A new dimension to Risk Assessment

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Abstract

Traditional risk assessment frameworks have been focused primarily on the factors of likelihood and impact, utilizing either a numerical (e.g. 1 to 5) or qualitative (e.g.low,medium, high) rating scale, resulting in the traditional two dimensional framework. The challenge of this model is that the focus is too narrow to effectively assess constantly changing risk environments and fails to differentiate between events that could take effect tomorrow and those which may arise over the business planning horizon (three to five years) or over an even longer time. Recently a third dimension has been added to the discussion of risk: velocity. However, this new concept has been implemented in only a few companies and is treated more as a complement to the traditional approach rather than as an integrated part of the risk assessment.

The aim of this thesis is to develop a new model combining all these three factors (likelihood, impact and velocity) into a single risk velocity assessment and, hence, give accuracy and relevance to risk assessments. Therefore it is crucial that a company has an understanding of how the use of risk velocity can affect the risk assessment and enable risk management to focus on the most relevant and immediate risks.

In this study we implement this risk assessment by using statistical techniques. Based on the idea of the loss distribution approach (LDA), we will estimate two probability distribution functions for each risk type; one on single event impact and the other on event frequency for the next three years. These distributions will be estimated from values obtained following a traditional risk assessment process - capturing risk velocity and retaining as much information as possible from the process to assist in calibrating the distributions. Based on the two estimated distributions, we then compute the probability distribution function of the cumulative operational loss over different time horizons and use this to develop a single velocity adjusted risk metric which can be used to prioritize risks.

We then show that a risk assessment which consider risk velocity can provide more valuable information and make the risk assessment process a more precise and useful tool. This will enable management to understand which risks require more attention and how different risk can affect business plans over different time horizons.

Contents

Chapter 1

Introduction

The first purpose of risk management is to generate and retain value. Risk management should be seen as a fundamental aspect to the companies and its means of creating a return on capital employed, instead of being a burden or a regulatory requirement [28].

Basel Committee or ISO 31000 risk management standards are released to assist companies in incorporating risk management into daily operations. They define the need for risk analysis as one of the steps of the risk management process.

This includes the measurement of the relative sizes of the risks identified. Up to now, this has been developed with two dimensions; likelihood and impact.

The common way to present the measurement of risk is on a heat map, where each risk is plotted as a dot.

This kind of evaluation tries to [28]:

(a) differentiate between the value of some risks

(b) understand the nature of the risk better, especially its likelihood of occurrence and its impact if it were to occur

(c) assist in the prioritisation of those risks that are negative and the mitigation level needed to transform that risk into a tolerable value and

(d) assist in the prioritisation of those risks that are positive and the investment level needed to create the positive outcome of that risk occurring.

This procedure has given rise to many discussions about what exactly this analysis does, and does not say clearly. This study will focus in one of those missing parts, and will try to improve this analysis with the addition of the third dimension of risk analysis, the risk velocity [28].

1.1 Aim of thesis

We could define "value" as a function of risk and return. We can increase, preserve or erode value with each decision. Since risk is inherent to the search for value, strategic enterprises do not make any effort to eliminate risk or even to minimize it. This perspective presents a change of mind from the traditional point of view. Risk was something we wanted to avoid. Now, companies try to manage risk exposures within their organizations so that, they can incur just enough of the right kind of risk to effectively meet strategic goals [10].

This is the reason why risk assessment is important for a company. Companies can get an idea of how significant each risk is to the achievement of their strategic goals.

To achieve this, enterprises require a risk assessment procedure that is practical, sustainable, and easy to understand. The process must follow a structured and disciplined procedure. It must be proportional to the enterprise's size, complexity, and geographic reach. Application techniques for enterprise risk management (ERM) discipline have been developing over recent years [7]. The aim of this thesis is to provide leadership with an overview of risk assessment approaches and techniques that have arisen as the most useful and sustainable for making decisions, and in particular the implementation of the new concept of velocity. We aim to help organizations in their development of a robust ERM process.

Chapter 2

Risk velocity - the third dimension of risk

2.1 Two scenario examples

To introduce the topic of risk velocity we will begin by defining two examples of risks that will enable us to better understand how the velocity affects the analysis of risks. We can look to the old industry of instant cameras (Polaroid) and consider two risks; an explosion at the assembling factory and digital cameras with screen reducing demand and breaking the business model.

Using the traditional two dimensional analysis, we can assume that both risk have a likelihood of occurrence of unlikely and impact of catastrophic, so both risk would be ranked equally as in Figure 2.1.

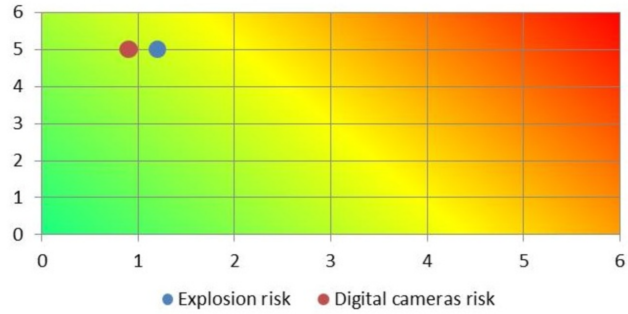

Figure 2.1: Traditional analysis. Likelihood and impact heat map for explosion risk and digital cameras risk examples.

Intuitively however, the explosion in the factory is more likely to keep you alert and worried. Why?
The answer may be related with the fact that each risk has a different risk velocity.

The first risk could happen tomorrow and therefore has a very short time horizon. The immediate impact in terms of stopping production will occur over a short time frame until the machines could work again. However, the frequency should be low and the impact, while large, will be limited.
The second risk works over a much longer term. The digital cameras that will replace the instant cameras didn't exist yet, and a camera company may have an idea about how soon it could be produced, this didn't happen over a short period of time, perhaps over 5-10 years. However, the new technologies have arisen so eventually something like this could occur, and when it did the business model has broken so that this event had an effectively infinite impact (in reality limited by the market capitalisation of the company).

The question then becomes: "Can we formulate a risk measure which incorporates the time value of risk and allows us to differentiate between comparable sized risks operating over different time horizons?".

2.2 Definitions

The term velocity is generally used to mean the rate of movement in a certain direction. Within our risk context this movement is from where we stand today to either the cause of a risk event, or its impact. We define the following metrics to quantify these concepts:

(a) Following the risk event, how long will it take for the impact to unfold. We will call this time to cause (TTC), or

(b) From the known position today, how long will it take for the risk to materialise. We will call this time to impact (TTI).

2.2.1 Velocity time to cause (TTC)

The traditional measure of risk likelihood is commonly defined as [28]:

- likely frequency within a given period (for example, ten times per year, once in five years)
- probability (percentage) of an event occurring (for example, 20 per cent)
- probability (percentage) of an event occurring within a given period (for example, 40 per cent chance in the one year)

We can apply this concepts to our two risks as in the Table 2.1.

Risk	Likely frequency	Probability of event ocurring	Probability of event ocurring in the next year
Explosion risk	Once in 10 years	20%	4%
Digital cameras risk	Once in 10 years	50%	1%

Table 2.1: Frequency and chance of occurrence

The first two measures defined above do not include an evaluation of the time, so the TTC is not take it into account. The last one does however include TTC and provides a better assessment of the likelihood.

2.2.2 Velocity time to impact (TTI)

TTI measures the speed at which a scenario moves from the initial cause(s) to the point where the impact(s) are felt. The explosion in the assembling factory risk has a very high TTI while the digital cameras risk has a very low TTI.

Traditional two dimensional analysis will often include this characteristic into the assessment of impact by measuring the impact of the high TTI risk greater than for the low TTI risk. The reason is because we can usually do less to mitigate the impact of a high velocity TTI risk before it is too late and the impact is felt.
Obviously there will be a positive correlation between TTI and impact due to the different time to take action. Then, we should think about consider velocity as a separate variable from likelihood and impact [28].

Is it certainly possible to combine a consideration of all three factors into a single risk velocity assessment? While 70% of finance executives agree that risk velocity is a core consideration, only 11% have introduced it into their risk assessments [6].
The rise of social networks (high TTI rate results in a rapid reputation impact) and on-line markets (high TTI speed due to lower entry barriers and speed to market of competence in products and services) [28] have created a strong incentive to bring a consideration of TTI into risk assessment and this is reinforced by a rapidly changing regulatory and technological environment.

We now consider TTI for our examples. The explosion in the assembling factory risk is very high and for the emergence of digital cameras risk as very low. We plot this new approach in the Figure 2.2, using different sizes of the risk dots to show velocity, a large dot for fast velocity and a small dot for slow velocity.

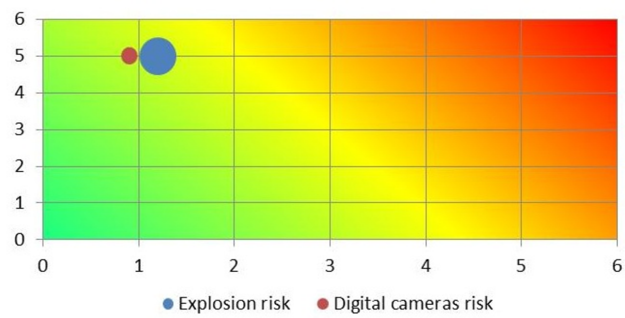

Figure 2.2: New analysis. Impact, likelihood and velocity heat map for explosion risk and digital cameras risk examples.

The measure of a risk's TTI therefore helps to differentiate risks that may have the same likelihood and consequence but be intuitively different in importance due to differing velocities.

As a conclusion we can say that clearly the explosion in the factory risk can have a quicker impact on the company compared to the second risk. And, of course, it is very important to note that the focus to mitigate and control this risk will be completely different.

In the case of the explosion risk, we must focus on minimizing the likelihood of the risk. For high velocity TTI risks it is necessary to have a quick response to mitigate the consequence of the impact. The need to develop a good crisis management plan for high velocity TTI risk becomes necessary in order to decrease the consequence of these kind of risks.

On the other hand, the emergence of digital cameras risk has a much slower velocity TTI. The focus here will be on monitoring controls and putting preventive controls in order to stop or at least decelerate the TTI risk. Perhaps even taking advantage of shifting customer demand to develop new markets and sources of profit.

2.2.3 Key risk indicators

"Key risk indicators (KRIs) are observable factors which behave as an indicator of some aspect of risk. Leading KRIs are used to detect measurable changes in risk causes which could indicate that a risk event may occur in the future. Lagging KRIs are used to detect that a risk event has already occurred and that there may be an impact coming." ([28], page 149)

For low velocity TTI risks, we may have trend analysis reports relating to the causes of the risk in order to assist in the detection of failures and consider some action. For high velocity TTI risks, detection of both, the occurrence and consequence of a risk, can assist in establishing the response needed to control the consequences of the risk events.[28]

2.2.4 Time to recover velocity

Velocity can be extended in other areas outside the risk assessment process. When risk events occur a response is needed in order to recover from the event. The question now is, do we need to notice how long it takes to recover from a risk event and measure that time as time to recover (TTR) velocity? *"TTR can assist in decision making around business recovery planning and the development of business resilience strategies"*([28], page 149).

Chapter 3

Risk Assessment

3.1 Operational Risk Assessment

"Basel Committee wants to enhance operational risk assessment efforts by encouraging the industry to develop methodologies and collect data related to managing operational risk. The scope of the framework presented in [1] focuses primarily upon the operational risk component of other risks and encourages the industry to further develop techniques for measuring, monitoring and mitigating operational risk. In framing the current proposals, the Committee has adopted a common industry definition of operational risk, namely: the risk of direct or indirect loss resulting from inadequate or ailed internal processes, people and systems or from external events. Strategic and reputational risk is not included in this definition for the purpose of a minimum regulatory operational risk capital charge. This definition focuses on the causes of operational risk and the Committee believes that this is appropriate for both risk management and, ultimately, measurement. However, in reviewing the progress of the industry in the measurement of operational risk, the Committee is aware that causal measurement and modelling of operational risk remains at the earliest stages. For this reason, the Committee sets out further details on the effects of operational losses, in terms of loss types, to allow data collection and measurement to commence" ([2], page 2)

3.1.1 Notations and Definitions

The calculation of operational risk capital with an advanced measurement requires a model approach. It is natural and intuitive to count the occurrence of events and to consider the impact of each loss. This ends up being what is known as a frequency and severity model. We will denote random variables by capital letters; generally X will be used for severities and N for frequencies.

([4], pages 6 - 8) For a continuous random variable X, we denote by $F(\cdot)$ the cumulative distribution function (cdf), which is defined by

$$F(x) = \mathbb{P}(X \leq x) \tag{3.1}$$

The cdf satisfies three properties:

- $lim_{x \to \infty} F(x) = 1$ and $lim_{x \to -\infty} F(x) = 0$
- $F(\cdot)$ is right continuous
- $F(\cdot)$ is non-decreasing monotonous

The derivative of $F(\cdot)$ is called the probability density function (pdf) denoted by $f(\cdot)$, then

$$F(x) = \sum_{t = \to -\infty}^{x} f(t)dt \tag{3.2}$$

For a discrete random variable N a similar notation will be used. A *risk measure* for variable X will generally be denoted by $\rho(x)$. In calculating capital requirements, the most widely used risk measure is Value-at-Risk at the α-level, $VaR_\alpha(X)$. This is known in statistics as the percentile function which is defined as:

$$VaR_\alpha(X) = \inf\{x \in \mathbb{R} : \mathbb{P}(X > x) \leq (1 - \alpha)\} \tag{3.3}$$

$$= \inf\{x \in \mathbb{R} : F(x) \geq \alpha\} \tag{3.4}$$

The meaning of Value-at-Risk indicates that the proportion of values of X that are observed over the threshold $VaR_\alpha(X)$ is $(1 - \alpha)$ (or $100(1 - \alpha)\%$), that is $100(1 - \alpha)$ in 100. If $\alpha = 99\%$, then a value of X above $VaR_\alpha(X)$ should be observed with probability 1%.

There are simple expressions for $VaR_\alpha(X)$, when X is assumed normally distributed or t-Student with ν degrees of freedom. Otherwise, more sophisticated, numerical methods need to be used to approximate the risk measure.

Another possibility, which is used in the Swiss Solvency Test approach to risk measurement in insurance companies is known as Tail Value-at-Risk at the α-level and denoted by $TVaR_\alpha(X)$. It is also referred to as expected shortfall, sometimes with slight definition changes due to how continuity and discontinuity in $F(\cdot)$ is assumed. The definition of $TVaR_\alpha(X)$ is:

$$TVaR_\alpha(X) = \frac{1}{1 - \alpha} \int_\alpha^1 VaR_u(X)du \tag{3.5}$$

Since Tail Value-at-Risk can be expressed as a conditional expectation of random variable X, it is also known as Conditional Tail Expectation ($CTE_\alpha(X)$),

$$TVaR_\alpha(X) = CTE_\alpha(X) = \mathbb{E}(X \mid X > VaR_\alpha) \tag{3.6}$$

Current regulation principles that rely on risk modelling approaches are based on the previous risk measures, provided a model is assumed for X.

Capital requirement is calculated as a simple function of the estimated risk measure, i.e. a proportion. In order to achieve a good model, the main challenge is to find an adequate statistical model for the aggregated loss. This is known as Loss Distribution Analysis (LDA). There are three different methods to calculate the risk measure in each case. The variance and covariance method requires the first and second moments to be estimated and a parametric distribution to be assumed. Historical simulation, which relies on past information and can only be implemented if we have a substantial amount of data by modelling historical data. Finally the Monte Carlo method, where the distribution of total loss is obtained by generating random values corresponding to losses [4].

3.1.2 Operational risk capital modelling methodology

Over the past few years a great deal of research has been conducted to develop the practical implementation of Basel II Advanced Measurement Approaches (AMA), usually based on the Loss Distribution Approach (LDA) and/or the Scenario Based Approach (SBA). Most of these issues are now sufficiently clarified to allow for a survey on operational risk quantitative techniques. [14]

Financial institutions such as banks must hold a sufficient quantity of capital to cover financial losses, including those related to operational risks (losses arising from inadequate or failed internal processes, people or systems or from external events). Risk is defined as the combination of severity and frequency of potential loss over a given time horizon. The legislation requiring calculation of capital requirements by financial services organizations (including operational risk) has therefore focused attention on the means of dealing with the real life risk behaviour requiring consideration of both the severity and frequency distributions calculations.

3.1.3 Loss Distribution Approach (LDA)

The principles of quantitative LDA come from actuarial techniques as they have been developed by the insurance industry for many years [14][13].

Under the LDA, an organization, using its internal data, estimates two probability distribution functions for each business line (and risk type); one on single event impact and the other on event frequency for the next (one) year. Based on the two estimated distributions, the organization then computes the probability distribution function of the cumulative operational loss. The capital charge is based on the simple sum of the VaR for each business line (and risk type). The approach adopted by the institution would be subject to supervisory criteria regarding the assumptions used.

Severity and frequency estimations are computed even though there is little data available, so it is important to note that the capital charge estimates will be inaccurate.

The choice of severity distribution is particularly challenging (as compared to frequency modelling) due to the importance of modelling the behaviour of catastrophic events. The chosen distribution should function reliably at all sizes of loss.

Computing the Loss distribution

LDA is presented in appendix 6 of [1]:

"Under the Loss Distribution Approach, the bank estimates, for each business line/risk type cell, the probability distribution functions of the single event impact and the event frequency for the next (one) year using its internal data, and computes the probability distribution function of the cumulative operational loss."

We need some definitions, in order to introduce the mathematical formulation of **LDA**[13]:

- According to the **New Basel Capital Accord**, we must consider different business lines and event types. We use the indices i and j to denote a given business line and a given type.
- We define $X(i,j)$ as the random variable which represents the amount of a single event for the business line i and the event type j. The loss severity distribution of $X(i,j)$ is denoted by $F_{i,j}$.
- We assume that the number of events between times t an $t+\tau$ is random (typically τ = one year). The corresponding variable $N(i,j)$ has a probability function $p_{i,j}$. The loss frequency distribution $P_{i,j}$ corresponds to

$$P_{i,j}(n) = \sum_{k=0}^{n} p_{i,j}(k) \tag{3.7}$$

In LDA, the loss for the business line i and the event type j between times t an $t+\tau$ is

$$\vartheta(i,j) = \sum_{n=0}^{N(i,j)} X_n(i,j) \tag{3.8}$$

Let $G_{i,j}$ be the distribution of $\vartheta(i,j)$. $G_{i,j}$ is then a compound distribution

$$G_{i,j}(x) = \begin{cases} \sum_{n=1}^{\infty} p_{i,j}(n) F_{i,j}^{n*}(x) & x > 0 \\ p_{i,j}(0) & x = 0 \end{cases} \tag{3.9}$$

Where $*$ is the convolution operator on distribution functions and F^{n*} is the n-fold convolution of F with itself.

Definition (Convolution). The convolution of a bounded point function φ with a probability distribution F is the function defined by

$$u(x) = \int_{-\infty}^{\infty} \varphi(x-y)F(dy) \tag{3.10}$$

It will be denoted by $u = F*\varphi$, When F has a density f we write alternatively $u = f * \varphi$ and we have

$$u(x) = \int_{-\infty}^{\infty} \varphi(x-y)f(y)dy \tag{3.11}$$

We have

$$F^{1*} = F \tag{3.12}$$

$$F^{n*} = F^{(n-1)*} * F \tag{3.13}$$

Remark. In LDA, the modelling of the loss distribution is done in two steps. We first consider a loss severity distribution and a loss frequency distribution. Then, we obtain the aggregate loss distribution by compounding them. We have illustrated this method in Figure 3.1 with $X(i,j) \sim LN(10, 3.2)$ and $N(i,j) \sim Po(30)$.

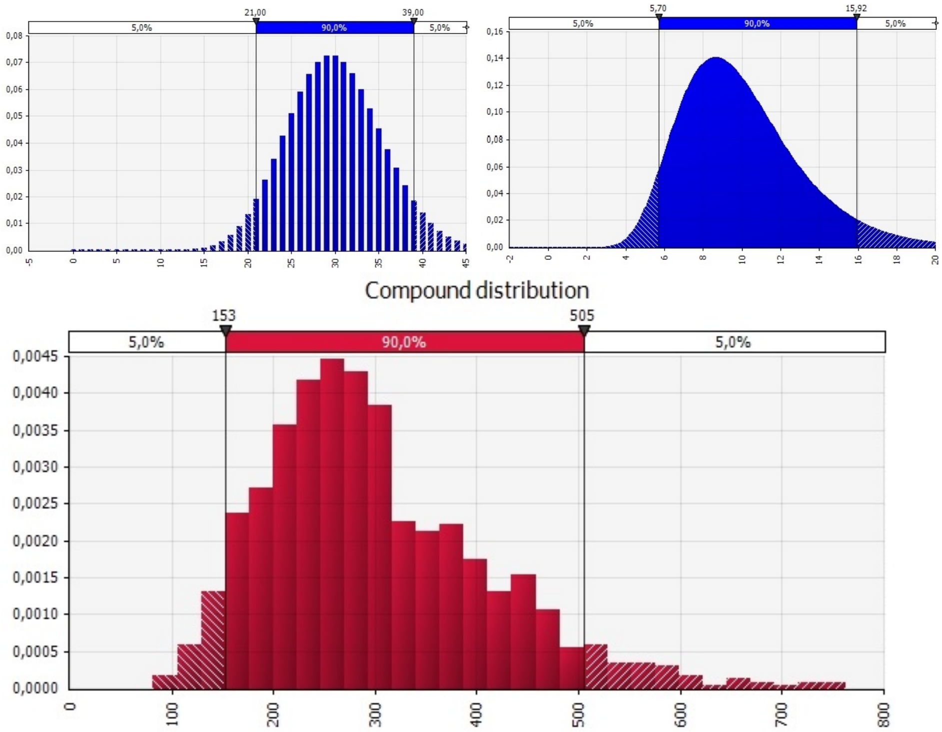

Figure 3.1: Computing the aggregate loss distribution. Poisson distribution for the likelihood and Lognormal distribution for the impact are plotted above. Compound distribution of Poisson and Lognormal distribution is presented below.

Remark. We assume that the random variables $X(i,j)$ are independently distributed and independent of the number of events.

In general, there is no analytical expression of the compound distribution. The existence of an analytical expression is related to the infinitely divisible property of the distribution $G_{i,j}$. This is for example the case of the negative binomial distribution, which can be written as a compound Logarithmic/Poisson distribution [11].

Computing the loss distribution requires numerical approaches. The most used are the Monte Carlo method, the Panjer's recursive approach and the inverse of the characteristic function[13].

- In the Monte Carlo method, the distribution $G_{i,j}$ is then approximated by the set $S\langle(\vartheta(i,j)\rangle = \{\vartheta_s(i,j), s = 1, \cdots, S\}$ of simulated values of the random variable $\vartheta(i,j)$. An estimate of $G_{i,j}$ is then obtained by the empirical distribution of $S\langle(\vartheta(i,j)\rangle$ (FISHMAN [12]) or by the Kernel method (SILVERMAN [25]).

- PANJER [1981] introduce a recursive approach to compute high order convolutions, based on the follow assumptions: Consider the family of claim number distributions satisfying the recursion

$$p_{i,j}(n) = \left(c_1 + \tfrac{c_2}{n}\right) p_{i,j}(n-1), \quad n = 1, 2, 3... \tag{3.14}$$

where c_1 and c_2 are constants and $p_{i,j}(n)$ denotes the probability that exactly n claims occur in the fixed time interval.
The density of total claims is

$$\begin{aligned} g_{i,j}(x) &= \textstyle\sum_{n=1}^{\infty} p_{i,j}(n) f^{*n}(x), \quad & x > 0 \\ &= p_{i,j}(0), & x = 0 \end{aligned} \tag{3.15}$$

when $f(x)$ is the density associated with $F(x)$.

Panjer then proves the next Theorem:
Theorem: For $p_{i,j}(n)$ and $g_{i,j}(x)$ defined by 3.14 and 3.15 respectively, and f(x) any distribution of the continuous type for $x > 0$, the following recursion holds

$$g_{i,j}(x) = p_{i,j}(1) f_{i,j}(x) + \int_0^x (c_1 + c_2 \frac{y}{x}) f_{i,j}(y) g_{i,j}(x-y) dy \tag{3.16}$$

SUNDT and JEWELL [1981] show that the probability distributions that satisfy (3.14) are the Poisson, binomial, negative binomial and geometric families. For example, if $N(i,j) \sim Po(\lambda_{i,j})$, we obtain

$$g_{i,j}(x) = \lambda_{i,j} e^{-\lambda_{i,j}} f_{i,j}(x) + \frac{\lambda_{i,j}}{x} \int_0^x y f_{i,j}(y) g_{i,j}(x-y) dy \tag{3.17}$$

- HECKMAN and MEYERS [1983] propose to compute aggregate loss distributions using properties of its characteristic function. Let X be a random variable with distribution H. The characteristic function of H is the defined by

$$\phi_H(t) = \mathbb{E}[e^{itX}] = \int_0^{\infty} e^{itX} dH(x) \tag{3.18}$$

We remark that the characteristic function of M independent random variables is the product of their characteristic functions

$$\begin{aligned} \phi_{H_1 * H_2 * \cdots * H_M}(t) &= \mathbb{E}[e^{it(X_1 + X_2 + \cdots + X_M)}] && (3.19) \\ &= \textstyle\prod_{m=1}^{M} \mathbb{E}[e^{itX_m}] && (3.20) \\ &= \textstyle\prod_{m=1}^{M} \phi_{H_m}(t) && (3.21) \end{aligned}$$

It follows that the characteristic function of $G_{i,j}$ is given by

$$\phi_{G_{i,j}}(t) = \sum_{n=0}^{\infty} p_{i,j}(n)[\phi_{F_{i,j}}(t)]^n \tag{3.22}$$

For example, if $N(i,j)$ is a Poisson $Po(\lambda_{i,j})$ distributed random variable, we obtain

$$\phi_{G_{i,j}}(t) = e^{\lambda_{i,j}[\phi_{F_{i,j}}(t)-1]} \tag{3.23}$$

We finally deduce the distribution function using the Laplace transformation:

$$G_{i,j}(x) = \frac{1}{2} - \frac{1}{2\pi i}\int_{-\infty}^{\infty} \frac{1}{t} e^{-itx}\phi_{G_{i,j}}(t)dt \tag{3.24}$$

Also we can use the general formula using the probability generating function for $N_{i,j}$ where

$$g_{N_{i,j}}(z) = \sum_{k=0}^{\infty} z^k p_{i,j}(k) \tag{3.25}$$

and,

$$\phi_{G_{i,j}}(t) = g_{N_{i,j}}(\phi_{F_{i,j}}(t)). \tag{3.26}$$

Computing the Capital-at-Risk (CaR)

With LDA, the capital charge (or the *Capital-at-Risk*) is a *Value-at-Risk* measure of risk. We first consider the CaR computation for a given business line and a given event type, and then the CaR for the whole organization[13].

For one business line and one event type: The *expected loss* EL(i,j) and the *unexpected loss* UL$(i,j;\alpha)$ at confidence level α are the defined by

$$EL(i,j) = \mathbb{E}\vartheta(i,j)] = \int_0^{\infty} x dG_{i,j}(x) \tag{3.27}$$

and

$$UL(i,j;\alpha) = G_{i,j}^{-1}(\alpha) - \mathbb{E}\vartheta(i,j)] = inf\{x \mid G_{i,j}(x) \geq \alpha\} - \int_0^{\infty} x dG_{i,j}(x) \tag{3.28}$$

The expected value of the random variable $\vartheta(i,j)$ correspond to the expected loss, and the unexpected loss is the percentile for the level α minus the mean. Now we define the CaR to be the capital cost for operational risk.

The Basel Committee on Banking Supervision define CaR as the unexpected loss

$$CaR(i,j;\alpha) = UL(i,j;\alpha) \tag{3.29}$$

Here the (CaR) is a *Value-at-Risk* measure. The expected loss can also be computed directly by this formula

$$\mathbb{E}\vartheta(i,j)] = \mathbb{E}[\mathbb{E}[\vartheta(i,j) \mid N(i,j)]] \tag{3.30}$$
$$= \mathbb{E}[N(i,j)] \times \mathbb{E}[X(i,j)] \tag{3.31}$$

Determination of $UL(i,j;\alpha)$ with good accuracy is in general difficult. The previous algorithm can give some errors and the true percentile and the estimated percentile can differ significantly, especially if the severity loss distribution is heavy-tailed and the confidence level is high. In the Consultative Document of Operational Risk, the Basel Committee on Banking Supervision suggest to take α equal to 99%. In economic capital modelling, α is related to the target rating of the bank. We give here the values of α that are generally used [13]:

Rating Target	BBB	A	AA	AAA
α	99.5%	99.9%	99.95%	99.97%

So it is very important to control the accuracy of $G^{-1}_{i,j}(\alpha)$. This can be done by verifying that the first estimated moments are close to the theoretical ones. We can consider the example of the Log-normal/Poisson compound distribution where $X \sim LN(\mu,\sigma)$ and $N \sim Po(\lambda)$. We compute the aggregate loss distribution by the Monte Carlo method for different number of simulations, S. Note the influence of the parameter σ on the accuracy of the estimates. In operational risk, the parameters μ and σ can get very large values, which requires a great number of simulations in order to get a good accuracy.

For the whole organization: Now we have the problem of computing the total capital charge for the institution. We may compute it as the simple sum of the capital charges across each of the business lines and event types:

$$CaR(\alpha) = \sum_{i=1}^{I} \sum_{j=1}^{J} CaR(i,j;\alpha) \tag{3.32}$$

This is the method given in the Internal Measurement Approach by the Basel Committee on Banking Supervision. It corresponds to the assumption that the different risks are *totally positive dependent*, or perfectly correlated [13].

Let ϑ be the total loss of the bank:

$$\vartheta = \sum_{i=1}^{I} \sum_{j=1}^{J} \vartheta(i,j) \tag{3.33}$$

If we consider that the losses $\vartheta(i$,j) are independent, the distribution G is the convolution of the distributions $G_{i,j}$. Thus, as we defined above, the *Capital-at-Risk* of the bank is either:

$$CaR(\alpha) = G^{-1}(\alpha) - \mathbb{E}[\vartheta] \tag{3.34}$$

The total unexpected loss $UL(\alpha)$ can be calculated using some approximations. The idea is to define $UL(\alpha)$ directly from the individual unexpected loss $UL(i,j;\alpha)$ without using the whole distribution G. One method is the "square root rule" which says

$$UL(\alpha) = \sqrt{\sum_{i=1}^{I} \sum_{j=1}^{J} UL^2(i,j;\alpha)} \tag{3.35}$$

This rule corresponds to a Normal approximation. But the formula (3.35) can give some significant errors [13].

3.1.4 Discount rate

When we analyse costs and benefits we should note that rarely occur within a short time period. The most common case is that at least some of the results occur over time.

"Let's say you expect 1,000$ in one year. To determine the present value of this 1,000$ (what it is worth to you today), you would need to discount it by a particular interest rate. Assuming a discount rate of 10%, the 1,000$ in a year's time would be equivalent to 909.09$ to you today (1,000 / [1.00 + 0.10]). If you expect to receive the 1,000$ in two years, its present value would be 826.45$."[16]

For this reason, it is necessary to discount future values of costs and benefits that occur over time to a common measure (present value). In other words, we can not compare cash flows over different time period, so this allows the companies to calculate the net present value [5].

Definition: The discount rate refers to the interest rate used in discounted cash flow (DCF) analysis to determine the present value of future cash flows" [16].

The discount rate in DCF analysis considers also how uncertain are future cash flows, and not just the time value of money [16]. If the uncertainty of future cash flows is greater, the discount rate will be higher. The discount rate can also be used by pension plans and insurance companies for discounting their charges.

The question now is, what is the appropriate discount rate to use for a project and in particular for our studies? *"Many entities use their weighted average cost of capital (WACC) if the project's risk profile is similar to that of the company."* The WACC is a computation of a company's cost of capital in which each category of capital is proportionately weighted. Companies often discount costs at WACC to estimate the Net Present Value (NPV) of a project, using the formula [17]:

$$\text{NPV} = \text{Present Value (PV) of the Cash Flows discounted at WACC} \tag{3.36}$$

We could name some other rates, as the Risk-Free Rate of Return or Hurdle Rate, but we will principally take the WACC to guide us in our analysis. Within insurance this would typically be the risk free rate. Once the money is borrowed it should be invested in the most risk free way possible. Provided the discount rate, longer term risks will get a benefit relative to shorter term risks.

Discount rates depend on the purpose we use WACC as keeping risk implies holding capital and the opportunity cost of this can be represented by the return expected on this capital if employed directly in the business, i.e, the WACC.

3.2 Develop Assessment Criteria

Traditional risk analysis defines risk as a function of likelihood and impact. These are important measures. However, unlikely events occur all too often, and many likely events don't come to pass. Worse, unlikely events often can occur with surprising speed. So these make us think that likelihood and impact alone don't solve the whole problem any longer.

It is necessary to measure vulnerability and velocity to be able to answer questions like how fast could the risk arise, how fast could you respond or recover, and how much downtime could you tolerate. If you measure how vulnerable you are to an event, you develop an idea of your needs. If you measure how quickly an event could happen, you understand the need for rapid adaptation and agility[10].

3.2.1 Assessment Scales

A definition of measurement of risk is necessary. We need a guide in order to compare and aggregate risks across the company. In this case the experts could define scales for rating risks in terms of impact, likelihood, and velocity. These scales include classification levels and definitions to give consistent interpretation and application of the various sectors. A balance between simplicity and comprehensiveness is needed, since their interpretation should be consistent, and enable a clear understanding for all relevant stakeholders [10].

Scales should allow significant differentiation for classification and prioritization. Five points scales give us better accuracy than three points scales.

Every organization is different and the scales should be made to fit the industry, size, complexity, and culture of the organization in question [10]. In this case our studies will be based on a five point scale, for simplicity.

3.2.2 Impact

Impact (or consequence) refers to the extent to which a risk event would affect the company. Impact assessment criteria may include financial, reputational, regulatory, health, safety, security, environmental, employee, customer, and operational impacts. We can define impact using a combination of these kinds of impact considerations, since certain risks can impact the company financially while other risks can have a greater impact on security or customer. To assign an impact rating to a risk, we assign the rating for most anticipated consequence [10].

The impact is commonly classified in a scale of five stages, from 1 to 5. We can define risks as extreme (5), major (4), moderate(3), minor (2) and incidental, depending on the effect that a risk could have in the company. Expert judgement must be used to evaluate the risks, taking in to account the factors described above (financial losses, coverage, repercussions to the employees, reputation) and then, assign a number to each event type in every business line. We will assign 0 if the net result has no effects in the company.

Impact Scale		
Rating	Description	Definition
5	Very High	Impact on net income by more than 2 millions
4	High	Impact on net income by between 1 and 2 millions
3	Moderate	Impact on net income of between 500,000 and 1 million
2	Low	Impact on net income of between 100,000 and 500,000
1	Very Low	Impact on net income of less than 100,000

Table 3.1: Example of impact scale

3.2.3 Likelihood

Likelihood refers to the probability that a given event will occur. We can define likelihood using qualitative terms (very high, high, moderate, low, very low), as percent or as frequency. Relevant time period should be specified when we are using numerical values as a percentage or frequency (annual frequency or the more probability over the time of the project or asset).

Likelihood Scale		
Rating	Description	Definition
5	Very High	Probability of the event occurring once within a three-year period is >50%
4	High	Probability of the event occurring once within a three-year period is 30 to 50%
3	Moderate	Probability of the event occurring once within a three-year period is 15 to 30%
2	Low	Probability of the event occurring once within a three-year period is 5 to 15%
1	Very Low	Probability of the event occurring once within a three-year period is <5%

Table 3.2: Example of likelihood scale

3.2.4 Velocity

This is the new concept that we would like to implement in our model, and then, to analyse its effects in our risk ranking. It can also be named as speed of onset (see [10]).Our goal is that this notion will be useful in planning and developing response.

As we have defined before, velocity refers to the time it takes for a risk event to manifest itself. In other words, *"it is the time that passes between the occurrence of an event and the point at which the company first feels its effects"* [10].

Velocity Scale		
Rating	Description	Definition
5	Very High	Very rapid onset, little or no warning, instantaneous, days
4	High	Onset occurs in a matter of days to a few weeks
3	Medium	Onset occurs in a matter of several months
2	Low	Onset occurs in a matter of one year
1	Very Low	Very slow onset, occurs over 3 years or more

Table 3.3: Example of velocity scale [10]

3.2.5 Inherent and Residual Risk

Something we may consider when assessing risks is inherent risk and residual risk. In [2] defines inherent risk as the risk to an entity in the absence of any actions management might take to alter either the risk's likelihood or impact. Residual risk is defined as *"the risk remaining after management's response to the risk"* [10]. These concepts and their applications have a lot of interpretations depending on the company. Some of them interpret inherent risk to be level of risk assuming controls already failing, and residual risk to be the level of risk assuming controls are working according to design. Some other entities interpret inherent risk to be the actual level of risk assuming existing controls work according to scheme and residual to be the estimated risk after controls under consideration have started. Both cases can be right and useful, depending on the purpose of the assessment and the kind of risk being analysed [10].

3.3 Assess Risks

Risk assessment is usually developed in two steps. An initial screening of the risks is performed using qualitative techniques followed by a more quantitative treatment of the most important risks [10]. Qualitative assessment consists of assessing each risk according to scales as described in the previous section.

Quantitative analysis uses numerical values for impact and likelihood taking data from several sources. The accuracy and completeness of the numerical values will affect the analysis. The validity of the model can also be affected, therefore, it is necessary to state and evaluate assumptions and uncertainty using, for example, sensitivity analysis.

Both techniques have pros and cons. In most of the cases the enterprises start with a qualitative analysis and if their decision needs require it they develop quantitative evaluation [10].

Qualitative technique The advantages to using qualitative techniques are that they are easy and quick to perform, provide good information further than impact and likelihood and are understandable for almost every employee who may not have knowledge of advanced quantification techniques. The disadvantages to using qualitative techniques are that differences between levels of risk are limited, imprecision, unable to show risk interactions and correlations, and provide limited capacities to compute cost-benefit analysis [10].

Quantitative technique The advantages to using quantitative techniques are that they give numerical aggregation taking into account risk interactions when using VaR, compute cost-benefit analysis of risk response options, enable risk-based capital allocation to business activities with optimal risk-return and help compute capital requirements to sustain solvency under extreme conditions. The disadvantages to using quantitative techniques are that they can be time-consuming and costly, must choose units of measure which may result in qualitative impacts being ignored, implication of greater precision using numbers and assumptions may not be apparent [10].

There are many assessment techniques which fall under the qualitative heading, but the most common used are scenario analysis, benchmarking, surveys, cross-functional workshops, interviews and expert judgement.

Quantitative techniques use benchmarking and scenario analysis to generate future point estimates (deterministic models) and then to generating prospective distributions (probabilistic models).

From an enterprise point of view, some of the most powerful probabilistic models are causal at-risk models. Those are used to estimate gross profit margins, cash flows, or earnings over a given time horizon at given confidence levels [10].

3.3.1 Expert judgement

This term is defined in the 3rd and the 4th edition of the PMBOK [21]. Expert judgement refers to a technique in which judgement is made by those people who possess specialized knowledge or training in a particular area or industry. Consultants, user groups, subject matter experts or senior managers are also people who can help in the assess of risk [26].

Judgement provided by those people with expertise in appropriate area is used to evaluate the scales of risks in order to do effective risk assessment. Their expertise is important to analyse historical information, define and ensure appropriate standards, get suggestions/advices, evaluate different options, determine best suited options [26].

Some sources of expert knowledge are stakeholders, customers, professional and technical organizations, and other industry groups that may provide these types of services for a small fee, or may provider them free of charge [22].

Although, experts elicitation also brings biases, but there is extensive literature on how to correct for such biases. For example, see COSO's recent paper [8].

Expert intuition can be obtained through scenario building. A scenario is given by a potential loss amount and the corresponding probability of occurrence. For example, an expert may assert that a loss of one million kronor or higher is expected to occur once every 5 years. This can be a very valuable information when loss data do not allow for statistically results or when we do not have historical loss data or are not sufficiently forward-looking. The principal goal is how one can obtain useful information from experts' scenarios and how it can be used in a normal risk assessment framework [8].

3.4 Prioritize Risks

After the steps above have been performed, it is time to show the risk in a comprehensive portfolio in order to prioritize risk response and report to responsible people in that area. Some companies prefer to show the portfolio in a hierarchical manner, some as a group of risk interpreted as dots in a heat map. Furthermore, companies having mature programs and quantitative capacities may add to the analysis distribution functions for every single type of risk, and then compound them into a cumulative loss probability distribution function and set that as the risk profile [10].

This is normally done in two steps. First, the risk are evaluated according to a impact rating multiplied by likelihood rating. Secondly, the risks are considered under other factors such as impact alone, the size of the gap between present and future desired risk level and as the new concept we are treating with, speed of onset.

3.4.1 Hierarchies

Organizing risk in a hierarchy is a simple method to aggregate risk. Some risk management processes are organized by risk type, organizational unit, geography, or strategic objective, so it is very easy to implement a hierarchy. This provides a complete list of the assessed risks but does not help with prioritizing[10].

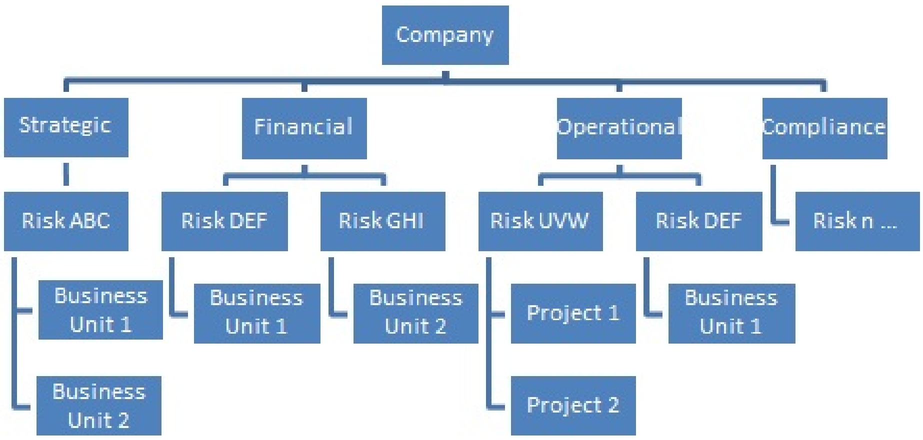

Figure 3.2: Example of Risk Hierarchies [10].

3.4.2 Risk Maps

Another way to study the risks is to build a risk map or a heat map. Usually they have been represented as a plot of impact against likelihood. But they can also show some other relationships such as impact against vulnerability. Even better information will be obtained if the shape of the data points can represent a third variable such as speed of onset.

The typical way to prioritize risk is by defining a risk level for each area of the graph, such as high, medium and low. We can set the boundaries between different levels depending on the organization needs and on the risk appetite [10]. When the points are plotted on the heat map risk can be ranked from highest to lowest in terms of risk level. The ranking can be done based also on vulnerability, or detailed knowledge of the nature of the impact. For example, if we have a group of risks categorized as high, those having extreme health and safety or reputational impacts should be prioritized over risks having extreme financial impacts but less health and safety or reputational impacts.

Note that when we use numerical ratings in a qualitative environment, the numbers are labels and not suitable for mathematical computation. Although some organization do multiply the ratings (impact x likelihood) to develop a preliminary ranking [10], it is difficult to place an interpretation on this measure.

Consider now the following example: A company identified 22 risks to include in its risk assessment. We used a combination of interviews, workshops, and a survey to perform an initial qualitative assessment of impact and likelihood criteria. Risk influences are evaluated for the highest risks and the assessments are refined. Risks are plotted on a heat map to perform an initial prioritization, as in Figure 3.3

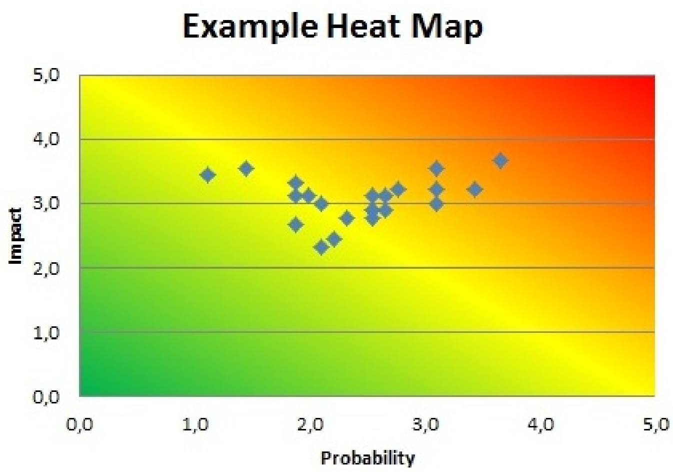

Figure 3.3: Example of probability and impact heat map for 22 risks. Dots represent the different risks.

Four risks plotted in the Very High risk level associated as red color in the right corner in the heat map can be taken, and described as key risks. This means that they will be reported to and controlled by leadership and the board of directors.

Another way to help clarify what type of response may be appropriate for specific risks is to use a tool known as a MARCI chart (for Mitigate, Assure, Redeploy, and Cumulative Impact) showed in Figure 3.4. The MARCI chart plots risks along the two axes of impact and vulnerability, and indicates each risk's speed of onset by the size of the data points [10]. Risks in the top right (Mitigate) quadrant represent high-impact risks to which the organization has high vulnerability that is, risks for which the organization's efforts have been relatively ineffective in holding the risk to a level consistent with leadership's risk appetite.

Risks in the top left (Assurance) quadrant are high-impact risks to which the organization has low vulnerability that is, the risk owners consider the organization's mitigation efforts adequate to bring the level of each risk within leadership's appetite for that kind of risk. For risks in this quadrant, risk owners should be able to provide reasonable assurance to management that the controls to prevent, detect, correct, or escalate a risk continue to be both effective and efficient in keeping the vulnerability to that risk within the company's appetite [9].

Risks in the bottom left (Redistribute) quadrant are low-impact risks that are currently being adequately controlled by the organization's risk management efforts. Given their relatively low impact, an organization may want to consider whether it is spending more to manage these risks than necessary, and whether it can or should redeploy resources from risks in this quadrant to risks in the Mitigate quadrant. It is important, however, to consider whether the risks in this quadrant interrelate with other risks in a more significant fashion before making a decision to redeploy resources [9].

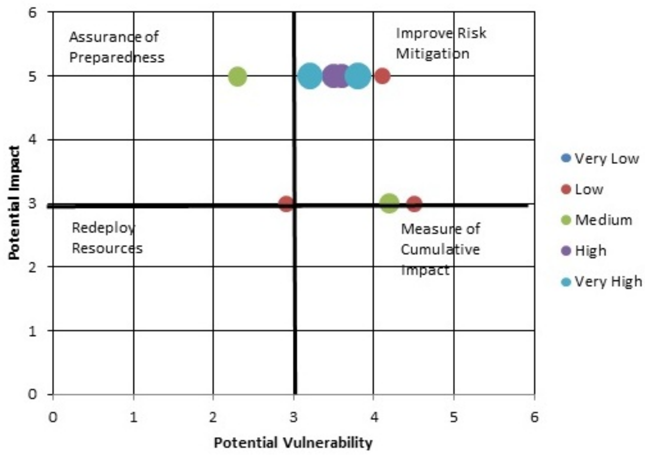

Figure 3.4: Example of MARCI chart. Dots represent risk #1 - #n and dot size reflects velocity.

3.4.3 Risk ranking

The COSO Framework defines risk assessment as *"...the identification and analysis of relevant risks to achievement of the [entity's] objectives, forming a basis for the determination of how the risks should be managed."*

Part of this identification is the prioritization of those events that can be bad for the company, what we will call risk ranking. We assume that it is very difficult to try to manage all that might be bad for the company. Every control action made to minimize risk could be expensive and take time. This is the reason why we should put our efforts and focus on the most dangerous risks which could affect and hit the entire organization [19].

Risk ranking should take into account the probability that an event happens, the consequences of the event and, as we want to introduce, the velocity that an event will take to impact the company. In general, the risk grows with the size of the potential loss.

The most simple way to rank the risks is defining a ranking scale, that should be simple enough. Also we can add written criteria that allows us to differentiate between levels of risk [19].

Chapter 4

Implementation

Following the regulatory standards, each type of risk in each type of business area must be rated and classified. In this case we will use the rating scales described above in order to evaluate the level of each individual risk, resulting on a table with values between 1 and 5 that we will use for our evaluation purposes.

Now, it becomes necessary to have a transformation of the values that will tell us how big is the consequence of an impact, or how frequent it will be a risk in certain time of period. For this purpose we will use a linear interpolation that will give precisely the value in mNOK of the different event impacts and the percentage of occurrence (%) of the different event probabilities. In other words, it will transform the scale of 1 to 5 and its intermediate points into quantitative values that we will use in our assessment for each intermediate value. Generally, linear interpolation takes two data points, say (x_a, y_a) and (x_b, y_b), and the interpolant is given by:

$$y = y_a + (y_b - y_a)\,\frac{x - x_a}{x_b - x_a} \text{ at the point } (x, y) \tag{4.1}$$

The table on which we rely for interpolation will look like this:

Likelihood (Probability)	
x	y
1	12,50%
2	38%
3	63%
4	88%
5	100%

Table 4.1: Scale value for interpolation (Probability). The right column has fixed points expressed in percentage of occurrence.

Consequence (Impact)	
x	y
1	1
2	5
3	35
4	75
5	100

Table 4.2: Scale value for interpolation (Impact). The right column has fixed points expressed in mNOK of impact.

For example, applying interpolation based on the fixed points above, a risk with an impact of 2,4 can be translated as a consequence of 18,33 mNOK and a probability of 3,1 as a 71% of occurrence in a year.

4.1 Probability distribution functions

Assuming our data is provided from a company that has performed an evaluation of their risks by expert judgement we can obtained and standard deviation of both, probability and impact rates. All the collecting data will be sorted in the corresponding spreadsheet in Excel in order to work quickly and easily with the data, and perform the analysis needed.

For simplicity, we will assume that the frequency distribution is a Poisson distribution. This distribution has many engaging characteristics: first it is extensively used in the insurance companies for modelling problems similar to operational risks; secondly it needs only one parameter (λ) to be defined and, third, the ML value of this parameter is the empirical average number of events per year [14].

Probably the most difficult task is to find the severity distribution. Theoretical techniques can hardly be used directly because available loss data are obtained by various sources of bias. But we will try to make it simple even though it may lead to highly inaccurate and failed capital charge. However, it is possible to make reasonable simplifications which deteriorate the accuracy of capital charge to an acceptable degree. We must also take into account that we are trying to mix data which are basically different by nature. It is obvious that (say) ”external fraud” losses have different structure from one country to another, from one large company compared to a small one, etc.

Many works have tried to find out a way to rescale severity distributions (see [24]), but that needs large sets of data from different sources (external and internal) and in most of the cases we do not have access to that information for all type of risks [14]. We should also note that scaling formulas must be estimated for each bank or company, i.e., scaling formulas cannot be used in other entities in the same way, they are not universal. As well, we should add into the discussion that there may be more differences between two business units in a company (for example, different countries) than between one internal business line and an external one. This turns into a hard work in the general risk assessment. We can conclude that biases must be considered and reported in order to provide a good calibration of the severity distributions.

In the practice we will simplify the procedure, the data from our spreadsheet will provide us the parameters needed. Our source gave us a percentage of occurrence of each risk event in a year, that will work as the parameter λ for the Poisson distribution function for the frequency estimation. For severity distribution function we will choose a Lognormal distribution with parameters μ and σ taken as well from our data source. We will take the gross consequence (in mNOK) as the parameter μ and the standard deviation σ will be the one given from our company source.

4.2 Monte Carlo analysis

Once the frequency and severity distributions have been computed in the spreadsheet, the computation of capital charge is quite simple, based on its own definition.

Capital charge calculation is done thanks to Monte Carlo simulation which is an important computational tool that rely on repeated random sampling to obtain numerical results. We shall not explain in detail how to Monte Carlo simulation is implemented since we can find it in almost every statistic book. We will obtain also the average, 90%, 95% and 99% percentiles of the compound distribution at the end, in order to have a better comparison of the different risks.

4.3 Adding velocity in the method

4.3.1 Methodology

We now need to introduce the new variable, velocity, in the whole risk assessment process. Velocity will adopt the same role as probability and impact, so we will set random values from 1 to 5 in each type of risk as a new column, representing the velocity. We will follow the rating scale defined in the previous chapter to guide us in understanding how fast the risk will impact the organization.

Velocity is closely related with the time of impact as we have defined before, so it becomes necessary to find a scale value where we will determine how many days will take for each type of risk to impact the organization. For this purpose we will perform linear interpolation, as we did with impact and probability, that will give us the number of days to impact related with scale of 1 to 5 used above and its intermediate points. We show the table with the fixed points:

Speed of Onset (Velocity)	
x	y
1	365
2	180
3	60
4	20
5	5

Table 4.3: Scale value for interpolation (Velocity). The right column has fixed points expressed in days to impact.

So then, we will know that 309,5 days to impact (approximately) correspond to a velocity of 1,3. In the same way as we performed above with impact and probability now we count with a new column giving us the number of days to impact.

We continue developing the new analysis by defining an indicator function in a 2 years time horizon. We fix 2 years horizon since an event can occur over a year but manifest itself in the next one if it has low velocity. The reason for adding an indicator function is that events cannot impact the organization before, already known, TTI. In other words, we set a function that tell us if the time to impact has reached certain period of time, and therefore could possibly hit us, or the opposite, the event could possibly not affected us. We will apply this concept splitting the 2 years in 8 periods of 90 days, so we will check if a risk could impact the organization in each of this periods. The indicator function will return a 1 if the risk could hit the organization in that period of time (for example, 90 days) and a 0 if the risk couldn't impact in that period of time. We can store this information in a table in excel called "Possibility of impact" (See Figure A.1).

After this step we will perform, as in traditional approach, the distribution functions for impact and probability but this time we will define the distribution every period of time that the risk could affect the organization. For the probability of events we use again a Poisson distribution with the same parameter λ as in the traditional approach defined before. Here we denote a new table as "Number of impacts" since the Poisson distribution, in fact, expresses the probability of a given number of events occurring in a interval of time (See Figure A.1).

The next process step is based on the Monte Carlo simulation already defined in order to compute the compound loss distribution. In a new table, "Total cost", we define the compound of both probability distributions, a Lognormal with the same parameters μ and σ as the traditional approach defined before, which correspond to the impact, and the Poisson distribution with parameter λ defined in the last step. Therefore, for each period of time where the risk could affect the enterprise we define a compound distribution function (See Figure A.2).

As last step of the process we include a discount factor for each period of time. As we describe in subsection 3.1.4 the discount factor will play an important role in this part of the analysis. We are analysing total losses in certain business areas, and we do not know if a risk could impact in a short or long period of time, and if this fact will affect us in the future. Moreover, the value of money tends to change over time, so the costs in the future for different business areas can not represent the same value as the cost today. This is why it is important to discount future values of costs in our assessment, in order to have a better knowledge of the net present value. In our calculation we will use a discount factor of 3% based on the WACC, as we described in subsection 3.1.4, for each period of time. Then, we compute the cumulative product between the discounting rate and the corresponding compound distribution at that period of time, so we can get a distribution of present values of total loss (See Figure A.2). We can also get the average, 99%, 95% and 90% percentile of the final distribution for our evaluation purposes.

4.3.2 Influences in the risk ranking

After all the computations we have obtained values for the total loss for each risk. However, the cost of capital has been changed with the new approach by adding the discount rate, and therefore we cannot compare directly the results with the traditional approach. But we can instead look at the risk ranking, which will give us great information about how the incorporation of velocity has affected the risk assessment. We will sort the risks in both, traditional and new approach, highest to lowest costs, and then we will take the top five. Some of the risk could coincide, mainly the first (highest) ones, and some other could differ in the order of prioritization or even new risks that we did not add in our top five list of risk before could arise.

If the risk measure including velocity provides a different ranking of risk to the traditional measure then we can conclude that the prioritization would be different (and we would suggest more appropriate) in an organization operating within a risk velocity framework and as a consequence the actions they would take would be different.

Chapter 5

Testing new model under different business lines

Now we will show the results of adding risk velocity to the risk assessment in different business lines and compare them with the current techniques.

5.1 Initial input data

The method described in the previous section needs to be initiated with an initial input data set. For this purpose, data from a grocery wholesaling group is used. The initial data consists of more than one business line, so we will use three of the business lines throughout all our analysis. We have worked in spreadsheets in Excel, where we have classified different types of risk for each business line. In this case, we have classified twenty business areas and each of these areas contains a collection of risks (between 30 and 45 risks) classified by experts following the standard requirements from Basel Committee. We will center our studies in the areas called Financial Economics which contains 27 types of risk (price war, new players in the market, abnormal consumer behaviour, trend towards low, lack of innovation, etc.), Group Data with 26 risks and Service Trade with 22 risks classified.

5.2 Business lines

In the following subsections three different business lines considered for the company are presented. The lines describe different types of risks that could affect the organization. For all business lines and all type of risks we get the values between 1 and 5 of the corresponding impact and probability of occurrence.

5.2.1 Line 1

This business line (Financial Economics) has 27 type of risks. We will perform our method in the data set on Figure A.3.

Following the method described above we will develop the risk assessment in both ways, traditional and new approach incorporating risk velocity. After all computations we get a top five risk ranking where we can appreciate better the results (see Table 5.1 and Table 5.2). A heat matrix with the top five risks and a 3D plot for the traditional approach and the new approach respectively are presented in Figure 5.1 and Figure 5.2.

Ranking	Risk Number	Risk Description
1	21	Inadequate quality of decision-making and supporting investments
2	26	High level of investment - long payback
3	20	Significant food scandals
4	8	Laws and regulations / conditions which limit the Group's freedom of action
5	27	High level of investment - the failure of completion

Table 5.1: Top five risks ranking for Line 1 (Financial Economics) for traditional approach.

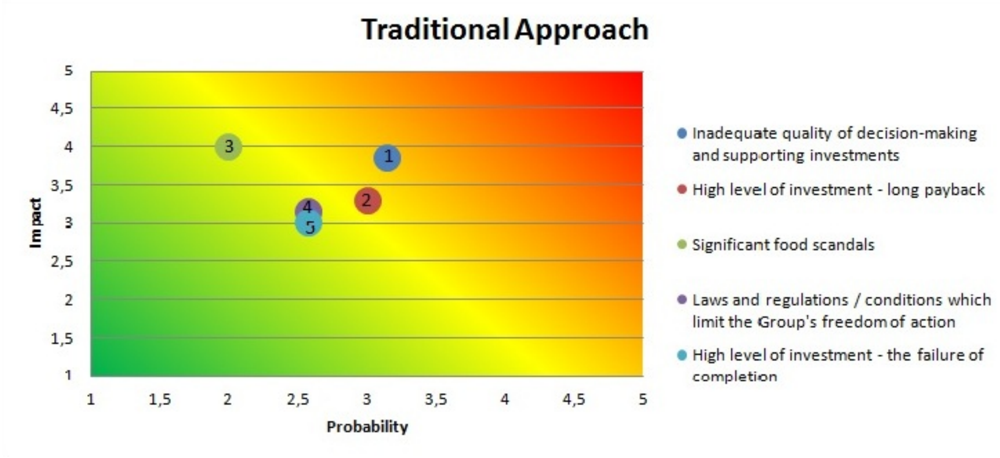

Figure 5.1: Top five risks heat matrix for traditional approach. Dots represent the different risks and the numbers indicate the position in the ranking.

Ranking	Risk Number	Risk Description
1	21	Inadequate quality of decision-making and supporting investments
2	20	Significant food scandals
3	26	High level of investment - long payback
4	27	High level of investment - the failure of completion
5	18	Inadequate quality in partnership accounting/ finance and management of the subsidiary and decision makers

Table 5.2: Top five risks ranking for Line 1 (Financial Economics) for new approach.

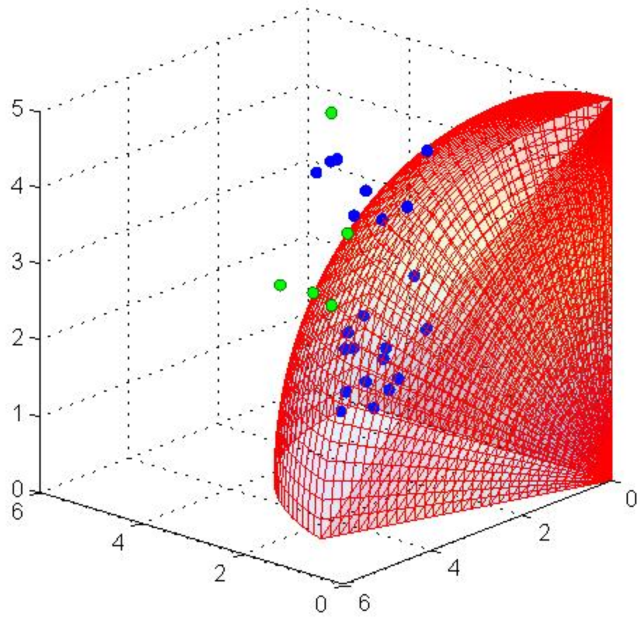

Figure 5.2: 3D plot for risks in new approach. Dots represent the different risks. Dots over the threshold are the most important and the first in our prioritization.

We can see in the tables that there are evident changes in the risk ranking when we compare both approaches. When we incorporate the velocity to our assessment we observe that the first three risks hold in the same position in our prioritization, the fifth risk has changed to the fourth position and one new risk has arisen while the risk number four has disappeared of the top five in the new approach.

5.2.2 Line 2

This business line (Group Data) has 26 type of risks. We will perform our method in the data set on Figure A.4.

Applying the method described above for this data we will develop the risk assessment in both ways, traditional and new approach incorporating risk velocity. After all computations we get the top five risk ranking (see Table 5.3 and Table 5.4). Heat matrix with the top five risks and 3D plot for traditional and new approach are presented respectively in Figure 5.3 and Figure 5.4.

Ranking	Risk Number	Risk Description
1	4	Group Data is not able to attract and develop the best minds
2	12	Shops in Group does not involve Group Data in key
3	7	Light management for election of new solutions and suppliers
4	18	Complex IT platform is a barrier to effective business development
5	17	Too little attention to enterprise architecture and business process

Table 5.3: Top five risks ranking for Line 2 (Group Data) for traditional approach.

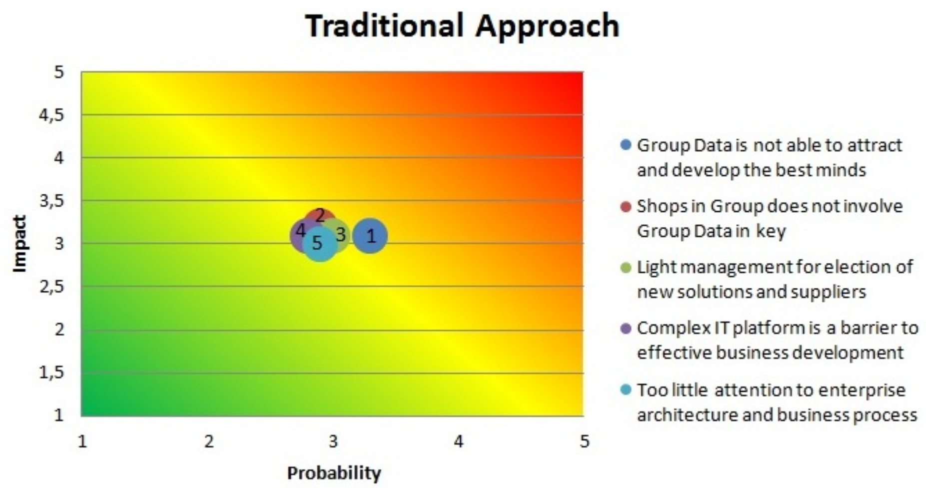

Figure 5.3: Top five risks heat matrix for the traditional approach. Dots represent the different risks and the numbers indicate the position in the ranking.

Ranking	Risk Number	Risk Description
1	4	Group Data is not able to attract and develop the best minds
2	12	Shops in Group does not involve Group Data in key
3	18	Complex IT platform is a barrier to effective business development
4	11	Group Data achieve in practice the role management model describes
5	7	Light management for election of new solutions and suppliers

Table 5.4: Top five risks ranking for Line 2 (Group Data) for new approach.

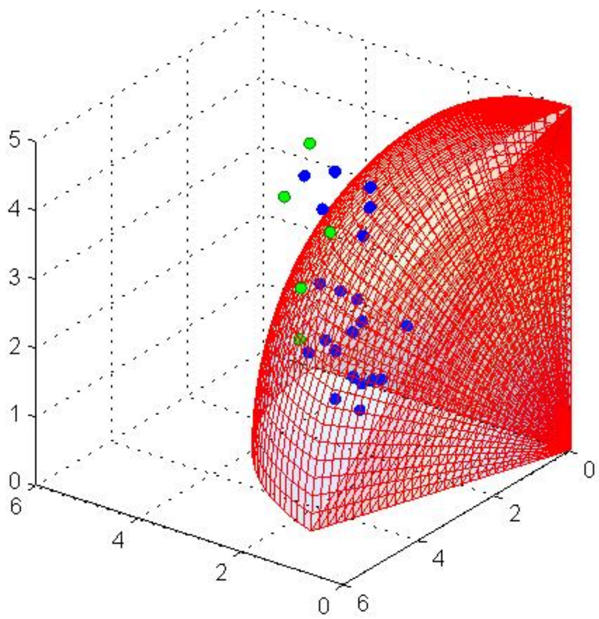

Figure 5.4: 3D plot for risks in new approach. Dots represent the different risks. Dots over the threshold are the most important and the first in our prioritization.

Again, as we expected we can see in the tables that there are evident changes in the risk ranking when we compare both approaches. When we incorporate the velocity to our assessment we observe that the first and the second risks hold in the same position in our prioritization, the third and the forth risks have interchanged positions and the risk number fifth has disappeared and become a new one in the top five in the new approach.

5.2.3 Line 3

This business line (Service Trade) has 22 type of risks. We will perform our method in the data set on Figure A.5.

Applying the method described above for this data we will develop the risk assessment in both ways, traditional and new approach incorporating risk velocity. After all computations we get the top five risk ranking (see Table 5.5 amd Table 5.6). Heat matrix with the top five risks and 3D plot for the traditional and new approach respectively are presented in Figure 5.5 and Figure 5.6.

Ranking	Risk Number	Risk Description
1	9	Access to skilled labour (including franchises)/ change in job market
2	3	Can not correct locations for new businesses
3	6	Increased competition from grocery
4	15	Do not get on or choose the wrong franchisees/ managers
5	13	Too few resources to achieve the targets set

Table 5.5: Top five risks ranking for Line 3 (Service Trade) for traditional approach.

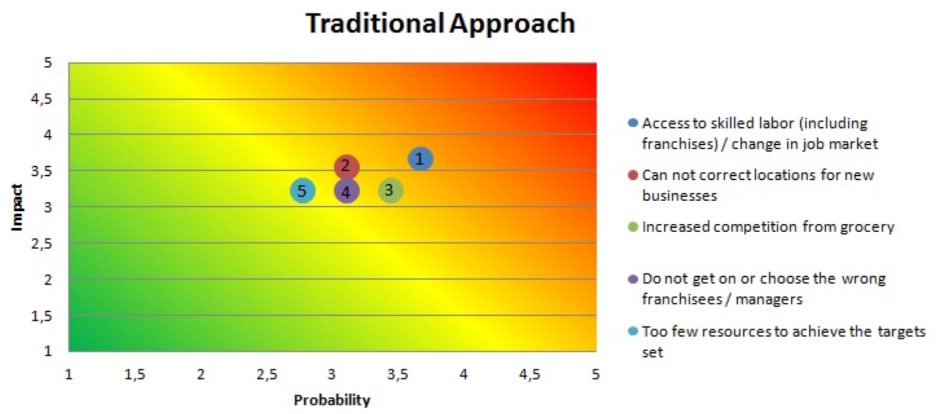

Figure 5.5: Top five risks heat matrix for the traditional approach. Dots represent the different risks and the numbers indicate the position in the ranking.

Ranking	Risk Number	Risk Description
1	9	Access to skilled labour (including franchises)/ change in job market
2	3	Can not correct locations for new businesses
3	2	Change in consumer behaviour - the trend towards low cost and cost awareness
4	13	Too few resources to achieve the targets set
5	21	A significant number of franchisees do not invest to the creation and / or improvement

Table 5.6: Top five risks ranking for Line 3 (Service Trade) for new approach.

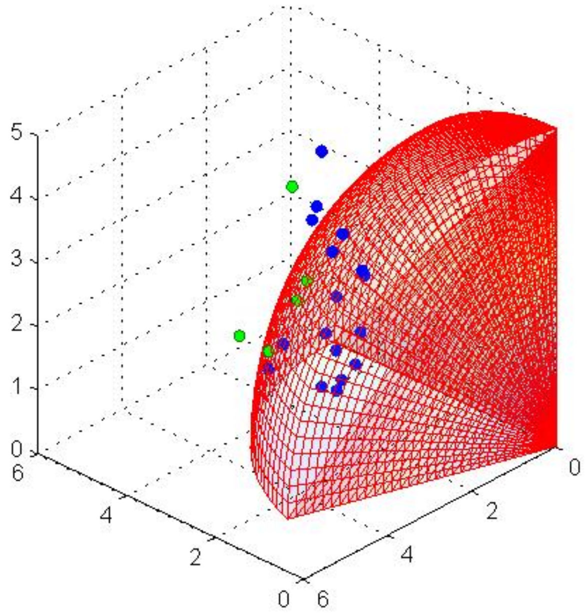

Figure 5.6: 3D plot for risks in new approach. Dots represent the different risks. Dots over the threshold are the most important and the first in our prioritization.

One more time, the tables show evident changes in the risk ranking when we compare both approaches. When we incorporate the velocity to our assessment we observe that the first and the second risks hold in the same position in our prioritization while the third, fourth and fifth risks have changed completely. Two new risks have arisen to take the third and fifth position while the risks in fifth position in the traditional approach has become the fourth risk in the prioritization for the new approach.

5.3 Sensitivity Analysis

As we stated before the discount rate added in the process plays an important role in the analysis, and will affect the evaluation if we change it. We could imagine also that if we vary the parameters used in the estimated distribution functions, it will have an effect in the final results. We can think that using time value will give different assessments of which risk is most important. This is the reason for performing a sensitivity analysis of the parameters used in the process described.

While analysing the effects of the discount rate when we change the percent for each period of time, we can find that the choice of cost of capital rate has an impact in the results. A high rate could be used for very short term risk capital, and a lower rate for those risks that can only materialise and impact over the long term. In Table 5.7 we have changed percentage of rate and performed the same analysis for risks we high and low value in the impact, probability and velocity scale to see its influence.

P	I	V	Rate	Discounted Cost
1,1	3,8	4,8	3%	71,15887613
1,1	3,8	4,8	15%	45,48814203
1,1	3,8	1,2	3%	42,48513951
1,1	3,8	1,2	15%	22,34300562
3,8	1,1	4,8	3%	8,156882324
3,8	1,1	4,8	15%	5,214267592
3,8	1,1	1,2	3%	4,87003593
3,8	1,1	1,2	15%	2,561160006

Table 5.7: Sensitivity analysis for different probability, impact, velocity and discount rate.

We observed that the final discounted risk value decreases when increasing the percentage rate, in both cases. The cost of capital is obviously greater when we have high value in the impact and high value in the velocity.

Now we should look at the risk ranking. How the change of discount rate will affect the final risk ranking? We can observe by changing the rate that the prioritisation of the risks is varying in fact. In Table 5.8 we show which number of risk is place it in the top five list. We see that between a 3% and a 5% rate the risk number 12 and 18 has exchanged positions,i.e., the risk number 12 is in the second position and the risk number 18 is in the third for a 3% rate and for a 5% rate is vice-versa. For a 8% discount rate the ranking changes for the risk in the fifth position, the risk number 7 is no longer in the list but 22 arise in the prioritization instead. For a 31% rate the risks are the same but this time the risks in the position third and fourth have exchanged position also. So, If we compare the prioritization of risks for a 3% and a 31 % of discount rate we see that they are completely different. The influence of the discount rate on the results is clear.

	Rate			
Ranking	3%	5%	8%	31%
1	4	4	4	4
2	12	18	18	18
3	18	12	12	11
4	11	11	11	12
5	7	7	22	22

Table 5.8: Risk ranking for different discount rates.

Note that although rate as high as 31% may seem extreme by today's standards, this would not have been the case in western economies in the 80's, or many developing nations today.

We can conclude from the results in this section that the discounting rates play an important role in the final ranking of risk. The choice of rate could affect directly the prioritization and therefore the actions we would take.

Also, it is important to mention the existence of other parameters, such as λ, μ and σ from the distributions functions, which could as well be modified and, perhaps, affect the ranking of risk. By this time we will just present the sensitivity analysis for the discounting rate.

Chapter 6

Conclusions

The different evaluations demonstrate a differentiation for different business areas, and the risk ranking could serve as a good indicator base for identifying potential excessive risks. Companies must focus on those risks that will have an effect over a short time horizon.

As we can see in the different business areas, it seems that the first risks in the ranking are very similar for both approaches. The most dangerous risks are the first ones and the most important for both assessments since the impact is very high. In these cases the velocity has contributed to reaffirm the importance of these risks, putting them at the highest level in our prioritization.

In some other cases we can appreciate that the same risks hold in both approaches but they have changed position in the ranking, this is due to the velocity's effect. In the traditional approach two risk could be very close in ranking since they had similar impact and likelihood, but what velocity does is to make that distinction between them; very similar risks get prioritised by looking at the different times they will impact in the organization.

The last case we have observed is the emergence of new risks in our risk ranking. Risks that before were not classified as potentially dangerous, now become more important. The velocity has had a clear effect in these kind of risks. The time to impact has made them move along the ranking and has placed them among the most important risks. These risks causes the most abrupt change in our point of view, since before they were not taken into account.

We can conclude that risk assessments including risk velocity give a different prioritization of the risks, make a distinction between level of risks and give an overview of risks had not previously been considered.

A good risk assessment must be simple, practical and understandable. Achieving success depends also on resources and senior executive commitment. The process must be developed by people with the right skills in order to give better accuracy in the results and have a better understanding of the whole picture.

Just as in the traditional assessment it is important to retain information about the impact, likelihood and time to impact within the information received by management.

Chapter 7

Discussions

After developing this study we could bring a lot of discussions and maybe come up with some other factors that would affect the risk assessment and, maybe, improve our evaluation.

Sensitivity analysis for the discounting rate has been shown, but it is important to note that there are other parameters that could affect the final results if we modified them. Sensitivity analysis for parameters such as λ, μ and σ from the distributions functions could be developed in future studies.

We could state that a high velocity has two effects on the impact: the residual risk impact is higher as there is less time to take the corrective action and the inherent impact may be greater simply because of the higher velocity.

We could also include in our discussion which effects will have velocity controls in the risks. We can slow the risk down so there is more time to take action or either slow the risk down so the impact is lower. The reader could think there is another factor missing in the whole evaluation, how fast should we respond to risk or events?, how will our decisions affect to the final impact? Two scenario cases can exemplify the questions. The risk hits the organization suddenly, and we did not see it or realize before we feel it. The other case is when we can see or realize the risk approaching the organization, so we could make some decision in order to stop or mitigate its effects, in a shorter or longer time.

The capacity of reaction against a risk must be taken into account. Companies with a good knowledge of their possibilities and vulnerable parts could react faster in mitigation plans. This capacity of facing risk could change abruptly the risk assessment process and help to minimize the impact of certain risks.

At last, we could introduce the recovering factor as well in our discussions. Once the risk has impacted the company we have a time to recover that becomes very important, so the risk could be treated correctly and deal with its consequences. Time to recover indicates as well how rapid an organization can handle the causes of a risk.

Appendix A

Data

A.1 Methodology

1 year Probability (%)	Possibility of Impact									Number of impacts(Poisson)							
	90,00	180,00	270,00	360,00	450,00	540,00	630,00	720,00		90,00	180,00	270,00	360,00	450,00	540,00	630,00	720,00
41%	0	0	0	1	1	1	1	1		0	0	0	0,40778	0,40778	0,40778	0,40778	0,40778
60%	1	1	1	1	1	1	1	1		0,60222	0,60222	0,60222	0,60222	0,60222	0,60222	0,60222	0,60222
52%	0	0	1	1	1	1	1	1		0	0	0,51889	0,51889	0,51889	0,51889	0,51889	0,51889
71%	1	1	1	1	1	1	1	1		0,71333	0,71333	0,71333	0,71333	0,71333	0,71333	0,71333	0,71333
46%	0	1	1	1	1	1	1	1		0	0,46333	0,46333	0,46333	0,46333	0,46333	0,46333	0,46333
46%	0	0	0	1	1	1	1	1		0	0	0	0,46333	0,46333	0,46333	0,46333	0,46333
63%	0	0	1	1	1	1	1	1		0	0	0,63	0,63	0,63	0,63	0,63	0,63
35%	0	0	0	1	1	1	1	1		0	0	0	0,35167	0,35167	0,35167	0,35167	0,35167
57%	0	0	1	1	1	1	1	1		0	0	0,57444	0,57444	0,57444	0,57444	0,57444	0,57444
69%	1	1	1	1	1	1	1	1		0,68556	0,68556	0,68556	0,68556	0,68556	0,68556	0,68556	0,68556
49%	1	1	1	1	1	1	1	1		0,49111	0,49111	0,49111	0,49111	0,49111	0,49111	0,49111	0,49111
60%	0	1	1	1	1	1	1	1		0	0,60222	0,60222	0,60222	0,60222	0,60222	0,60222	0,60222
27%	0	1	1	1	1	1	1	1		0	0,26667	0,26667	0,26667	0,26667	0,26667	0,26667	0,26667
41%	0	0	0	1	1	1	1	1		0	0	0	0,40778	0,40778	0,40778	0,40778	0,40778
24%	0	0	1	1	1	1	1	1		0	0	0,23833	0,23833	0,23833	0,23833	0,23833	0,23833
38%	0	0	0	1	1	1	1	1		0	0	0	0,38	0,38	0,38	0,38	0,38
60%	0	0	1	1	1	1	1	1		0	0	0,60222	0,60222	0,60222	0,60222	0,60222	0,60222
57%	1	1	1	1	1	1	1	1		0,57444	0,57444	0,57444	0,57444	0,57444	0,57444	0,57444	0,57444
35%	1	1	1	1	1	1	1	1		0,35167	0,35167	0,35167	0,35167	0,35167	0,35167	0,35167	0,35167
32%	1	1	1	1	1	1	1	1		0,32333	0,32333	0,32333	0,32333	0,32333	0,32333	0,32333	0,32333
44%	1	1	1	1	1	1	1	1		0,43556	0,43556	0,43556	0,43556	0,43556	0,43556	0,43556	0,43556
55%	1	1	1	1	1	1	1	1		0,54667	0,54667	0,54667	0,54667	0,54667	0,54667	0,54667	0,54667
15%	1	1	1	1	1	1	1	1		0,15333	0,15333	0,15333	0,15333	0,15333	0,15333	0,15333	0,15333
30%	1	1	1	1	1	1	1	1		0,295	0,295	0,295	0,295	0,295	0,295	0,295	0,295
18%	0	1	1	1	1	1	1	1		0	0,18167	0,18167	0,18167	0,18167	0,18167	0,18167	0,18167
60%	0	1	1	1	1	1	1	1		0	0,60222	0,60222	0,60222	0,60222	0,60222	0,60222	0,60222

Figure A.1: Indicator function and number of impacts tables corresponding to each type of risk in each period of time.

Total impact(lognormal and poisson)								Discount factor								Discounted risk				
90,00	180,00	270,00	360,00	450,00	540,00	630,00	720,00	90,00	180,00	270,00	360,00	450,00	540,00	630,00	720,00		Average	0,9	0,95	0,99
0	0	0	7,47592	7,47592	7,47592	7,47592	7,47592	0,97087	0,9426	0,91514	0,88849	0,86261	0,83748	0,81309	0,78941	31,3322	31,3443	61,7612	74,6117	90,9795
9,03333	9,03333	9,03333	9,03333	9,03333	9,03333	9,03333	9,03333	3%	3%	3%	3%	3%	3%	3%	3%	63,4112	63,4332	105,317	117,809	145,437
0	0	12,9722	12,9722	12,9722	12,9722	12,9722	12,9722									66,2391	66,1916	109,432	129,067	183,872
28,137	28,137	28,137	28,137	28,137	28,137	28,137	28,137									197,513	197,451	307,196	347,6	414,789
0	8,49444	8,49444	8,49444	8,49444	8,49444	8,49444	8,49444									51,3813	51,2454	92,1055	100,118	131,21
0	0	0	18,2759	18,2759	18,2759	18,2759	18,2759									76,5959	76,5774	135,109	165,493	202,675
0	0	24,85	24,85	24,85	24,85	24,85	24,85									126,89	127,036	224,305	240,567	302,302
0	0	0	12,3083	12,3083	12,3083	12,3083	12,3083									51,5852	51,6777	113,242	119,601	151,113
0	0	14,3611	14,3611	14,3611	14,3611	14,3611	14,3611									73,3311	73,3121	128,771	148,919	172,564
17,1389	17,1389	17,1389	17,1389	17,1389	17,1389	17,1389	17,1389									120,31	120,215	195,31	212,085	247,615
19,3716	19,3716	19,3716	19,3716	19,3716	19,3716	19,3716	19,3716									135,983	135,942	233,359	268,542	321,678
0	26,4309	26,4309	26,4309	26,4309	26,4309	26,4309	26,4309									159,875	159,936	266,283	302,999	367,195
0	15,2593	15,2593	15,2593	15,2593	15,2593	15,2593	15,2593									92,3006	92,4059	195,331	205,534	295,114
0	0	0	12,913	12,913	12,913	12,913	12,913									54,1193	54,0903	105,189	127,676	160,288
0	0	9,40092	9,40092	9,40092	9,40092	9,40092	9,40092									48,0032	48,0971	101,826	131,231	163,413
0	0	0	10,7667	10,7667	10,7667	10,7667	10,7667									45,124	45,1165	94,4045	115,53	141,174
0	0	21,0778	21,0778	21,0778	21,0778	21,0778	21,0778									107,628	107,752	181,038	208,671	257,04
22,6586	22,6586	22,6586	22,6586	22,6586	22,6586	22,6586	22,6586									159,057	158,934	250,653	285,989	351,303
11,1361	11,1361	11,1361	11,1361	11,1361	11,1361	11,1361	11,1361									78,1721	78,1118	140,046	161,563	200,93
14,1907	14,1907	14,1907	14,1907	14,1907	14,1907	14,1907	14,1907									99,6146	99,6815	188,571	202,218	276,801
17,1802	17,1802	17,1802	17,1802	17,1802	17,1802	17,1802	17,1802									120,6	120,595	209,737	241,467	280,441
17,3111	17,3111	17,3111	17,3111	17,3111	17,3111	17,3111	17,3111									121,519	121,452	195,544	224,666	262,413
10,137	10,137	10,137	10,137	10,137	10,137	10,137	10,137									71,1589	71,3724	170,366	180,637	241,999
10,325	10,325	10,325	10,325	10,325	10,325	10,325	10,325									72,4783	72,4407	128,984	154,88	192,624
0	4,54167	4,54167	4,54167	4,54167	4,54167	4,54167	4,54167									27,4717	27,5042	64,016	67,3237	88,294
0	15,0556	15,0556	15,0556	15,0556	15,0556	15,0556	15,0556									91,0684	91,0965	151,051	171,285	212,299

Figure A.2: Compound distribution, discount factor for each type or risk in each period of time, and discounted final risk table defined for each type of risk.

A.2 Initial Data

Risk Number	Risk Description	Probability	S.D.	Impact	S.D	Velocity	Days to Impact
1	Haphazard / inadequate management of risks	2,714	1,030	2,429	0,728	1,3	309,5
2	Lack of ownership / commitment to overarching decisions and preparation of policy documents	3,286	0,700	2,571	0,495	4,1	18,5
3	Missed process improvements in the interaction of the Group	2,571	0,495	2,143	0,350	1,7	235,5
4	Group companies do not use economic / financial expertise of the Group operators	3,571	0,495	2,571	0,495	3,9	24
5	Slower economic growth than expected in the country -ref international relations	2,571	0,728	3,000	0,756	2,1	168
6	Mister / not attract more talented managers and talents	2,857	0,833	2,714	0,700	1,2	328
7	Lower rate of innovation than competitors	1,857	0,639	3,000	0,756	1,9	198,5
8	Laws and regulations / conditions which limit the Group's freedom of action	2,571	0,495	3,143	0,350	1,1	346,5
9	Human error there after control deficiencies	2,714	0,700	2,714	0,452	1,8	217
10	Can not (ability / willingness) to simplify / standardize corporate processes - unnecessarily expensive	3,286	0,881	2,429	0,728	4,1	18,5
11	Cases of embezzlement / default / uncultured / lack of accountability in the Group	2,571	0,728	2,857	0,639	3,6	36
12	Improvement projects are not prioritized	2,143	0,350	2,000	0,756	2,7	96
13	Poor operation of existing business	2,000	0,756	3,286	0,700	2,5	120
14	Losing important new and existing locations	1,429	0,728	3,714	0,452	1,5	272,5
15	ICT breakdown	1,571	0,728	3,000	0,756	1,7	235,5
16	Miss significant number of key people over a short time	2,000	0,535	2,714	0,452	1,4	291
17	Low willingness / ability / opportunity from managers / key people in Group to follow financial policies and guidelines for financial activities	3,000	0,926	2,571	0,495	1,7	235,5
18	Inadequate quality in partnership accounting / finance and management of the subsidiary and decision makers	3,143	0,639	2,714	0,452	4,8	8
19	Violations of the Code of Ethics	2,143	0,833	2,714	0,881	3,6	36
20	Significant food scandals	2,000	0,756	4,000	1,00	2,8	84
21	Inadequate quality of decision-making and supporting investments	3,143	0,639	3,857	0,350	2,8	84
22	Direct / indirect economic losses or lost opportunities due to changes in interest rates, currencies and commodities	2,714	0,700	2,429	0,495	3,8	28
23	Violation of debt covenants	1,000	0,000	3,000	0,535	4,8	8
24	Do not get the loan / credit in the desired range	1,143	0,350	3,286	0,700	4,1	18,5
25	Significant errors in the consolidated accounts	1,143	0,350	2,857	0,639	2,4	132
26	High level of investment - long payback	3,000	0,756	3,286	0,452	2,6	108
27	High level of investment - the failure of completion	2,571	0,495	3,000	0,535	3,4	44

Figure A.3: Initial data set for business Line 1 (Financial Economics).

Risk Number	Risk Description	Probability	S.D.	Impact	S.D	Velocity	Days to Impact
1	Group losing business opportunities related to new technology	2,1	0,6	2,4	0,5	1,3	309,5
2	Group Data is not competitive on innovation	2,9	0,3	2,3	0,5	4,1	18,5
3	Group Data missing advisor skills / knowledge across the business side of the relationship IT - business	2,6	0,7	2,7	0,7	1,7	235,5
4	Group Data is not able to attract and develop the best minds	3,3	0,7	3,1	0,6	3,9	24
5	Group lose delivery of ICT services to other operators	2,3	0,5	2,4	0,7	2,1	168
6	Group Data perceived solely as an operational organization	2,3	0,8	3,1	0,6	1,2	328
7	Light management for election of new solutions and suppliers	3,0	0,7	3,1	0,3	1,9	198,5
8	Group Data experiencing serious reputation in company	1,9	0,6	3,0	0,5	1,1	346,5
9	Group Data has no framework for innovation	2,8	0,8	2,7	0,5	1,8	217
10	New section in the cost-benefit assessment is not made / not followed up	3,2	0,4	2,7	0,5	4,1	18,5
11	Group Data achieve in practice the role management model describes	2,4	0,5	3,1	0,3	3,6	36
12	Shops in Group does not involve Group Data in key	2,9	0,6	3,2	0,4	2,7	96
13	Significant disruptions / material weakness in the supply warehouse	1,6	0,5	3,6	0,5	2,5	120
14	Significant disruptions / material weakness in the supply store	2,1	0,6	2,9	0,7	1,5	272,5
15	Significant disruptions / material weakness in shipments Salary	1,4	0,5	3,1	0,6	1,7	235,5
16	Group Data seen as not competitive on price performance	2,0	0,7	2,8	0,4	1,4	291
17	Too little attention to enterprise architecture and business process	2,9	0,3	3,0	0,5	1,7	235,5
18	Complex IT platform is a barrier to effective business development	2,8	0,4	3,1	0,6	4,8	8
19	Group Data working without interest ("everyday weathering ")	1,9	0,3	2,9	0,7	3,6	36
20	Severe cases of unauthorized access to the IT system	1,8	0,4	3,2	0,6	2,8	84
21	Key suppliers for getting huge problem (financial , expertise , strategy , acquisitions)	2,2	0,6	3,1	0,6	2,8	84
22	Missing coordination of IT readiness and business areas contingency plans	2,7	0,7	2,9	0,7	3,8	28
23	Disaster (sabotage, terrorism and random events)	1,1	0,3	3,8	0,4	4,8	8
24	Severe case of sensitive data (personal , business) going astray	1,7	0,7	3,0	0,7	4,1	18,5
25	Severe case of any default of " disloyalty	1,2	0,4	2,7	0,5	2,4	132
26	Hidden charges (Group - target)	2,9	1,0	2,7	0,5	2,6	108

Figure A.4: Initial data set for business Line 2 (Group Data).

Risk Number	Risk Description	Probability	S.D.	Impact	S.D	Velocity	Days to Impact
1	Designated concept not adapted to new market trends	2,000	0,667	3,111	0,875	1,3	309,5
2	Change in consumer behavior - the trend towards low cost and cost awareness	3,111	0,875	3,000	0,471	4,1	18,5
3	Can not correct locations for new businesses	3,111	0,737	3,556	0,685	1,7	235,5
4	Lack of innovation	2,667	0,471	2,889	0,567	3,9	24
5	Significant loss of reputation	1,889	0,567	2,667	0,816	2,1	168
6	Increased competition from grocery	3,444	0,497	3,222	0,629	1,2	328
7	Increased competition from new concepts / actors	2,556	0,685	2,778	0,416	1,9	198,5
8	Significantly higher commodity prices	2,556	0,831	2,889	0,737	1,1	346,5
9	Access to skilled labor (including franchises) / change in job market	3,667	0,471	3,667	0,471	1,8	217
10	Mister tobacco and snuff	1,444	0,685	3,556	0,685	4,1	18,5
11	Sabotage, terrorism, random events	1,111	0,314	3,444	0,685	3,6	36
12	For poor service to customers	2,111	0,737	3,000	0,667	2,7	96
13	Too few resources to achieve the targets set	2,778	0,629	3,222	0,416	2,5	120
14	Error Establishing	1,889	0,567	3,111	0,567	1,5	272,5
15	Do not get on or choose the wrong franchisees / managers	3,111	0,737	3,222	0,416	1,7	235,5
16	Key people disappear	2,222	0,416	2,444	0,497	1,4	291
17	Logistics and Purchasing not adapted to the needs of Service Trade	2,333	0,471	2,778	0,416	1,7	235,5
18	Inadequate or late management information	2,556	0,956	2,889	0,567	4,8	8
19	Safe-food scandal	1,889	0,875	3,333	0,667	3,6	36
20	Significant violations of laws / rules / internal guidelines	2,111	0,737	2,333	0,667	2,8	84
21	A significant number of franchisees do not invest to the creation and / or improvement	2,667	1,054	3,111	0,567	2,8	84
22	Can not competitive operating costs	2,556	0,497	3,111	0,737	3,8	28

Figure A.5: Initial data set for business Line 3 (Service Trade).

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