imagine a data set as: $X_1, X_2, \dots, X_{n-1}, X_n$

The mean is calculated by: $\bar{X} = \sum_{i=1}^n \frac{X_i}{n}$

The standard deviation is calculated by: $s^2 = \sum_{i=1}^n \frac{(X_i - \bar{X})^2}{n}$



We just described that we assigned Triangular Distributions to each risk-variable combination. These distribution functions were the input of our model. A technique (the Monte Carlo Simulation) turned this input into a range of output. This technique is described in Section 2.6.2. Each risk-variable combination delivered a data set. For each risk-variable combination we could calculate a mean and a standard deviation. The mean will be the average value of the variable when it is influenced by the risk. The standard deviation is the average deviation of the variable when it is influenced by the risk. We considered this value as the value of the risk, because the variety of the variable is only caused by this risk. With the standard deviation we had an expression for the risk value!

2.5.5 Tests

Besides the mean and the standard deviation we also used *statistical tests* to get more information about certain risks. In [10] a statistical test is described as a method for making quantitative decisions about the risks. In this method we have to make a choice between two hypotheses: The *null hypothesis* and the *alternative hypothesis*. Oosterhoff and Van der Vaart [7] describe the hypothesis as follows:

Imagine a data set for which we can assign a cumulative distribution function (see Section 2.5.2). The distribution function consists of one or two parameters. We used one parameter (θ) in our tests. The total values range of the data set will be defined as Θ . Now imagine two values ranges: Θ_0 and $\Theta_1 = \Theta - \Theta_0$. The parameter θ belongs either to a collection Θ_0 or to collection Θ_1 . The hypotheses are as follows:

The null hypothesis: $H_0 : \theta \in \Theta_0$

The alternative hypothesis: $H_1 : \theta \in \Theta_1$

We interpreted the hypotheses were as:

The null hypothesis \rightarrow the risk does have great impact on the output

The alternative hypothesis \rightarrow the risk does not have great impact on the output

We took the values range of the net profit for the output. When does a risk have ‘great’ impact on the net profit?

We decided that if a company makes profit (net profit > 0), the risk does not have great impact. If a company makes loss (net profit < 0), then the risk does have great impact and cannot be simply ignored. The parameter θ will be the net profit. The values ranges will be assumed as (if net profit < 0) $\Theta_0 = (-\infty, 0]$ and (if net profit > 0) $\Theta_1 = [0, +\infty)$

If $\theta \in \Theta_0$, then the risk does have a great impact on the net profit.

If $\theta \in \Theta_1$, then the risk does not have a great impact on the net profit.

The theory behind statistical test is that we may doubt that the null hypothesis is true. We would like to reject the null hypothesis and believe that the alternative hypothesis is true. That is why we are going to test the null hypothesis. If the null hypothesis can be rejected, we can assume that the alternative hypothesis is true. But if the null hypothesis cannot be rejected, it does **not** mean that the null hypothesis is true! There is still a possibility that we do not have enough information to make a decision between the two hypotheses. This leads to two kinds of conclusions:

- 1 Reject the null hypothesis, assume that the alternative hypothesis is true
- 2 Do not reject the null hypothesis, but do not assume that the null hypothesis is true.

Besides these two conclusions, we can also make two kinds of mistakes:

- 1 Rejecting the null hypothesis, while the null hypothesis is true \rightarrow *error of first kind*
- 2 Not rejecting the null hypothesis, while the null hypothesis is not true \rightarrow *error of second kind*



The error of the first kind is a bigger mistake than the error of the second kind, because in the first case we have already rejected a hypothesis. In the second case, we just did not make the correct choice. The probability of making an error of the first kind is α . The probability of making an error of the second kind is β . Statisticians will try to keep α smaller than β . We will use α as the criterion for rejecting the null hypothesis. The way of (not) rejecting the null hypothesis is described in the next section.

2.5.6 Confidence Intervals

In the section above, α was described as the risk of making an error of the first kind. The risk is also called the *uncertainty* of a test. A confidence interval can be considered as an interval of values for which we are $(100-\alpha)\%$ sure that these values will occur. In practice, and thus in our research, the value of the uncertainty is often taken to be $\alpha=5\%$. We used this confidence interval for rejecting the null hypothesis. Imagine the output ‘Average Net Profit, based on Risk A’ of the model. The output is delivered as a range of values $X_1, X_2, \dots, X_{n-1}, X_n$. For these values we can make a cumulative distribution graph:

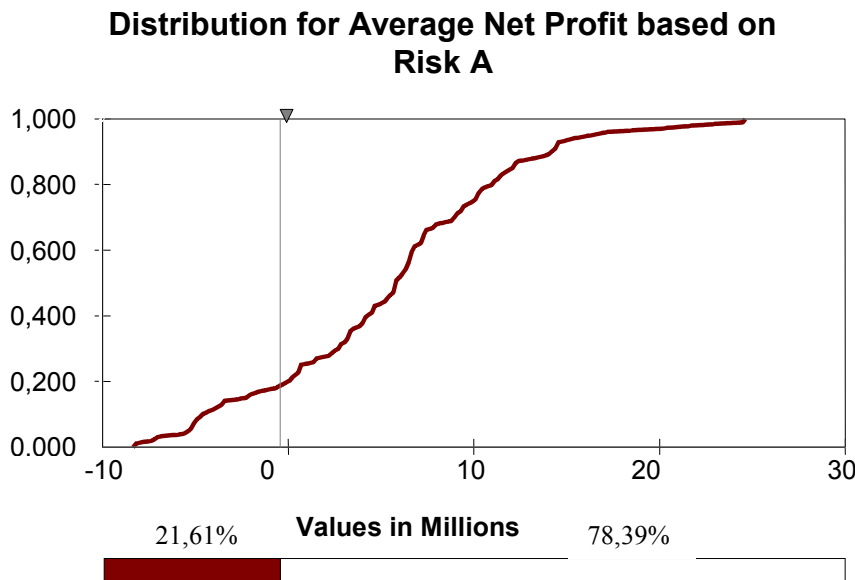


Fig.2.7 Cumulative Distribution Function for rejecting the null hypothesis

We look at the values on the x-axis and particular at the value $x = 0$. The interpretation of this value is that the average net profit is 0, under influence of risk A. Then we take the confidence interval and look at the value for α at the point $x = 0$. In our graph we see that $\alpha = 21,61\%$. This value is bigger than the standard value of 5%. The rule is: If $\alpha > 5\% \rightarrow$ do not reject the null hypothesis
If $\alpha < 5\% \rightarrow$ reject the null hypothesis

In our example this will mean that the null hypothesis will not be rejected. In words it means that risk A might have ‘great’ impact on the net profit. In other words: Risk A cannot be simply ignored.



2.5.7 Quantile Values

Another way for quantifying risks is with the help of the quantile function. This is how financial risks are quantified (Value at Risk). Imagine the graph of the probability density function:

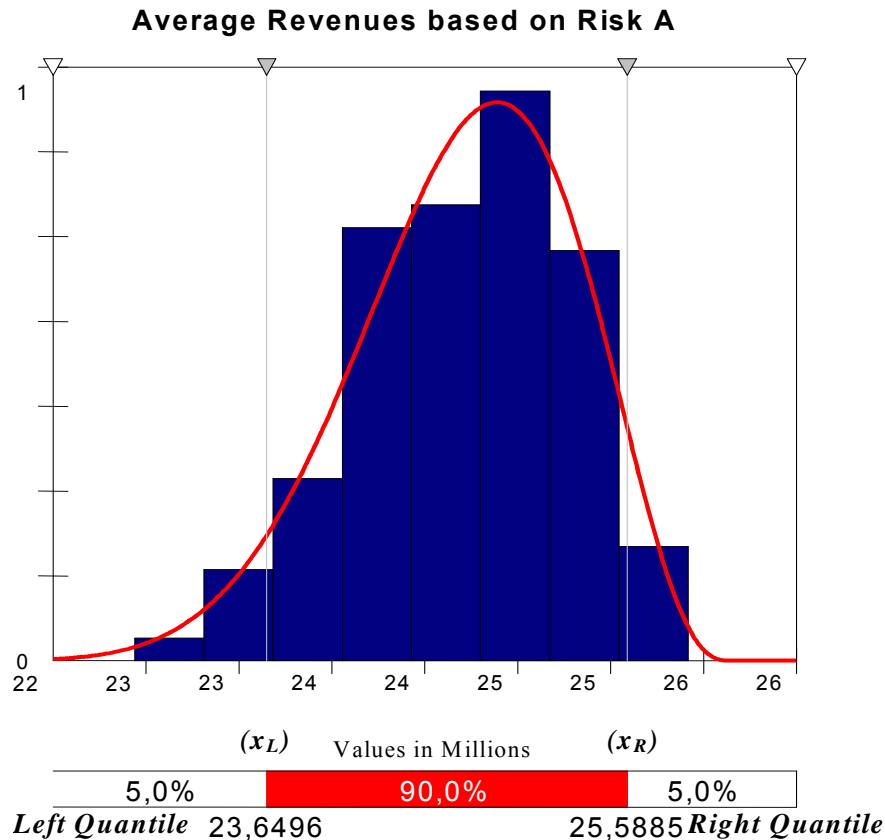


Fig.2.8 Probability Density Function for Quantile values

The blue bars are called the *histogram* (see Appendix IV ‘Data Analysis’). Each bar represents an interval of values. The histogram counts for each interval the amount of points from the data set.

Most graphs of probability density functions have ‘tails’. Tails are actually extreme values of the function. It is not hard to imagine that ‘tail-values’ have the smaller probabilities (the bigger a value the smaller the probability of occurrence). Take a 90%-confidence interval, which means that the tails are the last 5% of the extreme values. The extreme values at a 90%-confidence interval are x_L for the left quantile and x_R for the right quantile. The quantile values x_L and x_R are the least extreme values in the tails of the 90%-confidence interval.

The values can be interpreted as follows:

- x_L = The smallest value for the revenues in the tail of a 90%-confidence interval
- x_R = The biggest value for the revenues in the tail of a 90%-confidence interval

These extreme values can be considered as risk values, because they could have great impact on the company.

In our example it would mean that the impact of risk A could lead to a minimum revenues value of Fl.23.649.600,00 for the left quantile and a maximum revenues value of Fl.25.588.500,00 for the right quantile.



2.6 Simulation

In Section 2.5 we have mentioned that we used the *Monte Carlo Simulation* in our model. Therefore we used a tool called *@RISK* in which this technique is implemented. This section first gives a definition of simulation, followed by the Monte Carlo Simulation and ends with *@RISK*.

2.6.1 Definition

Arsham [11] described a simulation as:

‘Simulation in general is to pretend that one deals with a real thing while really working with an imitation’

We used simulation as a method to imitate the behavior of a model in a computer. It is the execution of a model, represented by a computer program (in Excel) that gives information about the system being investigated. Simulation is usually used when a model is too complicated to be calculated analytically. A simulation can be represented as follows:

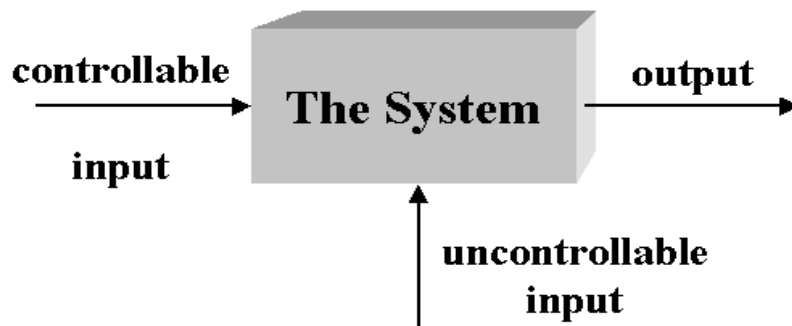


Fig.2.9 Simulation Model

In our model we used the expert knowledge as the *controllable input*. Controllable input is input estimated by experts. The input was turned into triangular distributions. *The System* is a construction of these distributions combined with the Monte Carlo Simulation. The importance of the Monte Carlo Simulation (Section 2.6.2) is that it takes the *uncontrollable input* into account. Uncontrollable input is input that cannot be estimated, like irregularities for instance. Finally, the simulation delivered output that was examined with the help of the statistical methods described in Section 2.5. Eventually, we were able to quantify our risks.

2.6.2 Monte Carlo Simulation

The Monte Carlo Simulation is a statistical simulation method. In [12] it is described as a method that randomly generates values for uncertain (input) variables over and over to simulate a model. These random values are samples of probability distributions. Probability distributions are assigned to the input variables of the system. In our model we only used the triangular distributions. The goal of Monte Carlo Simulation is to take uncertain values (*uncontrollable input*) in the calculations, in order to give outputs that are close to reality.

Each sample, also known as iteration, shows a possible “scenario” that could occur. At the end of the simulation the system delivers a whole range of possible outcomes. This output can be examined with statistical theories described in Section 2.5.



2.6.3 @RISK

For the Monte Carlo Simulation we used a tool that is run under Excel. It is called @RISK and it is a Risk Analysis and Simulation add-in for Microsoft Excel®. @RISK specifies uncertain input values in the spreadsheet as probability distributions. Risk Analysis with @RISK encompasses four steps, described in [17]:

1. **Developing a Model:**

Our model was developed during step 1 until step 5 of our approach, described in section 1.4.2. By defining the variables in step 3 we also took the correlations between the variables into account.

2. **Identifying Uncertainty**

Uncertainties were identified as the input variables in the Excel worksheet. Their possible values were specified with probability distributions. In step 6 of our approach we assigned probability distributions to the Risk-Variable Relations.

3. **Analyzing the Model with Simulation**

In step 7 we defined the outputs of our model that completed our risk quantification model.

4. **Making a decision**

Finally, after the input variables, the indications of the correlations, the assignments of the risk-variable relations and the simulation, we performed step 8: Analyzing the results of the simulation. Analyzing the simulation results can help management in making decisions about certain risks.



3 Part I: *Designing the Risk Quantification Model*

In Section 1.4.2 we described the eight steps of our methodology for ‘Quantitative Risk Modeling’. Section 2 described the theories behind the elements of the steps. This section describes the results of the first seven steps. We went to Schiphol Utility Services and asked for some information to design our risk quantification model. Our risk quantification model is a user-friendly model. This means that the input of the model can be changed any time the user wants to. The results will be presented in the next sections. The last step led to our conclusion and is described in Section 4.

A graphical representation of the elements of the model is as follows:

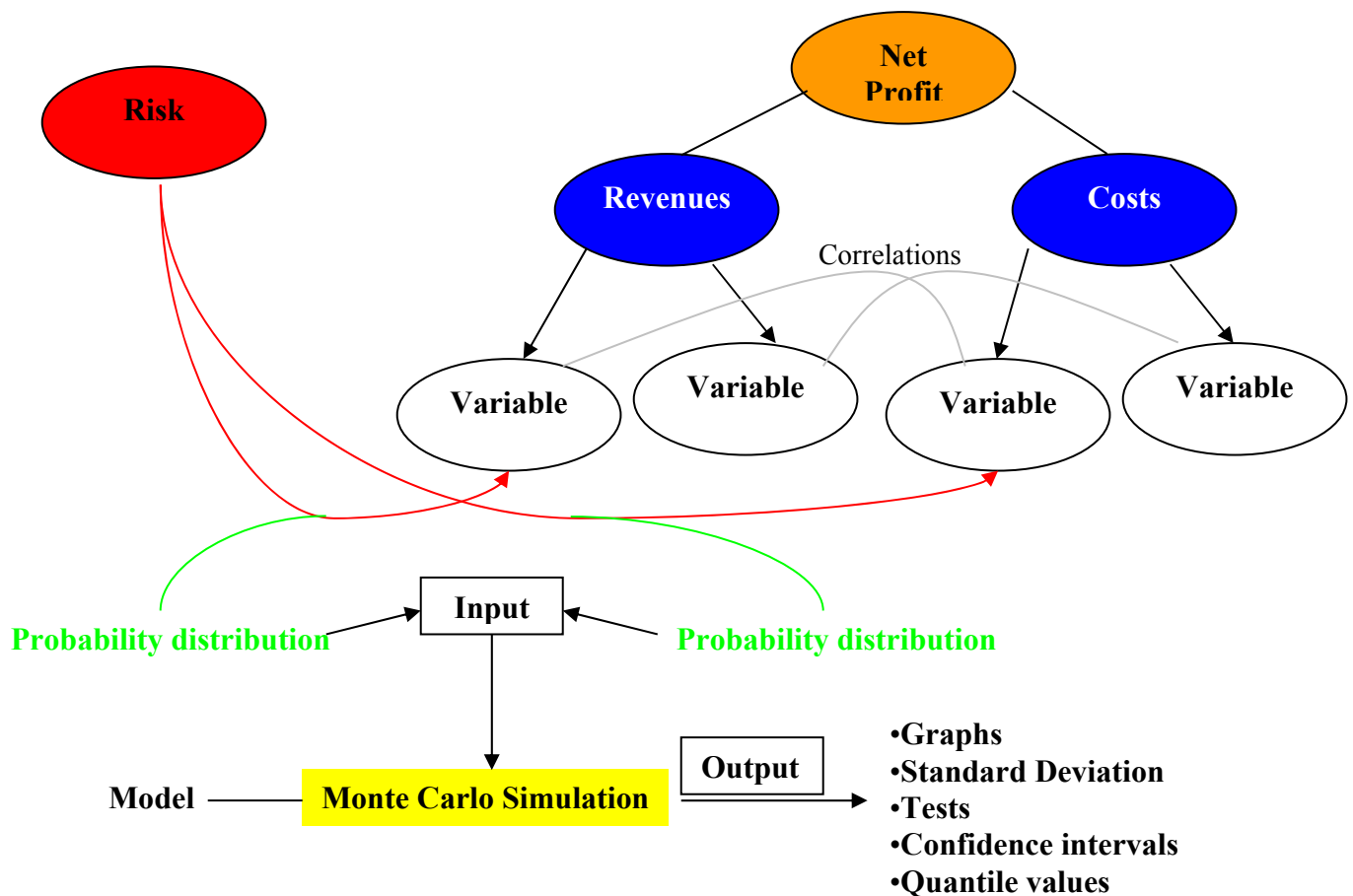


Figure 3.1 Construction of our Risk Quantification Model



3.1 Step 1: Getting Insight in the *Processes*

With the former controller of Schiphol Utility Services we defined the following processes:

- Sales;
- Purchase;
- Transport;
- Maintenance Cable Network and Pipelines;
- Realizing Connections and Infrastructure (according to building projects);
- Administration (accounting, debtor control, etc.).

3.2 Step 2: Studying the *Profit and Loss Account*

According to the same controller of Schiphol Utility Services, the following division of the revenues and costs determined the net profit:

We indicated the *groups* in blue, the *sub-groups* in green, the *elements* in black. The formulas of the elements are given behind each element. Prices are indicated by Dutch guilders (NLG).

Revenues:

UTILITY SERVICES (US)

Electricity Delivery (ED)	= ED Price	* Electricity Quantity (kWh)
Electricity Transport (ET)	= ET Price	* Electricity Quantity (kWh)
Gas Delivery (GD)	= GD Price	* Gas Quantity (m ³)
Gas Transport (GT)	= GT Price	* Gas Quantity (m ³)
Water (W)	= W Price	* Water Quantity (m ³)

REMAINING BUSINESS BENEFITS (RBB)

General Public Services (GPS)

Removal Waste Products (RWP)	= RWP Price	* Quantity (Tonnage)
Cleaning (CL)	= CL Price	* Quantity (Hours)
Green Service (GS)	= GS Fixed Price	
Sewage Purification (SP)	= SP Price	* Water Quantity (m ³)
Sewer Contribution (SC)	= SC Price	* Water Quantity (m ³)
Sprinkler (SPR)	= SPR Fixed Price	

Services and Activities Third Parties (SATP)

Amount	= SATP Fixed Price
--------	--------------------

Other Business Benefits (OBB)

Amount	= OBB Fixed Price
--------	-------------------

REMAINING BUSINESS REVENUES (RBR)

Amount	= RBR Fixed Price
--------	-------------------

INTERNAL REVENUES (IRev) = intern revenues

Amount	= IRev Fixed Price
--------	--------------------

**Costs:****INTERN HOURS MAXIMO (IHM)**

Amount = IHM Fixed Price

COSTS BOARD OUT JOBS (CBOJ)**Board Out (BO)**

Amount = BO Fixed Price

Maintenance (MAIN)

Amount = MAIN Fixed Price

Electricity, Gas and Water (EGW)

Electricity Purchase (EP) = EP Price * Electricity Quantity (kWh)

Gas Purchase (GP) = GP Price * Gas Quantity (m³)Water Purchase (WP) = WP Price * Water Quantity (m³)**Purchase and Consumption Materials (PCM)**

Amount = PCM Fixed Price

Hired External Employees (HEE)

Amount = HEE Salary * # HEE Employees

Remaining External Costs (REC)

Rental and Leasing (RL) = REC Price * Quantity (Tonnage)

Insurance and Taxation (IT) = IT Fixed Price

Commercial Costs (CC) = CC Fixed Price

Advice- and Accountants Costs (AAC) = AAC Fixed Price

General Costs(GC) = GC Fixed Price

EMPLOYEES COSTS (EC)

Amount = EC Salary * # EC Employees

DEPRECIATION AND VALUE DECREASE (DVD)

Amount = DVD Fixed Price

REMAINING BUSINESS COSTS (RBC)

Amount = RBC Fixed Price

INTERNAL COSTS (IC) = employees who provide services in office facilities

Amount = IC Salary * # IC Employees

The values for the revenues and costs elements are calculated according to the formulas. The total value of the sub-groups (in green) is the sum of the elements below them. The total value of the groups (in blue) is the sum of the sub-groups described below them. Finally, the total value of the revenues and the costs is the sum of their groups.

3.3 Step 3: Defining the Variables

The variables were found in the formulas of the elements defined in step 2. One part of the elements was calculated with the help of the general formula Price * Quantity. The variables were Price and Quantity. The other part consisted of elements whose values were taken from the bills. In our research we assumed that these amounts were fixed. We called the variables of these elements Fixed Price.



Part I: Designing the Risk Quantification Model

The values for the variables can be entered by the user him/herself. We call these values the *standard values*. A standard value of the variable indicates the value when the variable is not influenced by any risks at all. The model consists of a frame in which the user can enter standard values for all the variables:

Some variables appear in more than one element. These variables are indicated in the same color. It concerns the variables: Electricity Quantity (kWh), Gas Quantity (m³), Water Quantity (m³), and Waste Products Quantity (tonnage). The model changes all the corresponding element values when one of these variables is changing.

Once the variables were defined, we had to design a frame in which correlation values can be indicated and entered. Correlation values are between -1 and +1. The possibilities are restricted; otherwise the model would become too complex. In our case, we made the following assumptions:

- There is no correlation possible between variables of revenues elements and variables of costs elements (unless when it concerned variables that occur in both the revenues as costs elements);
- The variables Fixed Price could not be correlated and were not taken in the correlation matrices.

Correlation values are represented in correlation matrices. By filling in the correlation values, it might be possible that a correlation matrix is inconsistent. An inconsistent correlation matrix is a matrix that is not *positive semi-definite*. A positive semi-definite matrix has eigenvalues, which are all greater than or equal to zero, and at least one eigenvalue that is greater than zero. Eigenvalues can be explained by the following formula:

Imagine a matrix $A_{n,n} = \begin{bmatrix} a_{1,1} & \cdots & a_{1,n} \\ \vdots & \ddots & \vdots \\ a_{n,1} & \cdots & a_{n,n} \end{bmatrix}$, with a_i = variables, and a vector $X_n = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}$.

If there is a vector $X_n \neq 0$, such that $A_{n,n} * X_n = \lambda * X_n$, then λ is called the eigenvalue of the matrix $A_{n,n}$.



Part I: Designing the Risk Quantification Model

Before a simulation is run in the model @RISK will determine whether the correlation matrices are consistent. If they are not consistent, then @RISK will give you the option of letting @RISK generate the closest valid matrix to the entered invalid one. By entering the correlation values the user does not have to take the eigenvalues into account. @RISK will automatically generate a consistent correlation matrix.

Correlations between variables can be indicated in the following frame:

Correlations

On this frame you can indicate correlations between variables.
Once a correlation is indicated the model will ask for the correlation value immediately. Correlation values are between -1 and 1.

UTILITY SERVICES (US) [dropdown]
[dropdown]
Electricity Delivery (ED) [dropdown]

Price kWh

UTILITY SERVICES (US) [dropdown]
[dropdown]
Electricity Delivery (ED) [dropdown]

Price kWh

CANCEL

Once a correlation is indicated the model will ask for the correlation values immediately by the following frame:

Values

Enter the Correlation Value

0

OK CANCEL



Part I: Designing the Risk Quantification Model

After some expert knowledge of the former controller of Schiphol Utility Services, we received the following two correlation matrices in our model:

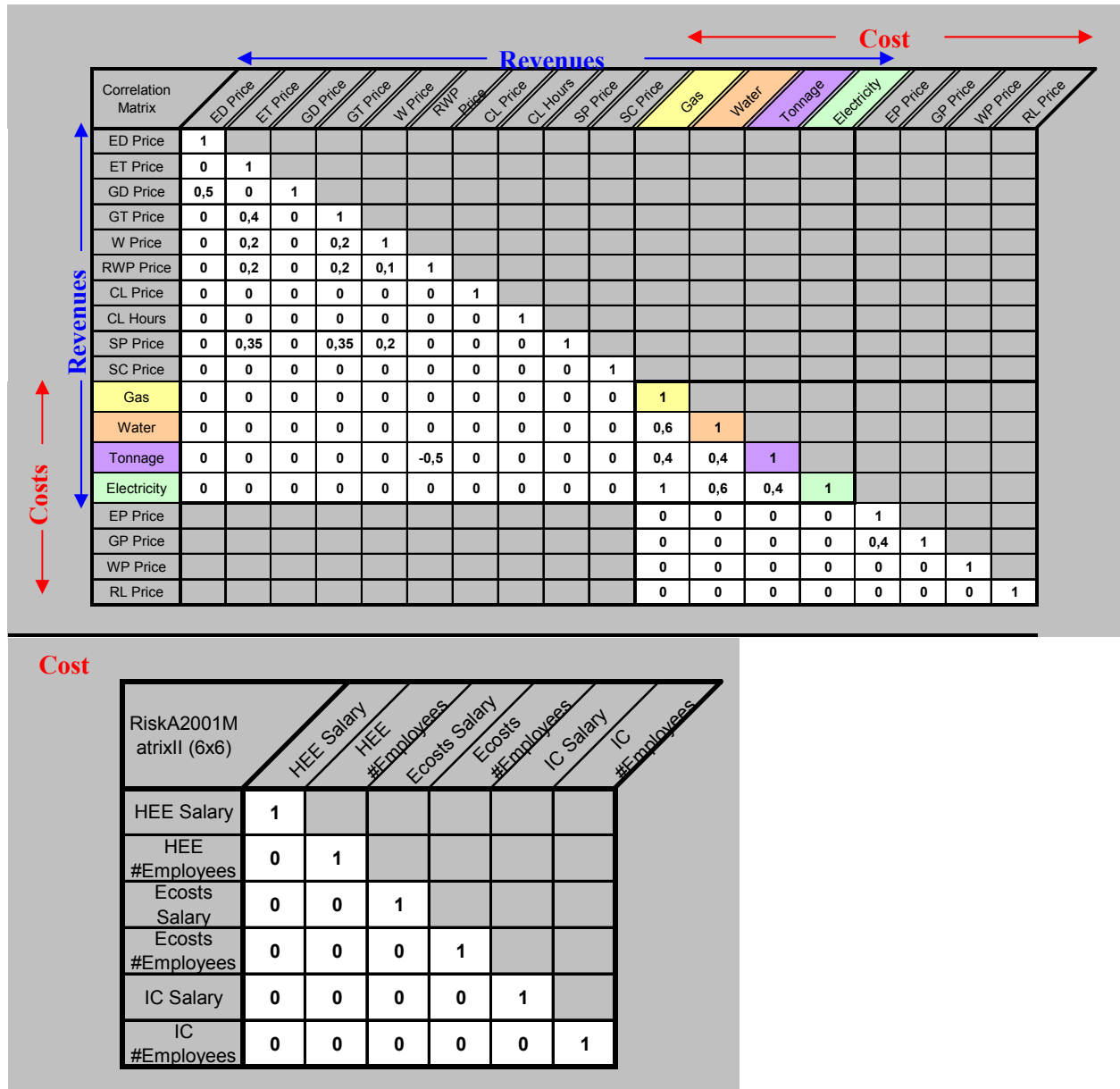


Figure 3.2 Overview of the correlations between variables

3.4 Step 4: Defining the Risks

Our risk quantification model is made to quantify five risks of the Schiphol Utility Services. The total overview of the risks in SUS is given in Appendix V ‘Description Risks’.

This section defines the risks that were implemented in the model:



Part I: Designing the Risk Quantification Model

- 1 **Competition** = Actions of existing competitors or the entrance of new competitors influence the competition advantage and the existence of the organization.
- 2 **Human Resources** = The existence of the necessary knowledge, skills, experience, and motivation at the employees in the organization influence the achievement of goals.
- 3 **Knowledge Sharing** = Ineffective or inefficient processes for knowledge sharing in the organization results in high costs, longer response times, unmotivated employees, and restriction of the growth of the employee.
- 4 **Capacity** = The quality of the product of the organization influence the reputation of the organization and the customer relations.
- 5 **Disturbance** = The damage of pipes could disturb the transport of their products (electricity, gas and water).

To understand the effects of the risks, we first had to understand the meaning of the changes. We described what it meant when the risk would increase:

- IF **Competition Risk** ↑ THEN The number of competitors ↑
The influence of competitors ↑
- IF **Human Resources Risk** ↑ THEN The existence of the necessary knowledge, skills, experiences and motivation ↓
- IF **Knowledge Sharing Risk** ↑ THEN The number of people with non-shared specific knowledge ↑
- IF **Capacity Risk** ↑ THEN The difference between bought and sold capacity ↑
- IF **Disturbance** ↑ THEN The amount of delays ↑

3.5 Step 5: Indicating the Risk-Variable Relations

With a list of variables and a list of risks we could indicate possible risk-variable relations. There is a risk-variable relationship when the risk has impact on the variable. The user can indicate any possible risk-variable relation by the following frame in the model:



Risks & Revenues

On this page you can create risk-variable relations.
If a risk affects a revenue variable there is a relationship.
Once a relationship is indicated the model will ask for the values of the corresponding triangular distribution.

Revenues

UTILITY SERVICES (US)

Electricity Delivery (ED)

Price

kWh

REMAINING BUSINESS BENEFITS (RBB)

GENERAL PUBLIC SERVICES (GPS)

Removal Waste Products (RWP)

Price

Tonnage

REMAINING BUSINESS REVENUES (RBR)

Fixed Price

INTERNAL REVENUES (IRev)

Fixed Price

CANCEL

COMPETITION (Risk A)

For different kinds of risks we needed different kinds of expert knowledge. For our research we managed to get knowledge from one expert in Schiphol Utility services. This expert was the former controller of SUS and was able to indicate the influence of the risk Competition on the variables of the net profit. The expert indicated the following Risk-Variable Relations:

- Risk A (Competition);
IF Risk A ↑ THEN Electricity Delivery Price ↓
IF Risk A ↑ THEN Gas Delivery Price ↓
IF Risk A ↑ THEN Removal Waste Products Price ↓
IF Risk A ↑ THEN Electricity Quantity ↓
IF Risk A ↑ THEN Gas Quantity ↓
IF Risk A ↑ THEN Waste Products Quantity ↓
IF Risk A ↑ THEN Board Out Costs ↓
- Risk B (Human Resources);



Part I: Designing the Risk Quantification Model

- Risk C (Knowledge Sharing);
- Risk D (Capacity);
- Risk E (Disturbance).

The overview of the risk-variable relations in our risk quantification model was as follows:



Part I: Designing the Risk Quantification Model

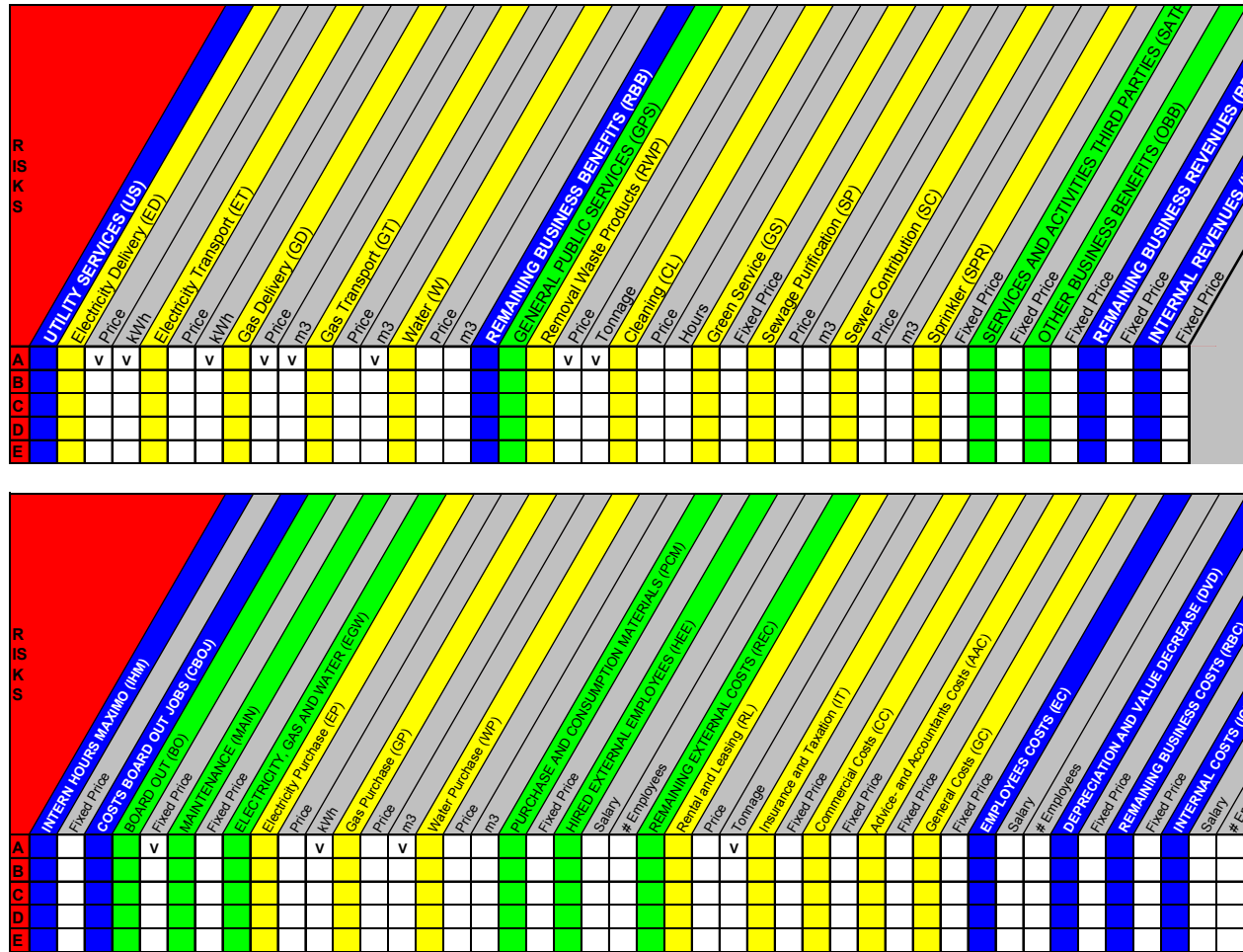


Figure 3.3 Overviews of risk-variable relations

3.6 Step 6: Assigning Probability Distributions

As mentioned before, we assigned triangular distributions to measure the impact of the risks on the variables. Triangular distributions need three parameters: The minimum value, the maximum value and the most likely value. Once the user indicates a risk-variable relation, the model will ask for these values immediately. A frame will appear that also shows the standard value of the variable:



The screenshot shows a dialog box titled "Distributions Values" with a close button (X) in the top right corner. The main title is "Enter the Distribution Values". There are three input fields: "Most Likely" at the top with the value 0.0926, "Minimum" on the left with the value 0.0926, and "Maximum" on the right with the value 0.0926. At the bottom, there are two buttons: "OK" and "CANCEL".

The user only has to indicate the values once, and the model will quantify the risks for the years 2001 until 2004. Year 2001 takes the entered values. Year 2002 until 2004 take the average value of the previous year as the most likely value. The minimum and the maximum value of each year have the same percentage deviation from the most likely value as in year 2001. The reason for this algorithm is because in practice the values of variables in one year depend on their values of the previous year. This algorithm prevents situations like a price of Fl. 100,00 in year 2001 and this same price of Fl. 2,00 in year 2002 for instance. This would not give a realistic output.

In formulas this algorithm is presented by:

Probability Distribution parameters for year 2001: Minimum Value = a
 Maximum Value = b
 Most Likely Value = c

Probability Distribution for year 2002: Minimum Value = $Min2 = ML2 * \frac{a}{c}$
 Maximum Value = $Max2 = ML2 * \frac{b}{c}$
 Most Likely Value = $ML2 = \frac{a+b+c}{3}$

Probability Distribution for year 2003: Minimum Value = $Min3 = ML3 * \frac{a}{c}$
 Maximum Value = $Max3 = ML3 * \frac{b}{c}$
 Most Likely Value = $ML3 = \frac{Min2 + Max2 + ML2}{3}$



Probability Distribution for year 2004:

$$\begin{aligned} \text{Minimum Value} &= \text{Min4} = \text{ML4} * \frac{a}{c} \\ \text{Maximum Value} &= \text{Max4} = \text{ML4} * \frac{b}{c} \\ \text{Most Likely Value} &= \text{ML4} = \frac{\text{Min3} + \text{Max3} + \text{ML3}}{3} \end{aligned}$$

For the risk-variable relations of the risk Competition, the expert indicated the following values for year 2001:

Risk Competition	Minimum Value	Most Likely Value	Maximum Value
Variables			
Electricity Delivery Price	Fl. 0,0700	Fl. 0,0800	Fl. 0,0926
Gas Delivery Price	Fl. 0,1550	Fl. 0,1900	Fl. 0,2012
Removal Waste Products Price	Fl. 0,2455	Fl. 0,2600	Fl. 0,2728
Electricity Quantity	165523800 kWh	248285700 kWh	275873000 kWh
Gas Quantity	24112335 m ³	36168503 m ³	40187225 m ³
Waste Products Quantity	28397650 m ³	33409000 m ³	41761250 m ³
Board Out Costs	Fl. 6621572,0000	Fl. 7421572,0000	Fl. 7421573,0000


Figure 3.4 Distribution values for the variables influenced by the risk Competition

3.7 Step 7: Designing the *Simulation Model*

Our risk quantification model has a 'start'-page that consists of different kinds of buttons. Five buttons are supposed to allow the user to enter the input values. Two buttons will summarize a part of the output. Finally, there are two buttons that represent the net profit and the risks.



The 'start'-page is as follows:



Start

This is the start page of the business model for Schiphol Utility Services to quantify five sorts of risks with the help of the net profit. The model can be used by pressing the buttons below. Each has a description of its function.

For Changings:

in revenues and costs values for 2001

Values	This button shows the useform in which you can change the values of the revenues and the costs when they are not influenced by any risks at all.
--------	--

in relationships between risks and variables, click

Risks & Revenues	This button shows the useform in which you can indicate the relationships between the risks and the revenues variables. Every relationship has to be indicated by a triangular distribution that describes the effects of the risks on the variable.
Risks & Costs	This button shows the useform in which you can indicate the relationships between the risks and the costs. Every relationship has to be indicated by a triangular distribution that describes the effects of the risks on the variable.

in correlations between the variables, click

Revenues	This button shows the useform in which you can indicate the correlations between the revenues variables. Every correlation has to be indicated by a value between -1 and +1.
Costs	This button shows the useform in which you can indicate the correlations between the costs variables. Every correlation has to be indicated by a value between -1 and +1.

After Simulation:

Summarize	This button shows a summary of the output values. It indicates the extreme risk values in red color. It can only be used <u>after</u> the simulation.
Risk Values	This button shows the values of the risks for year 2001 until 2004. It can only be used <u>after</u> the simulation.

For Overviews click:

Net Profit	This button brings you to the profit and loss account that shows the risk values of the revenues and costs. The profit and loss account shows four revenues elements and six costs elements.
Risks	This button brings you to the revenues and costs values, based on the impacts of the risks seperately. The calculation of the values is based on the triangular distributions of every risk-variable relation.




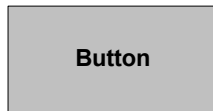
For Report Settings, click		on the @RISK Excel Add-in Toolbar
For Simulation Settings, click		on the @RISK Excel Add-in Toolbar
For Simulation Running, click		on the @RISK Excel Add-in Toolbar

Figure 3.5 'Start'-page of our risk quantification model

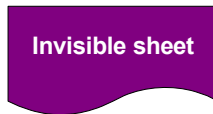


Part I: Designing the Risk Quantification Model

The construction of the model can be represented in a flow chart. The figures have the following meaning:



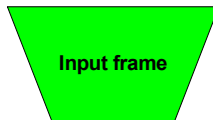
This is a button that either shows an input frame or a sheet by pressing it.



This indicates a sheet that is not visible for the user. The function of this sheet is to store the input values and the choices made by the user.



This is a sheet that is visible for the user. The function of this sheet is to show some values as the result of the choices made by the user.



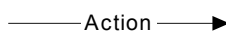
This is a frame for input values. With the help of this frame the user can enter risk-variable relations, values for the variables, correlations or correlation values.



This is storage for the summarized data. The model consists of methods to summarize data into an understandable way for the user.



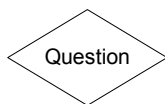
This is storage for the simulation data. It is not visible and can be considered as a 'memory' in Excel for the Monte Carlo Simulation.



This represents the action between two flow chart objects.



This represents transfer of data from one flow chart object to another.



This represents the choice that can be made by the user. The user can decide whether there is a risk-variable relation or a correlation between two variables.



This is the end of any action.



4 Part II: Analyzing the Risk Quantification Model

The expert knowledge that we received from the former controller of Schiphol Utility Services was presented in Section 3. The processes of Schiphol Utility Services were described in Section 3.1. Section 3.2 defined the list of the revenues and costs elements and their formulas. The variables of the formulas were described in Section 3.3, together with their correlation values. In Section 3.4 we described the five risks that could be quantified in our risk quantification model. The description was given by indicating what happened when the risks would increase. Then, in Section 3.5 we presented the risk-variable relations of the risk Competition. Unfortunately we were not able to ask for risk-variable relations of the other four risks. In Section 3.6 we defined the distribution values of the risk-variable relations mentioned in the section before. Finally, in Section 3.7 we showed how the risk quantification model is constructed and the different possibilities of the model.

After the input of the expert knowledge for the risk Competition, we ran the simulation in our model. We ran the Monte Carlo Simulation with 1000 iterations. The model was randomly taking 1000 samples from the probability distributions as values for the (input) variables. We received some output and analyzed it with the methods described in Section 2.5. The results are presented in this section.

4.1 Step 8: Analyzing the Results of the Simulation

For the analysis of the output we used the methods described in Section 2.5. We present three different kinds of results:

- 1 The standard deviations as risk values for the years 2001 until 2004.
- 2 The results of the tests whether to ‘ignore’ the risk Competition or not.
- 3 The quantile values of the risk Competition at an uncertainty of 5%.

4.1.1 Standard Deviations as Result

For the standard deviation as risk values, we looked at the output range of the total revenues and the total costs:

Mean of the revenues:
$$\bar{X} = \sum_{i=1}^{1000} \frac{X_i}{1000}$$

Standard deviation of the revenues:
$$S_{Revenues} = \sqrt{\sum_{i=1}^{1000} \frac{(X_i - \bar{X})^2}{1000}}$$

Mean of the costs:
$$\bar{Y} = \sum_{i=1}^{1000} \frac{Y_i}{1000}$$

Standard deviation of the costs:
$$S_{Costs} = \sqrt{\sum_{i=1}^{1000} \frac{(Y_i - \bar{Y})^2}{1000}}$$

The standard deviation represents the uncertainty value of the output. The risk Competition both influences the revenues as the costs. We had two values for the standard deviation and thus two values for the uncertainty. The final value for the risk Competition is the standard deviation of the revenues minus the standard deviation of the costs, because that is how the net profit is calculated as well (Revenues minus Costs).

The risk value of Competition is thus calculated as follows: $S_{Revenues} - S_{Costs}$



We also calculated the risk value as a percentage of the net profit, in order to have a comparable view of the risk value with the net profit.

The results are:

- The risk value for Competition in 2001 is Fl. 1405133,8772 (39,6858607915601 % of the net profit)
- The risk value for Competition in 2002 is Fl. 2024307,7651 (61,657501089351 % of the net profit)
- The risk value for Competition in 2003 is Fl. 2292701,7009 (74,1511604654165 % of the net profit)
- The risk value for Competition in 2004 is Fl. 2451671,4441 (82,2090737347756 % of the net profit)

We saw an increasing course of the risk values. It meant that the risk value is getting higher every year. We made two conclusions out of this result:

First, this increasing course of the risk value will be the case if the company does not take care of the risk. It is not hard to imagine that if a company does not deal with a certain risk, it will have bigger impact on the company in the future. If the risk value would decrease by itself, we would not be speaking about a risk anymore.

The second conclusion is that as we try to estimate risk values further in the future, these values will become more unreliable. This is expressed in the bigger values for the standard deviation in the future. It does not mean that the risk values in the future are not true at all, but it does mean that future risk values are not as precise as the present ones.

4.1.2 Test as Result

By doing tests for the risks, we could decide in what year the risk would have 'critical' impact on the net profit. We had to make a choice with the help of two hypotheses:

The null hypothesis: H_0 : Competition does have great impact on the net profit

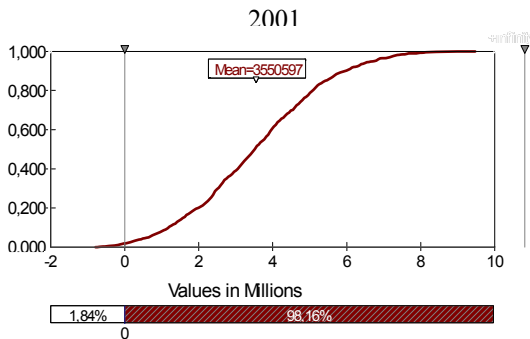
The alternative hypothesis: H_1 : Competition does not have great impact on the net profit

From each year we made a cumulative distribution graph of the output range of the net profit. We took a maximum uncertainty percentage of 5%. Then we looked at the values range and at the uncertainty percentage α for the value 0. If $\alpha < 5\%$, we could reject the null hypothesis. If $\alpha > 5\%$, we could not reject the null hypothesis.

With the help of test we could see that the risk Competition started to have critical impact on the net profit in 2002. The cumulative distribution graphs were as follows:

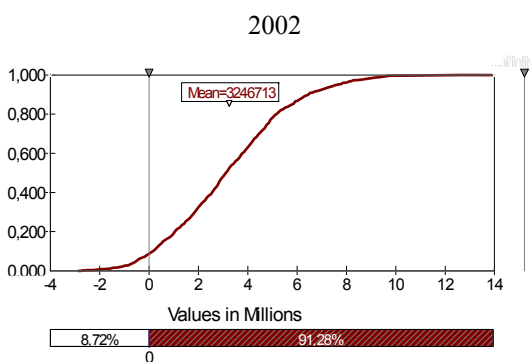


Part II: Analyzing the Risk Quantification Model



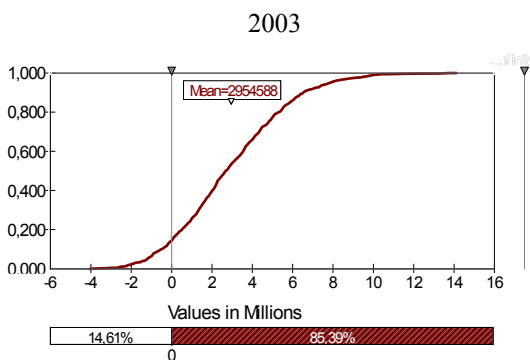
$\alpha = 1,84\% < 5\%$ for net profit = 0

The null hypothesis could be rejected.
The impact of the risk Competition might not be that big in 2001.



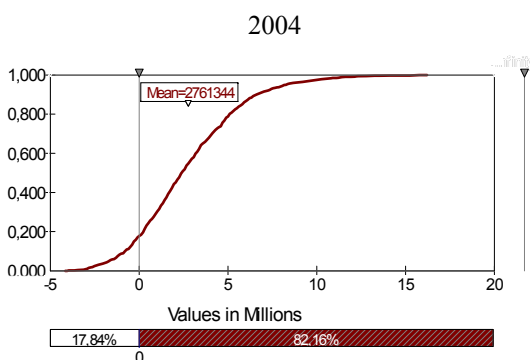
$\alpha = 8,72\% > 5\%$ for net profit = 0

The null hypothesis could not be rejected.
The risk Competition might have great impact on the net profit in 2002.



$\alpha = 14,61\% > 5\%$ for net profit = 0

The null hypothesis could not be rejected.
The risk Competition might have great impact on the net profit in 2003.



$\alpha = 17,84\% > 5\%$ for net profit = 0

The null hypothesis could not be rejected.
The risk Competition might have great impact on the net profit in 2003



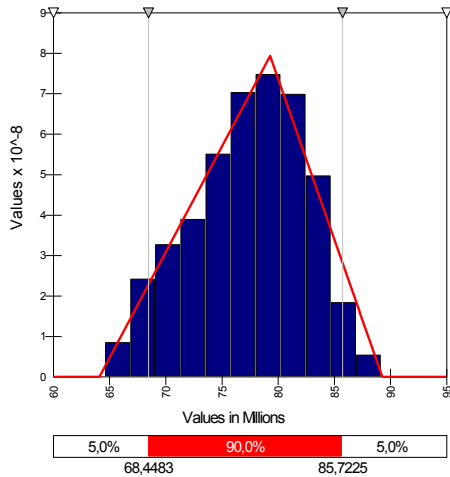
Part II: Analyzing the Risk Quantification Model

4.1.3 Quantile Values as Result

Quantile values are the extreme values of a confidence interval. In our research we looked at a 90%-confidence interval. For each output of the revenues and the costs, we had a left quantile value x_L and a right quantile value x_R .

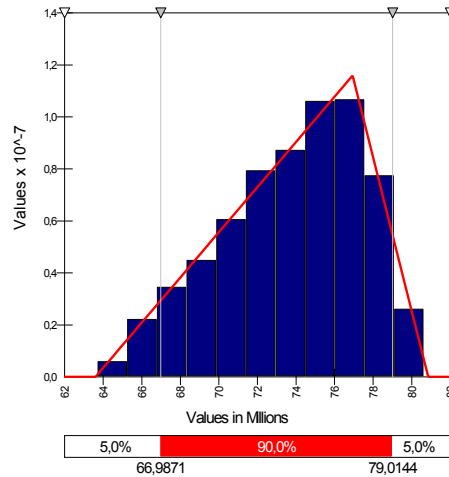
For the risk Competition, we received the following results:

Output of the revenues in 2001, influenced by Competition



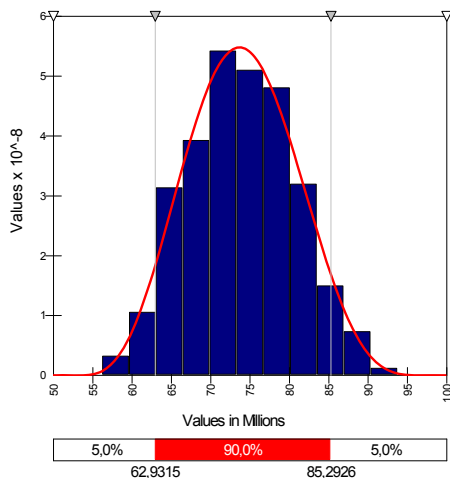
$x_L = 68.448.300,00$
 $x_R = 85.722.500,00$

Output of the costs in 2001, influenced by Competition



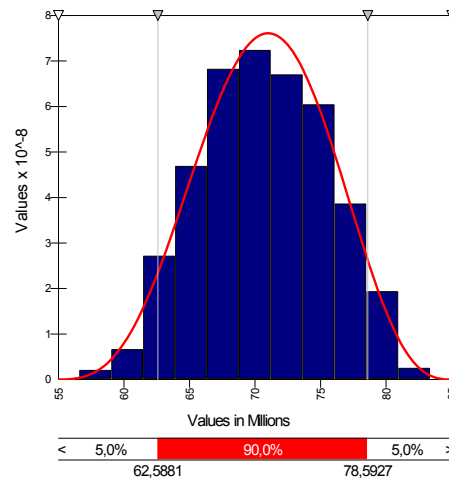
$x_L = 66.987.100,00$
 $x_R = 79.014.400,00$

Output of the revenues in 2002, influenced by Competition



$x_L = 62.931.500,00$
 $x_R = 85.292.600,00$

Output of the costs in 2002, influenced by Competition

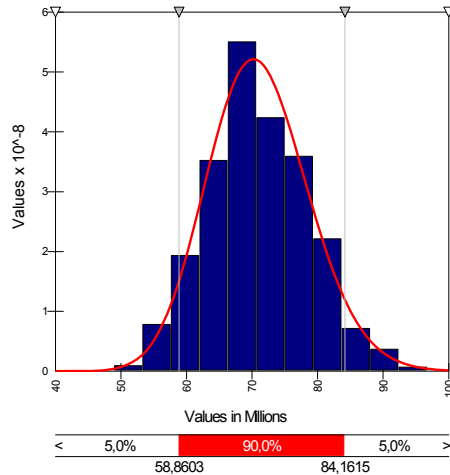


$x_L = 62.588.100,00$
 $x_R = 78.592.700,00$



Part II: Analyzing the Risk Quantification Model

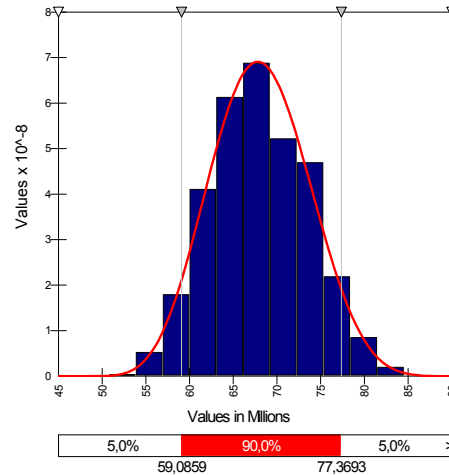
Output of the revenues in 2003,
influenced by Competition



$$x_L = 58.860.300,00$$

$$x_R = 84.161.500,00$$

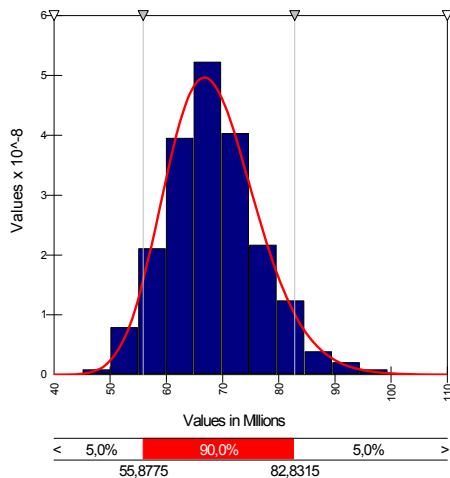
Output of the costs in 2003,
influenced by Competition



$$x_L = 59.085.900,00$$

$$x_R = 77.369.300,00$$

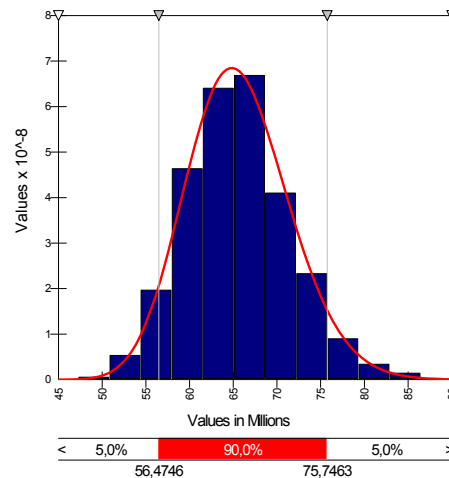
Output of the revenues in 2004,
influenced by Competition



$$x_L = 55.877.500,00$$

$$x_R = 82.831.500,00$$

Output of the costs in 2004,
influenced by Competition



$$x_L = 56.474.600,00$$

$$x_R = 75.746.300,00$$

Minimum revenues:	Fl. 68.448.300,00	Fl. 62.931.500,00	Fl. 58.860.300,00	Fl. 55.877.500,00
Maximum revenues:	Fl. 85.722.500,00	Fl. 85.292.600,00	Fl. 84.161.500,00	Fl. 82.831.500,00
Minimum costs:	Fl. 66.987.100,00	Fl. 62.588.100,00	Fl. 59.085.900,00	Fl. 56.474.600,00
Maximum costs:	Fl. 79.014.400,00	Fl. 78.592.700,00	Fl. 77.369.300,00	Fl. 75.746.300,00



4.2 Difficulties

By using our model we have to keep one important thing in mind:

The results (output) are only reliable if the expert knowledge (input) is estimated as precisely as possible.

During this research we have been through some difficulties by getting our input:

First, we wanted to quantify the risks with the help of historical data. Historical data can be analyzed (Appendix V data analysis) and with the results of the analysis we could make predictions of the data behavior (see Section 2.5.1). Unfortunately, in practice it was difficult to get data. Another problem was that data might not be representative any more the make reliable predictions. Reasons for this problem was for instance the change of the business structure, change of the market or accidents that have influenced the company.

We decided to use expert knowledge and therefore we needed time of the experts. It turned that in reality it was pretty hard to get their time. The needed time from experts should not be under-estimated. The problem was that our output is only reliable if their input is reliable. And for reliable input we needed enough time. Fortunately we were able to get some expert knowledge, but for such a small model we have waited a long time for what we eventually received.

Many people might doubt the reliability of our model. It is always hard to quantify operational risks, with or without data. It is even harder to convince people of its reliability when the results are based on estimations. We believe in the reliability of our model because it was constructed close to reality. It can and probably should be improved in order to get a general risk quantification model. We can try to quantify more risks at once. We can try to use more different kinds of probability distributions besides the triangular distributions. We also can try to specify the Monte Carlo Simulation to get more detailed results. We can still try so many things in risk quantification, but therefore we need people to believe in it and to invest their time in it.



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Appendices



I. Enterprise-Wide Risk Management

I.1. Risk Management

Every company has to deal with risks. It does not matter what kind of company it is or in what kind of department, risks are anywhere, any time and at all kind of levels (from strategic to process levels).

The existence of risks is because of the uncertainty of what can happen in the future. It does not matter how well a company defines its strategies, nobody will know what might happen in the future. The best thing a company can do is to be well prepared for unexpected situations. With good preparation a company can change its plans quickly to adapt itself to the new situation in order to follow its strategies. The trick is to deal with a company's risk in such a way, that it results in a positive outcome.

This is how Deloach [2] describes Risk Management:

'Understanding and effectively manage risk as it (the company) executes its strategies to achieve its business objectives and create value'

The current state of risk management is especially about the past and the present. Risk managers tend to focus their business risks on the recent past. It seems that their theories and strategies are based on facts and tangible assets, which is not enough in these days. To be able to deal with business risks successfully, companies should take the future into account when developing risk strategies. It is not only about the improvement of the past and present any more, but also about evaluation and optimization of the future.

It is necessary to continually improve your company because the world is changing every day and it does not seem to stop. Customer values are becoming higher, technology developments are not ending and competitors seem to show up everywhere, just to name a few developments.

A new way of managing risks has been developed and this new way is called Enterprise-Wide Risk Management (EWRM). EWRM is much broader than the current risk management and identifies and addresses the full range of risks and opportunities.

I.2. Enterprise Wide Risk Management

Deloach [2] describes EWRM as follows:

'EWRM is a structured and disciplined approach: it aligns strategy, processes, people, technology and knowledge with the purpose of evaluating and managing the uncertainties the enterprise faces as it creates value'

The biggest difference compared to risk management is that EWRM is focused on 'Enterprise-Wide', which means the following according to Deloach [2]:

'An elimination of functional, departmental or cultural barriers. It is a truly holistic, integrated, forward-looking and process-oriented approach to managing all key business risks and opportunities – not just financial ones – with the intent of maximizing shareholder value for the enterprise as a whole'

Eventually, EWRM wants to create an organization that is ideal when it satisfies the following:



Enterprise-Wide Risk Management

- It understands and continually re-evaluates its opportunities and risks;
- Its leadership, processes and people are keenly focused on and motivated towards continually refining strategies and tactics to achieve superior results;
- It knows how to ‘price’ both its risks and its opportunities, and it allocates its capital –intellectual, financial and otherwise- accordingly;
- It is an organization with a shared, collectively developed vision, clear operating objectives and optimal communication both internally and externally;
- It is ‘in control’ and yet its emissaries are free to manoeuvre within the scope of their objectives and capabilities.

DeLoach describes eight essential steps in [2] to implement EWRM in a company:

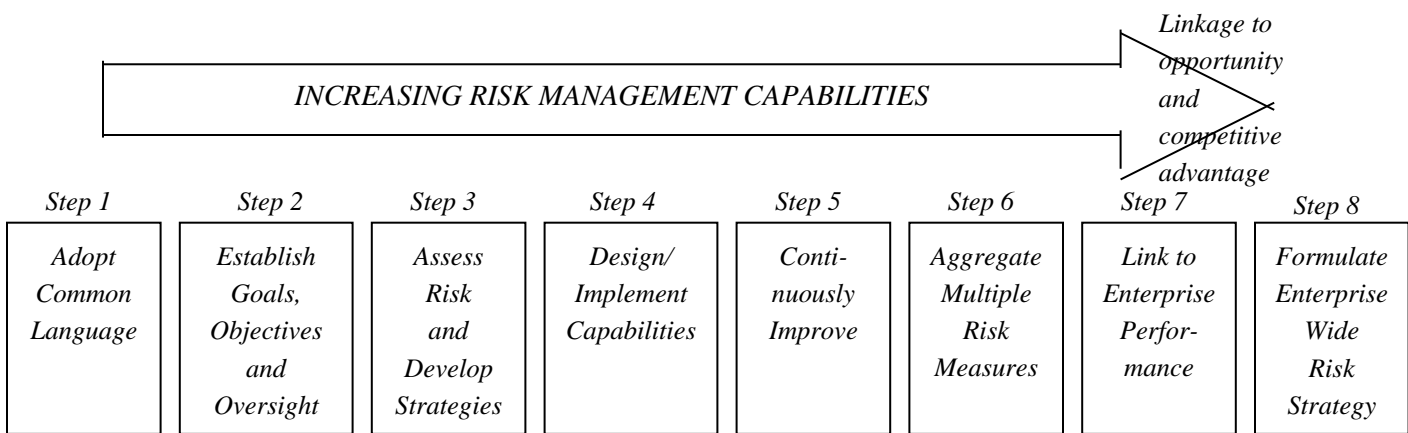


Figure I.1 Steps along the journey to EWRM

These steps will be described more detailed in Appendix II ‘Steps for EWRM’.



II.Steps for EWRM

II.1.Step 1

Adopt a common language

Imagine you have to work with someone who does not speak the same language as you do. That is, of course, an impossible job. Now imagine your partners are speaking the same language as you do; is this enough for a successful cooperation? Unfortunately, that is not what a common language is meant here. What is meant is that partners should have the same understanding and perspective for the project they are working on. Managers from different departments of the same company might have different definitions for risks. They should start with defining what 'risk' is to the firm and then developing a useful risk model consistent with that definition (oversight structure). If a project does not start with a common language between the performers, it could not be performed smoothly and maybe not even successfully.

Adopting a common language can be done in two ways:

Top-down: the top of the organization determines the risks. They analyze the risks of every department of the organization and on that base they will decide what the consequences will be for the organization as a whole.

Bottom-up: key operating and functional support personnel determine the risks of the organization, with the support of top management.

II.2.Step 2

Establish overall risk management goals, objectives and oversight structure

Every project has a goal and an objective. To perform risk management successfully, you should know what you have to reach and the direction you are working for. Especially when this concerns Risk Management that has to affect the whole company ('Enterprise-Wide') and thus should be performed by more than one person. A clear definition of this management's purpose is necessary in order to get a successful cooperation.

In [2] US General George S. Patton once said:

'Never tell people how to do things. Tell them what to do and they will surprise you with their ingenuity'

After a clear definition of the goals and objectives is reached, tasks should be assigned over the company. This creates an organizational oversight structure that makes clear what which department should do. If people know what a company wants to reach, but do not know what their participation in the project is, it does not really work.

As Deloach described in [2]:

'Defining business risk management goals and objectives and establishing an effective organizational oversight structure for risk management is the logical way for senior managers to lead the transition to EWRM from the top'



II.3.Step 3

Implement uniform processes for assessing business risk and developing risk management strategies

After the goals and objectives are defined, the tasks are distributed (in great lines); the next thing that is needed is a process to start working on. This process is needed in order to ensure a comprehensive, well controlled, consistent and yet effective approach to implement this business risk management.

Andersen has created a process that is as follows:

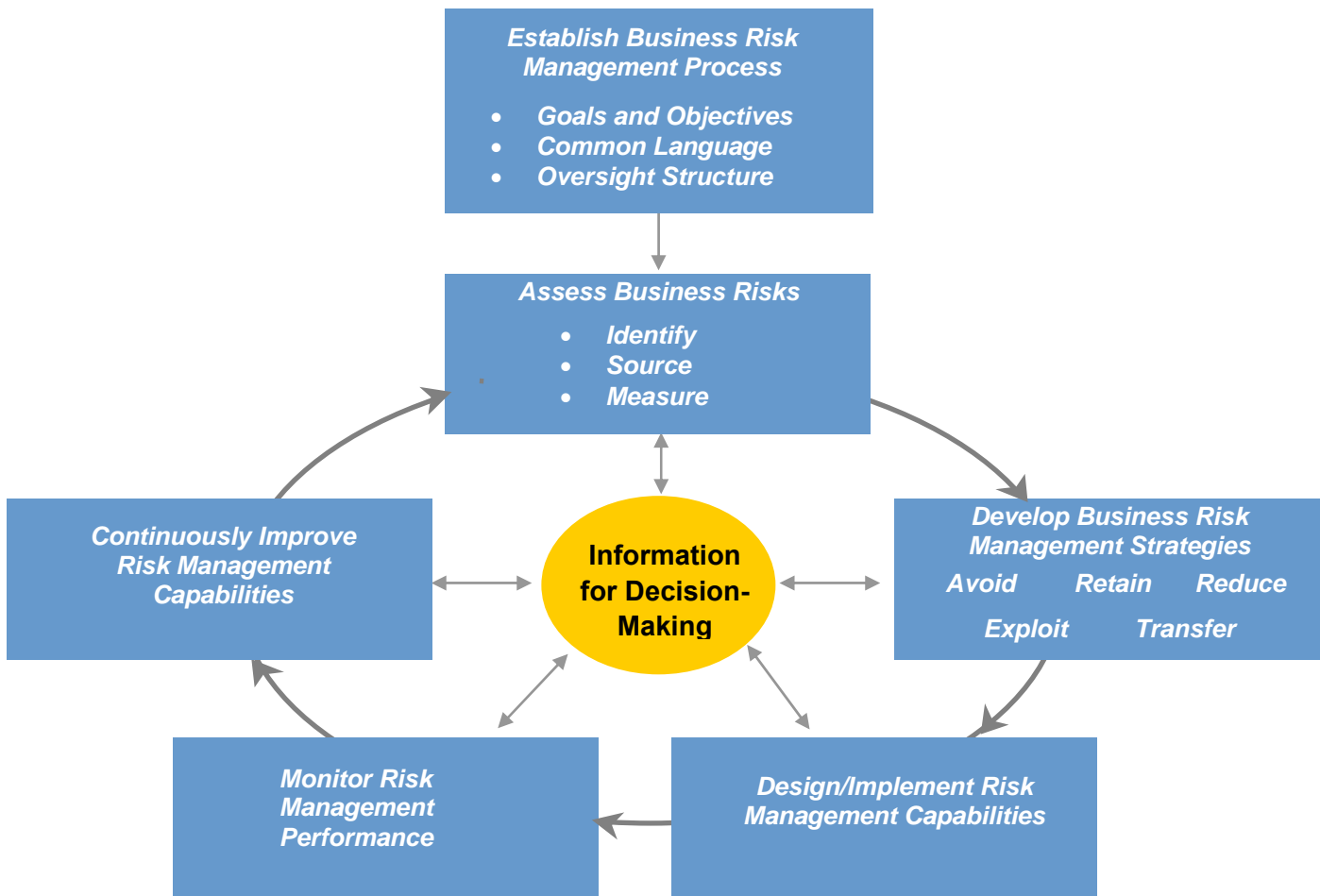


Figure II.1 Andersen business risk management process (BRMP) [2, page 116]

In [2] Deloach describes BRMP as follows:

‘The BRMP is a systematic approach to building and improving risk management capabilities and is a catalyst for continuous improvement’



BRMP achieves two ends:

- *It equips designated process and risk-owners with a useful framework for defining the essential tasks of risk management*
- *It is a systematic process for building and improving comprehensive risk management capabilities which, as they evolve enterprise-wide, provide the launchpad for a true EWRM environment*

The first task of the BRMP is described in step 1 and step 2 of the implementation of EWRM.

The following two tasks of the BRMP belong to step 3 of the implementation of EWRM and will be described below:

Assess business risks

To assess the business risks, BRMP starts with *identifying* the risks. It is a matter of thinking about the uncertain situations the company could have and deciding what kind of risks is related to that.

Then we have to find the *sources* of these risks. We should understand as precisely as possible why, how and where the risks originate (both internally and externally). This could help risk managers to decide which data are needed and are available to measure these risks and it could facilitate the selection of strategies for managing these risks.

Finally we have to *measure* the severity, likelihood and financial impacts of risk. After risks are measured, risk managers will have a better idea about what kind of decisions should be made and how to formulate the strategies. This is necessary for managing these risks.

Develop business risk management strategies

After the assessment of business risks, a strategy should be developed to make the BRMP work. Keijzer defines strategy in [3] as follows:

‘Strategy is the formulation of the objectives in operational statements. These formulations indicate the paths along which, and the resources with which, the organization wants to realize the proposed objectives’

In many cases, the amount of assessed business risks is too big. In this case, you should filter the risks that are the most important to do this research on. Then you can decide which strategy to use.

II.4.Step 4

Design and implement risk management capabilities to execute defined risk management strategies

The following two tasks of the BRMP belong to step 4 of the implementation of EWRM and will be discussed below:

Design/implement risk management capabilities

A strategy is a good start of the BRMP, but it needs to be executed. For this execution it is necessary to implement risk management capabilities like processes, people, reports, methodologies, and technologies (systems and data). Andersen has made an infrastructure of these capabilities, included the strategy:



Figure II.3 Six infrastructure components comprising risk management capabilities [2]
(The infrastructure is developed one link at a time, each component driven by the previous one)

Here follows a short description of the need of each capability:

- *Business strategies and policies*: This component was mentioned above.
- *Business risk management processes*: A strategy that concerns a whole company can only be followed when there are well-defined processes available. Every risk owner (manager who is responsible for losses experienced when undesirable risk incidents occur) has its own process to be performed in order to reach the goal of this strategy.
- *People*: For a successful performance of a process, it is important that every performer (people) has to know clearly what his or her task is within this process. There should also always be a manager to lead the process.
- *Management reports*: Managers are the ones who decide and not who perform. In order to be involved in the processes, it is important that every process delivers risk reports for the management.
- *Methodologies*: Methodologies organize key tasks and a working body of knowledge within a logical framework and are needed to support decision-making.
- *Systems and data*: Without systems and data, methodologies will not serve their intended purpose.

Monitor risk management performance

The fifth step of BRMP is intended to monitor the effectiveness of the previous step of BRMP (design/implementation of risk management capabilities). Monitoring is like checking the processes by independent executives and functions at appropriate levels of the firm. This is necessary for the management to be sure that the processes are performed to the right directions.

II.5.Step 5

Build on the above foundation to continuously improve strategies, processes and measure for individual risks

Finally, the last task of the BRMP belongs to step 5 of the implementation of EWRM and will be discussed here:

Continuously improve risk management capabilities

A couple well-executed processes to perform the BRMP are not enough for a company to implement EWRM. EWRM is about taking a look into the future and try to match the risks with it. EWRM is needed because the world is constantly changing and these changes seem to accelerate as well. That is why a good working process



is not enough. The last task needed for the BRMP is continuous improvement of this process in order to enhance risk management capabilities. This will lead to the identification of the firm's most pressing exposures and uncertainties and new activities on the capabilities required for those exposures and uncertainties.

This was the last task within the BRMP. It does not mean that the steps for implementing EWRM are finished already. What is needed now is the 'finishing touch' to make a difference between the current Risk Management and EWRM. Three more steps have to be taken to make this distinction.

II.6.Step 6

Aggregate multiple risk measures

In the BRMP the strategy was divided into multiple processes that had to be performed by different risk owners. This resulted in individual risks and thus individual risk measures. In step 6 of the implementation of EWRM these individual steps will be aggregated in order to improve the methodologies for measuring individual risks. Managers will be able to make even better decisions concerned their risk strategies.

As Deloach described in [2]:

'Aggregation of multiple risks makes sense for activities directed at achieving a common enterprise-wide purpose'

II.7.Step 7

Link aggregate measures to enterprise performance

Imagine the following situation:

You see nice shoes in a shop. Those shoes are the ones you have always been looking for and they just exactly meet your picture of the ideal shoes. Then you try them on and it turns out that they do not fit your feet at all.

It might sound funny, but this could happen to EWRM as well. It does not matter how well defined the risk management strategies are, if they do not fit your enterprise performance, it simply does not work. It is important to understand the effects of comprehensive risk management strategies on enterprise performance, because every company is different and thus has its own results.

II.8.Step 8

Build on all of the above capabilities to formulate an enterprise-wide risk strategy, results in new insights which spawn new risk management capabilities

Finally, the last thing to do for the implementation of EWRM is to define an enterprise-wide risk strategy. Earlier, in step 3, we already defined a strategy for the BRMP. However, this strategy was based on individual risks and groups of related risks. What is needed now is an enterprise-wide strategy formulation, based on the aggregated risk measures. If this is done, then you have successfully implemented EWRM to your company.



III. Level of processes

An organization creates value through a **Value Chain**. The Value Chain is a queue of successive activities to transport a product/service from the very beginning of the organization (input) to the consumer (output).

A Value Chain consists of **Business Processes** (the ‘arrows’). There are three main divisions of business processes: Primary business processes, secondary business processes, and tertiary business processes. Business processes have their own business process goals to realize the value creation of the organization.

The way to reach these goals happens through the **Processes** within the Business Process. Processes indicate the activities, the execution order and the responsibilities of a business process. It describes the most effective way to reach the business goals.

Processes on its turn are divided in **Process Steps**.

Each process step contains **Tasks**. Tasks are the simplest activities of a value chain, which are almost always performed by just one person and not in a particular order.

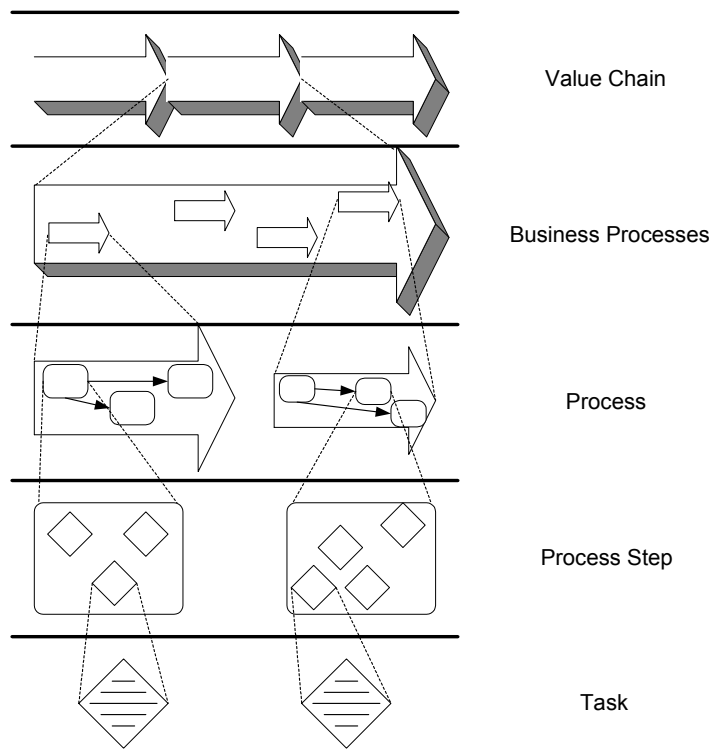


Figure III.1 Level of Processes



IV. Data Analysis

If we have collected a data set we would be able to analyze them with the help of data analysis. Data analysis starts with data summary. De Gunst and Van der Vaart [15] have described the following questions to get data summary:

- Which values do the majority of the data take and how are the data distributed over these majority values?
- What are the **biggest and smallest** observations; are there extreme values?
- Are there data that **often occur**: is there a matter of 'one-top' or 'more-tops' distribution; is there a domain of values that hardly occurs: is there a hole in the value domain?
- Are there values more or less **symmetrically distributed** around a certain point; if so, does the distribution look like a familiar symmetrical one: homogeneous, normal, etcetera; if not, does the distribution look like a familiar asymmetrical one: exponential for instance.
- Are the values **rounded off**?
- Do the values have to be **grouped** for separate analysis?
- Is there **influence of other variables**, like time for instance?
- Is there a **correlation** between certain values?

After you have collected a set of data, how do you do a data analysis? What techniques be used? What do the various techniques focus on? What conclusions can you expect to reach?

One of the first things to do is to make plots of the data in one of the many available statistical programs (S-plus, SPSS). Several plots are possible and each of them gives different information about the data. Some of the common used plots are:

- **Histogram** = the intervals of the data are shown on the x -axis and the number of scores in each interval is represented by the height of a rectangle located above the interval.

The histogram graphically shows the following:

- Center (i.e., the location) of the data;
- Spread (i.e., the scale) of the data;
- Skewness of the data;
- Presence of outliers;
- Presence of multiple modes in the data.

An example of a histogram is as follows:

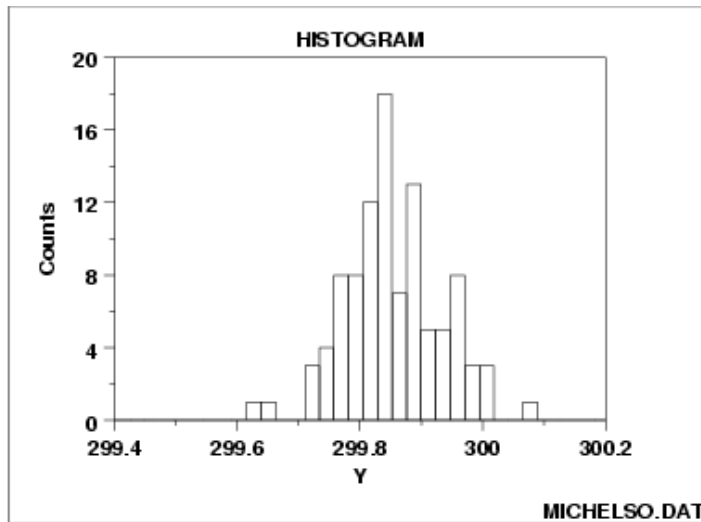


Figure IV.1 Example of a histogram

- **Stem-and-leaf plot**= a stem-and-leaf plot does not really show a plot like the histogram, but gives you a summary of the data. It gives you the number of the values and indicates the value that is in the middle position of the data set (the Median) and the values that are in the quarter positions of the data set (Quartiles). Then it gives a summary of the values by splitting it into single digits.
For example: if you have a value of 52, two values of 66 and four values of 68 in your data set, a stem-and-leaf plot will summarize it as:
5:2
6:668888
It is like a histogram except it portrays a little more information, like the quartiles and the median.
- **Numerical** = it shows the number n , the mean \bar{x} (for the impression of the location), and the variance s^2 (for the impression of the spread of the distribution).
- **Boxplot** = formulated by the response variable (on the vertical axis) and the factor of interest (on the horizontal axis). It calculates the median and the quartiles (the lower quartile is the 25th percentile and the upper quartile is the 75th percentile). It plots a symbol at the median (or draw a line) and draws a box (hence the name box plot) between the lower and upper quartiles; this box represents the middle 50% of the data (the "body" of the data). Then it draws a line from the lower quartile to the minimum point and another line from the upper quartile to the maximum point. Typically a symbol is drawn at these minimum and maximum points, although this is optional.
Thus the box plot identifies the middle 50% of the data, the median, and the extreme points.



An example of a boxplot is as follows:

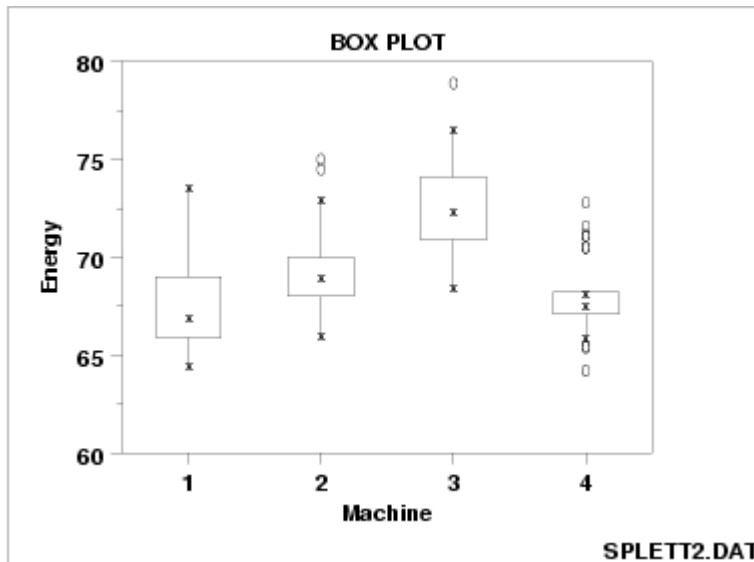


Figure IV.2 Example of for box-plots

By making plots of the data set, you either get ‘nice’ plots that give you insight in the distribution of the data, or you get plots in which there is no structure at all. In this case the data set is not measurable in the way it is presented. The data should be transformed to a new series of measurable data. This can be done by:

- Linear transformations $y = a + bx$ with x is the original data set;
- Power transformations $y = x^\lambda$ with x is the original data set.

Once you know more about a data set, you have to find a distribution that fits the data. When you have this distribution, you can make a lot of calculations to get insight in the behavior of the data. The theory described in Section 2.5 will help you to calculate the risk values of the data.



V. Description of the risks in Schiphol Utility Services

For our research, we implemented five risks in the risk quantification model for Schiphol Utility Services. These risks are Competition, Human Resources, Knowledge Sharing, Capacity and Disturbance. These five risks are not the only ones identified in Schiphol Utility Services. The total collection of their risks is described in appendix:

- **Law & order** = Changes in law influence the competitive pressure and the way in which the organization is able to fulfill her commitments.
- **Competition** = Actions of existing competitors or the entrance of new competitors influence the competition advantage and the existence of the organization.
- **Unexpected events** = Events, beyond the sphere of influence of the organization, can influence the process, the service, and the reputation of the organization.
- **Industry** = The attraction of the industry as a unit is influenced by the changes in chances and threats, like developments at the suppliers, possibilities of competitors.
- **Human resources** = The existence of the necessary knowledge, skills, experience, and motivation at the employees in the organization influence the achievement of goals.
- **Knowledge sharing** = Ineffective or inefficient processes for knowledge sharing in the organization results in high costs, longer response times, unmotivated employees, and restriction of the growth of the employee.
- **Health and safety** = The way in which a safe work environment is created for own employees as well as thirds influence the reputation of the organization and the management.
- **Purchase price** = Fluctuations of the input price influence the profit of the organization.
- **Capacity** = The available capacity influence the possibilities of the organization to fulfill the wishes of the customers and the possibility to operate with competitive charges.
- **Product/ service failure** = The quality of the product of the organization influence the reputation of the organization and the customer relations.

