Directorate Supervision

Risk measurement within financial conglomerates: best practices by risk type

Working group on Economic Capital Models

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Risk measurement within financial conglomerates: best practices by risk type

First report of the Working group on Economic Capital Models*

The Working Group has been set up by de Raad van Financiële Toezichthouders, de Nederlandse Vereniging van Banken and het Verbond van Verzekeraars

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0. Introduction and executive overview

In 2001 Oliver, Wyman & Company published a report on the risk profile and capital adequacy of mixed financial conglomerates.\(^1\) The report concluded that adding up stand-alone capital measures would provide a reasonable approximation of holding company capital requirements based on existing requirements. Internal risk and capital frameworks would offer the best solutions to overcome limitations of what was dubbed the ‘silo approach’. Accordingly, the primary role of the supervisor would be to review the internal risk assessment and the resulting capital allocation within financial conglomerates.

Following up on this report, a Working group on Economic Capital Models (WECM) has been established, consisting of representatives of the Council of Financial Supervisors (RFT), the Dutch Banking Association (NVB), and the Dutch Insurance Association (het Verbond). The objective of the working group is to conduct further research into internal economic capital models of bank and insurance activities, in order to assess their suitability to chart a financial conglomerate’s risk profile.

Economic capital models have recently come into vogue as a tool to measure risk and return on a firm-wide basis and to allocate capital accordingly. Further research into this subject was deemed of common interest to both the financial industry and financial supervisors, as the regulatory regime is increasingly shifting toward reliance on internal models. This paper is meant to be the first of a sequence that, together, should provide an overview of the status and usefulness of economic capital models for supervisory purposes.

Aim of the first paper is to achieve a common risk language for the various stakeholders, each having their specific background. In practice, risk assessment and economic capital allocation still differs across banking and insurance activities, reflecting differences in the dominant risk types that have traditionally been confronted. Banking institutions mainly focus on credit risk (with only more recent attention for additional risks such as market, interest rate, and operational risk). On the other hand, insurance companies mainly focus on insurance-technical risks and ALM risk. In order to construct a common risk language across a financial conglomerate, the differences in the sector specific frameworks should be identified and, to the extent possible, agreement should be sought on a joint framework that encompasses all relevant risks in a uniform way.

The paper is organized as follows. The remainder of this overview chapter will outline the main issues surrounding risk measurement and capital allocation, summarize our main findings, and briefly lay out our future research agenda. It will conclude with a table containing a classification of risk types that financial conglomerates typically distinguish. Each risk type will then in turn be elaborated upon in a separate chapter, presenting definitions, the main risk drivers, and the various alternative approaches to quantify the risk.

0.1 Risk measurement and economic capital

Financial institutions make a return by taking financial risks for their own account, or by accepting financial risks from customers and by providing services that aim to mitigate those. Within financial institutions, risks from individual clients – stemming from their inability to effectively deal with the frequency, timing and/or severity of pertinent contingent events themselves – will be transferred to a pool of similar risks. Risk management can thus be seen as one of the core activities of a financial institution. In order to perform this activity in a controlled and well-informed manner, risk identification followed by risk measurement is a natural starting point.

Risk measurement – a generic term describing a wide variety of techniques – typically starts rather autonomously in the different business lines within a financial institution. To compare these techniques, however, one has to come up with an overall standard to measure risk. Recent developments within the financial industry have converged toward the use of economic capital as this common risk standard. Economic capital can be defined as the amount of capital that a transaction or business unit requires in order to support the economic risk it originates, as perceived by the institution itself. Such a risk measure can also be used for risk-adjusted performance measurement, which compares returns to the risk incurred in earning those returns (such as RAROC and RORAC).

Risk is a concept that is given different definitions, depending on the context; an often-applied definition in the context of capital management is ‘unexpected loss’. Risk is a function of the volatility of outcomes – the expected outcome can be compared with the mean of all possible outcomes, and risk relates to the variability of outcomes. Economic capital can then be defined in more operational terms as a buffer against all unexpected losses, including those not incurred on the balance sheet (such as potential loss arising from a derivatives position or a guarantee), at the company’s desired level of comfort. The statistical analysis essentially ascertains the potential maximum loss in value of assets and other exposures (or increase in value of liabilities) over a given time period, at a given confidence interval.

The concept of unexpected loss relates to the loss in market value, not in accounting earnings. This concept is also reflected in Value-at-Risk (VaR), a statistical technique that is often applied for measuring market risk in banking (section 1.2). The basic components to calculate the VaR are the current value of the portfolio, the sensitivity of the portfolio to changes in underlying factors (default rates, financial market prices, etc.) and the potential change in underlying factors. Essentially these are bottom-up methodologies, as the risk (and capital) is calculated by first defining and measuring the risk drivers separately and then quantifying the effects of these on the entire financial conglomerate.

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2 A more elaborate discussion of economic capital can be found in Chris Matten (2001), Managing Bank Capital; Capital Allocation and Performance Measurement, chapter 9.
3 The similarity usually refers to risk characteristics, although pooling could occur over time as well.
4 Risk measurement, risk assessment, and risk management are often used interchangeably. In this paper risk measurement refers to the quantification of risk. Risk assessment is a broader concept in the sense that it also entails interpreting non-quantitative pieces of information. Risk management, in turn, encompasses risk assessment as well as risk mitigation.
The value of non-liquid assets and liabilities can be approximated (marked-to-model) by the net present value of the cash flows. The net present value approach is the main basis for the calculation of insurance risk capital (unexpected loss) on the liability side. The risks arise from differences between expectations and realisations relating to the different factors that drive the cash flows. The following sources of these deviations can be quantified separately:

- the fluctuations around the expected value used in the cash flow projections, generally referred to as volatility;
- the uncertainty with respect to setting (long term) assumptions in general (parameters and distributions); and
- what is generally referred to as extreme event risk. Extreme events occur with a low frequency and a high severity. Owing to the low frequency, this risk cannot be estimated on the basis of statistical evidence dating back only a few years. For relevant risk categories it should therefore be recognized as a separate category.

The bottom-up (or risk-based) unexpected loss techniques contrast with techniques that focus on the volatility of earnings and can be classified as top-down, aggregate or index-based models. These use peer-group analysis and/or earnings-volatility analysis to determine economic capital. A major limitation, however, is that these methods do not separately identify the risks manifest from the loss history and, by implication, fail to provide clear guidance how to manage risks and where to allocate economic capital accordingly. Some institutions nonetheless apply a combined form of peer-group and earnings volatility analysis to capitalize for residual business risks (section 6).

### 0.2 Risk typology

Worldwide several institutions are developing economic capital models for banking as well as insurance activities. Over the past few years significant progress has been made and modeling approaches are gradually converging. In order to facilitate benchmarking across institutions, much work has also been done on developing risk typologies. Such typologies can form the basis for largely quantitative exercises such as setting up economic or regulatory capital frameworks as well as for more qualitative purposes such as supporting a risk-oriented on-site supervisory process. While there appears to be a fair amount of consensus on the classification of traditional banking risks, there is less agreement on a single and generally accepted classification system of insurance risks.

On the banking side the Basle Committee on Banking Supervision (BCBS) has traditionally played a stimulating role in the development of risk measurement in banking institutions. The BCBS is currently engaged in the process of revising the capital adequacy framework, which will form the basis for a revised capital adequacy directive for banks in the EU. This framework entails inter alia separate capital requirements for credit, market, and operational risk, combined with a supervisory review process to assess the capital coverage of other risks including interest rate risk in the banking book. In order to support its supervisory process De Nederlandsche Bank (DNB) currently uses a Risk Analysis\(^5\) that distinguishes between credit risk

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\(^5\) De Nederlandsche Bank (1999), *Risk Analysis as a Tool of Supervision.*
(including cross-border), price risk, interest rate risk, foreign exchange risk, liquidity risk, operational risk, IT risk, strategic risk, legal & integrity risk, and reputation risk.

On the insurance side the Dutch pensions and insurance supervisory authority PVK recently issued principles for a financial assessment framework that aims to assess an insurer’s capital adequacy in a risk-oriented way.\(^6\) At the EU level a working party called Solvency II has been established, which, in turn, has commissioned KPMG to conduct a study into the risk profile of insurance undertakings.\(^7\) After having taken stock of risks that are company-specific, industry-specific, and economy-wide, respectively, the report identifies underwriting risk, credit risk, reinsurance risk, matching risk, provisioning risks, jurisdictional and legal risk, and interest rate risk as the key risks facing an insurance undertaking. At the global level, the International Actuarial Association (IAA) was recently requested to support the International Association of Insurance Supervisors (IAIS) in developing ‘Principles on Capital Adequacy and Solvency’. IAA recently provided a first report that surveys various risk classification schemes and categorizes six major risk headings: underwriting risk, credit risk, market risk, operational risk, liquidity risk, and event risk.\(^8\)

Based on these various sources, the WECM has first tried to arrive at a risk typology for mixed financial conglomerates that would be sufficiently general in nature in order to accommodate the slightly varying approaches taken by the four largest financial conglomerates domiciled in the Netherlands (ABN AMRO, Fortis, ING, and RABO). The typology presented in table 1 is by no means prescriptive, but should rather be seen as providing a collective framework within which stand-alone risks and economic capital in a mixed financial conglomerate can be assessed. The risk classification in table 1 builds upon the risk types traditionally recognized by financial institutions and their regulators. This choice is partly motivated by the observation made earlier that risk measurement typically starts rather autonomously in decentralized business lines that each individually focus on the risks most relevant to them. The approach could therefore be regarded as ‘piecewise’ or ‘incremental’.

In order to properly assess the risk profile and economic capital requirement of the entire institution, however, correlations and diversification across risk types have to be taken into account. One approach to do so would be to build an economic capital framework by and large ‘from scratch’, for instance by focussing on the risk drivers and their aggregate effects across all the institution’s activities. While risk types are distinguished by the manifestation of the risk, risk drivers (such as interest rates, default rates etc.) aim to identify the underlying causes of the risk. Table 1 suggests a fair amount of similarity between risk drivers across banking and insurance activities. An economic capital approach directly built off risk drivers would internalize diversification effects across risk types and would also circumvent certain boundary issues that exist between the various risk types. To our knowledge, however, such models are still in their embryonic stages of development.

As we perceive the majority of institutions to have opted for the former route thus far, the remaining chapters of this stock-taking paper will build upon the ‘traditional’ risk

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\(^7\) KPMG/European Commission (2002), *Study into the Methodologies to Assess the Overall Financial Position of an Insurance Undertaking from the Perspective of Prudential Supervision*.

typology presented in table 1. In turn, each risk type will be discussed in terms of definition, main risk drivers, risk measurement, and economic capital allocation.

0.3 Conclusions and directions for further work

This paper has provided a description of current practice with respect to risk measurement and economic capital allocation within mixed financial conglomerates. By establishing a common risk language, it has sought to develop a risk typology that should be applicable to banking and insurance companies alike. Building on the actual experience of leading Dutch financial institutions, the framework identifies the risk types traditionally distinguished as well as their most important risk drivers.

Most interesting element at this stage was understanding the various definitions of the risk types and how they are applied to banking and insurance activities. Even if a risk type has the same label, it does not necessarily follow that it represents the same definition and that it applies the same risk measures across institutions. ALM risk proved to be a case in point here, where perspectives from bankers and insurers slightly deviate. Whereas banks’ risk management traditionally focuses on the asset side of the balance sheet, insurers tend to approach this risk from the liability side.

Having laid the foundation of a common risk standard, a logical next step would be to consider more fundamental aspects of economic capital models. For the sake of parsimony, many of those have been neglected here. The working group’s initial research proposals centered around four main themes:

1) Risk types and risk drivers;
2) One common risk measure;
3) Application of models/approaches;
4) Regulatory and organizational issues.

This paper has focussed on the first perspective, namely risk types and risk drivers.

The second perspective focuses on the question whether it is possible to construct one common risk measure for a particular risk type that is applicable to both the banking and the insurance sector. Is it possible from a theoretical vantage point to merge traditional banking and traditional insurance approaches into one consistent and coherent risk measure? How do we aggregate the distinct risk types, and how do we measure diversification effects within a financial conglomerate?

The implementation of economic capital models raises a third set of issues. First, line risk managers are confronted with several stumbling blocks regarding data availability and crucial modelling assumptions. Subsequently, in due course these models need to be validated by senior management and financial supervisors. That brings us at a final set of regulatory and organizational issues, including the integration of economic capital models into the day-to-day risk management and their potential role in the supervision of group-wide regulatory capital adequacy for mixed financial conglomerates.
Table 1: Summary of risk classification

<table>
<thead>
<tr>
<th>RISK TYPES&lt;sup&gt;9&lt;/sup&gt;</th>
<th>SUB TYPES</th>
<th>DEFINITIONS</th>
<th>RISK DRIVERS</th>
<th>TYPICAL MEASURES AND MEASUREMENT APPROACHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Market/ALM</td>
<td>Market or trading</td>
<td>The risk of adverse movements in market factors (such as asset prices, foreign exchange rates, interest rates), their volatilities and correlations</td>
<td>Equity and commodities prices, foreign exchange rates, interest rates; their volatilities and correlations</td>
<td>VaR, scenario analysis</td>
</tr>
<tr>
<td></td>
<td>ALM&lt;sup&gt;10&lt;/sup&gt; (including interest rate risk)</td>
<td>The risk of adverse movements in the prices of assets and liabilities</td>
<td>Interest rates, equity prices, commercial and residential real estate prices</td>
<td>Duration mismatch, scenario analysis (CFT), liquidity gap reports</td>
</tr>
<tr>
<td>2) Credit&lt;sup&gt;11&lt;/sup&gt;</td>
<td>Cross-border (or transfer or country risk)</td>
<td>The risk due the possibility that funds in foreign currencies cannot be transferred out of a country</td>
<td>Foreign exchange rates, interest rates, local business cycle, political developments</td>
<td>(see above), VaR, foreign currency sovereign spread</td>
</tr>
</tbody>
</table>

<sup>9</sup> Reputation risk is an indirect loss, driven by one of the other risk types. In principle, all risk types include the following splitting up of risk: (i) volatility, (ii) model risk (uncertainty about what is measured) and (iii) extreme event or tail risk. Liquidity risk is not considered in this survey, as it is questionable whether covering it by capital makes sense.

<sup>10</sup> ALM includes interest rate, equity and (commercial) real estate investment risk.

<sup>11</sup> This includes both on balance sheet credit risk as off balance sheet credit risk (counterparty risk in credit and other derivatives).

<table>
<thead>
<tr>
<th>RISK TYPES</th>
<th>SUB TYPES</th>
<th>DEFINITIONS</th>
<th>RISK DRIVERS</th>
<th>TYPICAL MEASURES AND MEASUREMENT APPROACHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>3) Life</td>
<td>Mortality</td>
<td>Deviations in timing and amount of the cash flows due to (non-) incident of death</td>
<td>Mortality and longevity expectancy</td>
<td>Surplus, resilience, solvency and stress tests, second order foundation</td>
</tr>
<tr>
<td></td>
<td>Morbidity or disability</td>
<td>Deviations in timing and amount of the cash flows due to (non-) incident of disability and sickness</td>
<td>Morbidity and disability expectancy</td>
<td>(see above)</td>
</tr>
<tr>
<td>4) P&amp;C or non-life</td>
<td>Extreme event or catastrophe P&amp;C</td>
<td>The risk of loss due to unforeseen increase in catastrophe claims, such as hurricanes or earthquakes</td>
<td>13 Exceedence probability curves</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-catastrophe P&amp;C (including morbidity risk)</td>
<td>The risk of loss due to unforeseen increase in non-catastrophe claims, such as car accidents, fires, etc.</td>
<td>Frequencies/severeties of insured risks (accidents, fires, etc.)</td>
<td>Frequency severity modelling, loss triangle analysis, historical claim ratio</td>
</tr>
<tr>
<td>5) Operational</td>
<td>(including legal risk)</td>
<td>The risk of loss resulting from inadequate or failed internal processes, people and systems or from external events</td>
<td>Quality of control, volume of cash flows or other business measures</td>
<td>Scorecards, expected and unexpected loss, VaR, extreme value theory</td>
</tr>
<tr>
<td>6) Business or strategic</td>
<td>(including lapse risk and expense risk)</td>
<td>The risk of loss due to adverse conditions in revenue/exposure, such as decreased demand, competitive pressure, etc.</td>
<td>Other risks, such as changes in volumes, margins and costs, strategic risk (choice of products and markets), risk of mergers, acquisitions &amp; divestitures</td>
<td>Historical earnings volatility, analogues/peers</td>
</tr>
</tbody>
</table>

13 It is difficult to distinguish risk drivers here. ‘Frequencies or severeties of catastrophes’ would describe the extreme events, which occur in any risk category.
1. Market/ALM risk

1.1 Introduction

Market risk and Asset and Liability (ALM)-risk are narrowly related. Both types of risk are defined as ‘the risk of adverse movements in market factors (such as asset prices, foreign exchange rates, interest rates) and their volatilities and correlations’. The term market risk is typically used by banks and refers to trading, usually a short-term activity, and focuses on changes in market/fair value. The term ALM risk is used by both banks and insurance firms and relates to the consequences of changes in market factors for all asset and liability items of the balance sheet.

In banks ALM risks typically refers to interest rate risks in banking books with a focus mostly on accrual earnings where long term assets are funded by short term liabilities. Insurance companies face the opposite problem. Typically the liabilities are longer than the assets and the asset portfolio may include some equity investments. Furthermore, both banks and insurance companies have increased ALM risks due to embedded options in their assets and liabilities. This chapter discusses the two risks separately and describes their application in both banking and insurance. The ALM section also includes a brief discussion of the replicating portfolio concept as a tool to manage interest rate risk.

1.2 Market risk

Definition and risk drivers
Market risk is defined as the possibility of losses owing to unfavourable market movements. Such losses occur when an adverse price movement causes the mark-to-market revaluation of a position to decline. It can be due to a large number of risk factors, including fluctuations in interest rates, exchange rates, equity prices and commodity prices, as well as changes in volatility of these rates and prices that affect the values of options or other derivatives, as well as changes in correlations between those risk factors. The definition specifically applies to liquid, actively traded books (bank models for market risk typically have a 1 up to 10 days horizon).

Measurement approaches
Several methodologies can be used to determine market risk. The most commonly used methodology is Value-at-Risk (VaR), a statistical measure of the potential loss that could occur owing to movements in market rates and prices over a specified time horizon, at a given confidence level. To calculate VaR, it is necessary to first generate the forward distribution of the portfolio values at the risk horizon or, equivalently, the expected distribution of changes in the value of the portfolio. Three approaches to derive this distribution are typically applied: a) Variance-covariance approach; b) Historical simulation approach; and c) Monte Carlo approach. Each approach is described in more detail below.

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14 As the mean value of the assets is their current market value, the expected loss is virtually zero. In other risk classes, most notably credit risk, there is an expected level of loss (section 2).
a) Variance-covariance approach
The variance-covariance or delta normal approach assumes that portfolio exposures are linear and that risk factors are jointly normally distributed. As the portfolio return is a linear combination of normal variables, it is itself normally distributed. This implies that the variance of the portfolio return $R$ can be written as follows:

$$\sigma^2(R_{p,t+1}) = x_t^T \Sigma_{t+1} x_t$$

In this formula $x_t$ is the position factor at time $t$ and $\Sigma_{t+1}$ is the forecast of the covariance matrix over the horizon. VaR is directly obtained from the standard normal deviate $\alpha$, that corresponds with the confidence level:

$$VaR = \alpha \sigma (R_{p,t+1})$$

For trading books, $\alpha$ typically equals 2.33, corresponding to a 99% confidence interval. This is called diversified VaR, as it accounts for diversification effects. Undiversified VaR is simply the sum of the individual VaR’s of each risk factor. It assumes that all prices will move in the worst direction simultaneously, which is unrealistic. The main benefit of the variance-covariance approach is simplicity. It cannot account for non-linear effects, such as encountered with options. It also likely underestimates the occurrence of large deviations owing to its reliance on a normal distribution (there are techniques available to mitigate this issue, e.g. Gumboll).

b) Historical simulation approach
The most widely used methodology to calculate VaR is the so-called historical simulation method. First, the changes in relevant market prices and rates are analyzed over a specific historical period, say one to four years. The portfolio is then revalued, using changes in the risk factors derived from the historical data, in order to create the distribution of portfolio returns. Each simulated daily change in the value of the portfolio yields an observation in the distribution. The approach involves three steps:
1) Select a sample of actual daily risk factor changes over a given period of time, say 250 days;
2) Apply those daily changes to the current value of the risk factors and revalue the current portfolio as many times as the number of days in the historic sample; and
3) Construct a histogram of portfolio values and identify the VaR that isolates the first percentile in the left hand tail, assuming VaR is derived at the 99% confidence level.

The major attraction of historical simulation is that it is completely nonparametric; it does not depend on any assumption about the distribution of the risk factors. The nonparametric nature also implies that volatilities and correlations do not have to be estimated as they are already reflected in the data set. Major disadvantages of this approach are that history does not necessarily repeat, that it can not accommodate changes in market structure and that extreme events may not be part of the data set (survivorship bias).

c) Monte Carlo approach
A Monte Carlo simulation consists of repeatedly simulating the random processes that govern market prices and rates. Each simulation (scenario) generates a possible value for the portfolio at the target horizon. If enough scenarios are generated, the simulated
distribution of the portfolio values will converge toward the true but unobservable
distribution from which the VaR can be inferred. The Monte Carlo simulation also
involves three steps:
1) Specify all relevant risk factors and estimate the parameters of their stochastic
processes such as expected values, volatilities, and correlations;
2) Construct price paths using a random number generator; and
3) Value the portfolio for each scenario. Each path generates a set of values for the
risk factors that are used as inputs into the pricing models, for each security
composing the portfolio. This process is repeated a large number of times, to
generate a distribution of portfolio returns at the risk horizon. This step is similar
to historical simulation, except that Monte Carlo simulation can generate a larger
number of scenarios.
VaR at the 99% confidence level can now be derived as the distance between zero and
the first percentile of the distribution.

Economic capital
Economic capital for market risk is usually based on the VaR measure, but it may be
defined by a different time horizon and confidence interval. To derive economic
capital from VaR some adjustments have to be made, for example:
- **Confidence interval conversion.** Depending on their (desired) rating, each bank
  has to make adjustments to the confidence interval accordingly. For that purpose
  the hypothetical value distribution from which the VaR is derived, has to be fitted
to a well-known theoretical distribution (like normal, lognormal, T-student, etc).
  Alternatively, scaling to extreme confidence intervals can be achieved by applying
  Extreme Value Theory (EVT);
- **Fat tails correction.** Depending on the chosen distribution, a correction that takes
  into account the ‘fat tails’ may need to be made;
- **Time scaling:** As the economic capital calculation is based on a 1 year time
  horizon, the holding period applied in the calculation of VaR needs to be scaled
  up to a one-year risk evaluation. This adjustment assumes that daily distributions
  are statistically independent. For positions that are managed on a daily basis, this
  is probably a valid assumption. If not, errors for longer economic capital horizons
  can be quite significant;
- **Management intervention.** Large losses are likely to result in some form of
  management intervention to mitigate the losses from the book in question. Monte
  Carlo simulations may determine the risk mitigation provided by the intervention.

1.3 ALM risk

**Definition and risk drivers**
Asset-liability management (ALM) is the practice of managing a business such that
decisions on assets and liabilities are coordinated. It can be defined as the ongoing
process of formulating, implementing, monitoring and revising strategies related to
assets and liabilities. ALM-risk can be considered as the impact of fluctuations in
market forces on the value of assets and liabilities or, more precisely, on the present
value of future profits arising from a block of business.

In a banking environment the structural interest rate mismatch between banking book
assets and liabilities constitutes the most important driver of ALM risk. The time to
maturity of the assets (loans) generally exceeds the maturity of the liabilities (deposits, other debt). This can lead to two effects:

a) in the first years the liabilities will reprice sooner than the assets. Increases in interest rates will therefore lead to larger increases in costs of liabilities than in revenues on assets (income effect);

b) a rise in interest rates implies a larger decrease in (market) value of the assets than of the liabilities, thereby decreasing the market value of equity. This is labeled the mark-to-market effect.

Other ALM risk drivers are equity, commodity and real estate prices.

In the Dutch insurance environment ALM risk is generally caused by guaranteed returns. Several years of low investment returns will put downward pressure on profits because it will be difficult to cover expenses and guarantees. The risk is further increased when there is a significant asset/liability mismatch. For traditional life business asset durations will generally be shorter than liability durations. Also it is not uncommon that surplus or even part of the policyholder liabilities are invested in equities. Needless to say this increases the ALM risk considerably.

Embedded derivatives or options constitute important drivers of ALM risk, for both insurance companies and banks. The most common example is a policy where the client is effectively guaranteed a minimum annual return on each premium and an option on the excess return on the asset portfolio. Variable savings accounts issued by banks contain a similar structure. Here the credited rate is more or less determined by the market environment, but there is a 0% guarantee on each deposit. Other examples of derivatives embedded in insurance policies are:

- **Settlement option**: beneficiary to choose the form of benefit payment (lump sum, annuity);
- **Policy loan option**: borrow against the accumulated asset value of an insurance policy;
- **Surrender privilege**: allows the policyholder to halt the insurance contract prematurely and stop paying premiums.

The following embedded options relate to both banking and insurance:

- **Renewal privilege**: right to either continue or to halt the agreement at the end of the policy period;
- **Pipeline/offered rate option**: the option to determine the contracted interest rate within a certain period (e.g. for mortgages);
- **Over-depositing or prepayment option**: allows a product or policy-holder to make higher payments than required, which will be credited at a pre-specified rate of interest or used to prepay a loan;
- **Interest rate consideration ('rentebedenktijd') option**: during the last year(s) of the fixed interest rate period a client has the option to determine the point in time (and thus implicitly the level of the interest rate) for a renewal of a loan facility.

There is an obvious degree of overlap between the treatment of embedded options under ALM risk and the more general occurrence of lapse risk, as categorized under the heading of business risk in chapter 6. As a practical demarcation, ALM embedded options risk is typically restricted to those lapses that can be modelled as a direct consequence of movements in market factors such as interest rates. This risk can be
priced and is therefore tradeable and hedgeable. Lapse risk then refers to lapses induced by all other (and often more idiosyncratic) risk drivers.

**Measurement approaches**
The following techniques and concepts are used to quantify ALM-risk:

a) The cash flow mismatch (CFM) is easily quantified by the net asset/liability cash flow for several time buckets. In the banking industry this method is normally labeled maturity gap analysis. Table 2 presents a simple example. A variant of the standard gap analysis is known as a duration gap analysis. Hereby a net duration position is determined per time bucket leading to a total net position. The duration of the total net position indicates the exposure of the value of the block of business to parallel yield curve shifts. Gap analysis is widely used by banks but applies equally well to insurance activities.

<table>
<thead>
<tr>
<th>Maturity period in buckets</th>
<th>0-90 days</th>
<th>91-180 days</th>
<th>181-365 days</th>
<th>1-5 years</th>
<th>Over 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assets</td>
<td>25</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Liabilities</td>
<td>40</td>
<td>25</td>
<td>15</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Maturity gap</td>
<td>(15)</td>
<td>(10)</td>
<td>5</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Cumulative gap</td>
<td>(15)</td>
<td>(25)</td>
<td>(20)</td>
<td>(15)</td>
<td>0</td>
</tr>
</tbody>
</table>

b) Cash flow testing (CFT) estimates the earnings volatility of today’s risk position based on a set of market scenarios. Possible scenario’s may include:

- no deviation from current rates;
- 0.5 percent rise/fall of rates each year for ten years;
- rates rise/decline 1 percent a year for five years;
- rates rise/decline 3 percent immediately, then level.

Monte Carlo or historical simulation can also be used to derive probability distributions of future earnings levels. These techniques are describes in more detail in section 1.2 on market risk, but they apply equally well to ALM risk. Cash flow testing is used both by banks and insurance companies. In banks CFT is sometimes known as Earnings-at-Risk. Insurance companies may also use embedded value instead of earnings.

c) Value-at-Risk (VaR) determines the sensitivity of the overall ALM-position to changes in the underlying risk factors. The same techniques as for market risk may be used: variance-covariance method, historical simulation and Monte Carlo simulation (see section 1.2). For insurance operations Monte Carlo simulation is seen as the preferred approach in particular when the portfolio contains significant embedded options.

**Economic capital**
With regard to economic capital calculations there are two possible approaches:

1) Scenario simulation approach: economic capital is calculated based on losses occurring in case of a set of worst case scenarios. The magnitude of such losses and their probability of occurrence determine the amount of economic capital. This approach is normally used as a substitute for Monte Carlo simulation in situations where revaluation of the assets or liabilities requires too much run time.
To reduce the computational burden the number of scenarios is limited to those that are expected to determine the tail of the P&L distribution.

2) Market value approach: within this approach the economic capital is derived from the VaR measure (method c). The appropriate techniques are explained in the market risk section and apply equally well to ALM-risk.

**Annex: Replicating portfolio concept**

Generating replicating portfolios is often used as the approach to model interest rate sensitivity of embedded option products. Replicating portfolios are portfolios that replicate, as close as possible, the interest rate risk incorporated in a certain portfolio based on actual (in the market available) assets or liabilities. Usually replicating portfolios are established for portfolios representing similar products sold to clients with similar behaviour. Buying the replicating portfolio is the best hedge immunising interest rate risk in non-trading portfolios. As modeling can never be perfect and hedging instruments may not always provide a perfect match, a small residual risk remains within the original portfolio. The replicating portfolio-hedge transfers interest rate risk to a different book (or management level) – normally a treasury book in a bank environment – where all interest rate risk is accumulated and risk taking can take place. Risk taking in ALM-terms, for example a long position on long-term interest rates, normally bears the risk of higher refinancing costs in the future. To control for this a risk limit is commonly set on the risk-taking activities. The diagram below illustrates the use of the replicating portfolio when separating interest rate risk from the non-trading portfolios to the trading or investment portfolios.

<table>
<thead>
<tr>
<th>Risk type</th>
<th>Interest rate risk</th>
<th>Residual risk (imperfect modelling/hedging)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual funding or investment portfolio</td>
<td>Replicating portfolio</td>
<td>Portfolio of assets and/or liabilities</td>
</tr>
</tbody>
</table>

Activity

- Risk taking
  - Best hedge (neutral ALM modelling)
2. Credit & transfer risk

2.1. Credit risk

Definition and risk drivers
Credit risk can be defined as the possible decline in value of an institution’s assets due to the potential failure of counterparties to honour their financial obligations. Typical risk drivers are adverse changes in the business cycle, sectoral developments and – as credit risk is often reduced by the use of collateral – prices of shares, bonds, other financial products, commodities, commercial and residential real estate and other collateral. In terms of assets on which institutions face credit risk, we distinguish:

- **Loans.** In this case credit risk arises because a borrower may not be able to pay interest or repay the principal amount of the loan. Borrowers can be both companies and private individuals;
- **Contingent credit facilities.** These are facilities on which credit risk may arise in the future. Examples are guarantees (which will be invoked only when a borrower on whose behalf the guarantee has been provided defaults on his obligations) and undrawn credit lines (under which the beneficiary may decide to draw down funds at a future point in time). Contingent liabilities are recorded off-balance sheet as long as there is no direct exposure on the counterparty;
- **Traded or invested assets, such as bonds.** Credit risk is present because the value of the assets may decline as a result of an increase in the perceived likelihood that the issuer will not be able to meet scheduled payments in the future. When present in a bank’s trading book, credit risk on the assets is usually captured under market risk (as in the 1996 Market Risk Amendment to the 1988 Capital Accord) and measured over a short time period (section 1.2);
- **Derivatives.** Credit risk in this case only exists if the market value of a derivatives contract is positive (i.e., the net present value of all cash flows owed by the counterparty exceeds the net present value of all payments to be made by the institution). Credit risk on derivatives transactions is usually referred to as counterparty risk;
- **Re-insurance contracts.** Credit risk is present as the re-insurer may not be able to pay when a claim arises. The timing and size of such claims are obviously uncertain. An additional complication is that the creditworthiness of the re-insurer and the institution itself may be correlated.

For most banks, lending activities are typically the main source of credit risk. Oliver, Wyman & Co estimate that credit risk is also the main source of risk for banks in general.\(^{16}\) For a typical P&C and life insurer, however, Oliver, Wyman & Co attribute only 5 to 10 percent of total risk capital to credit risk.

Measurement approaches
The risk measure commonly used by financial institutions is economic capital. Unexpected credit losses are potential credit losses in excess of the expected credit

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\(^{16}\) Oliver, Wyman & Company (2001), *Study on the risk profile and capital adequacy of financial conglomerates*, section 2.6 and figure 2.8.
loss over a specified time horizon with a high probability (confidence level).\textsuperscript{17} Credit losses may be defined as losses due to default events only (corresponding to book-value accounting) or include mark-to-market losses as well (market-value accounting). Almost invariably a time horizon of one year is used. Institutions typically relate the confidence level to their desired credit rating (e.g., a confidence level of 99.97\% corresponding to an AA rating). One institution considers a lower confidence level (e.g., 97.5\%) when credit risk is looked at in isolation, while using a higher rating-based confidence level when all risk types are aggregated.

In its simplest form, economic capital is determined by taking a percentage of the value or notional of a credit-risky asset. This percentage may vary as a function of the credit rating of the counterparty and the tenor of the asset, and can be based on historical loss experience. A drawback of such an approach, however, is the difficulty to take concentration and diversification effects within a portfolio into account. Concentration refers to the presence of large exposures to individual clients, and diversification to the level of correlation between credit events of different clients. Both banks and insurance companies therefore increasingly apply portfolio models to determine economic capital, either externally developed (KMV, CreditMetrics, CreditRisk+) or proprietary.

Credit risk portfolio models derive the probability distribution of credit losses during the model horizon using the following main inputs:

- default and possibly migration probabilities per counterparty;
- exposure-at-default estimate (per facility);
- loss-given-default estimate (per facility);
- if credit losses include mark-to-market losses in case of downward migrations, market valuation routines are needed as well. Market values can for example be based on actual yield and spread curves;
- correlation between default and possibly migration events of counterparties. Evidence exists that correlation is also present between loss-given-default and the realized default rate (higher losses per facility in bad economic times), as well as with the creditworthiness of a borrower some time before default (higher losses per facility for less creditworthy clients).

The probability distribution of credit losses is typically determined numerically, for example through Monte Carlo simulation. Economic capital can be derived as the quantile of the distribution that corresponds to the chosen confidence level, minus the expected credit loss. Given the high confidence level typically chosen, specialized statistical techniques may be applied to obtain reliable numerical estimates of the quantile. Sometimes economic capital is approximated as a multiple of the standard deviation of the probability distribution. The standard deviation can be calculated analytically using the above elements.

The crux of any portfolio model is the way in which correlation is modelled, and we will briefly describe different approaches in what follows. We will limit the description to the modelling of correlation between credit events of different counterparties. As the modelling of correlation is often directly related to the way in

\textsuperscript{17} Unlike the market risk area, there is an expected and positive level of credit loss that would normally be (more than) covered by future margin or premium income.
which default and migration events are modelled for individual counterparties, we will also touch upon this below.

Modelling approaches
Portfolio credit risk models can be classified broadly as being either 1) Structural models; 2) Latent-variable models; or 3) Actuarial models.

1) Structural models
Structural models consider default as the event that the value of the assets of a firm falls below the value of its liabilities. In its purest form, these models thus require an estimate of the value of the assets and liabilities of a firm, and how they may change over time (e.g., drift and volatility of assets and/or liabilities). It is, however, impossible to reliably estimate these quantities directly from available data.

To circumvent this problem, it is typically assumed that the level of the liabilities is a deterministic function of time, while the value and volatility of the assets are derived from equity prices in the market. This makes use of Merton’s idea to view equity as a call option on the assets of the firm, with its strike price equal to the value of the liabilities.\(^\text{18}\) Given the market value of equity, one can then back out the initial asset value as well as its volatility if one assumes that the stochastic process for the asset value satisfies standard Black-Scholes option pricing assumptions.

The KMV model employs these ideas.\(^\text{19}\) However, KMV does not directly calculate a default probability for the counterparty once the value of assets and asset volatility have been determined. Instead, it determines a quantity called distance-to-default, which is defined as the number of standard deviations between the value of assets and liabilities. Subsequently, historical data on defaults is used to associate a default probability with the distance-to-default measure.

Correlation between default events of different counterparties is naturally modelled through correlation between their asset returns in this approach, and thus implicitly through correlation between their equity returns. Instead of estimating these equity return correlations directly for each pair of counterparties, KMV employs a factor model in which the common factors relate to geographical regions and industry sectors. By letting individual asset returns depend on the same common factors, correlation between default events is induced. KMV distils the common factors by applying principal components analysis to historical equity returns of a large pool of individual companies.

Clearly, this approach is only directly applicable for firms that have traded equity so that the market value of equity is available. For this reason, this approach is mainly used to analyze the credit risk arising from exposures to large corporates.

2) Latent-variable models
Latent-variable models associate a random variable with each firm, the realisation of which determines whether default occurs within a given time horizon, or more in general, its change in credit quality. CreditMetrics is the best known example of this


The CreditMetrics model associates a standard normal random variable with each firm. The range of possible realisations is bucketed, with each bucket corresponding to a certain credit quality (rating) or default. The size of the buckets is determined so as to match empirical historical default and rating migration probabilities.

CreditRiskPortfolioView of McKinsey21 is another example of a latent-variable model. In this model the value of the (unobservable) latent variable is written as a function of a number of observable macro-economic variables. The common dependence on these macro-economic variables thus induces correlation between the latent variables of different counterparties. Default probabilities are obtained by a logit transformation of the latent variables.

Latent variable models are typically used to model the aggregate credit risk arising from corporate exposures, where a latent variable is associated with each individual entity in the portfolio. Although the approach could also be applied to homogeneous groups of exposures, which could for example be identified in portfolios of loans to small firms or residential mortgage loans to individuals, this seems to be less common. For these types of exposures, mostly an actuarial approach is used.

3) Actuarial (or reduced-form) models
In actuarial models one specifies a stochastic process for the default probability directly, instead of deriving it from the distribution of one or more other variables as is done in structural and latent-variable models. A well-known example is CSFB’s CreditRisk+.22 In this model the default rate of an individual entity or group of homogenous entities is written as:

\[ p = \bar{p} \cdot \left( \theta_0 + \sum_k \theta_k x_k \right) \quad \text{with} \quad \theta_0 + \sum_k \theta_k = 1 \]

where the random variables \( x_k \) are independent Gamma distributed with mean 1. Volatility in the common factors \( x_k \) directly induces correlation between default probabilities of individual entities within a group, as well as in different groups.

The actuarial approach is often used for retail products such as residential mortgages or loans to small businesses, characterized by a large number of each relatively small exposures. The parameters may be estimated using aggregate portfolio data and historical information on credit losses (expected loss, volatility, distribution).

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2.2 Transfer or cross-border risk

**Definition and risk drivers**
Transfer or cross-border risk captures potential losses stemming from the possibility that funds in foreign currencies cannot be transferred out of a country as a result of action(s) by the authorities of the country or by other events impeding the transfer. This includes the risk owing to the inability of a counterparty to obtain foreign currency to meet its financial obligations, and/or the risk associated with certain hedging or proprietary positions in securities of the country at risk. Transfer risk is generally related to specific economic situations in which countries place restrictions on the convertibility of their local currency.\(^{23}\) Hence, the main risk drivers are foreign exchange rates, interest rates, local business cycles and political developments.

**Measurement approaches**
Transfer or cross-border risk measurement approaches are highly related to the credit risk measurement. Transfer risk is measured with two separate metrics, expected transfer loss and unexpected transfer loss. Transfer risk capital is the unexpected transfer loss times the capital multiple needed to achieve the institution’s desired confidence level (or rating). A similar variety of techniques for estimating underlying frequency and severity parameters (probability of countries placing restrictions, loss given transfer event, transfer risk exposure, correlations) and portfolio models exist.

Differences compared to credit risk can be found because:
- Transfer risk default (i.e. placing restrictions) rates are difficult to calibrate;
- Transfer risk portfolio are different in nature (few borrowers with very different exposures);
- Transfer severities are richer in nature. Sovereigns face a wider range of options than other clients as no formal bankruptcy process exists. Moreover, pure country risk factors (such as economic development, legal jurisdiction) are generally separated from product (facility) risk factors;
- No transfer risk only models are available in the market, leading to larger differences in approaches.

\(^{23}\) Transfer Risk is also sometimes known as (in)convertibility risk.
3. Life risk

3.1 Introduction

An insurance contract is characterized by the agreement that the policyholder pays an amount or a series of amounts (i.e. premium) to the insurer first and in return the insurer subsequently pays one amount or a series of amounts (i.e. benefits) to the policyholder or another beneficiary, conditional on the occurrence of an event that is specified in the contract. Generally there are two types of policies: ‘traditional’, where both premiums and benefits are fixed during the contract term, and other types where either one or both are variable (e.g. ‘unit linked’ business, where the proceeds are invested in funds). The difference in timing between premium receipts and payments of the benefits (if any) results in the requirement for insurers to hold provisions to meet the projected future policyholder obligations.

In life business the term of a policy is often one or more decades. Concluding such a transaction inherently requires both insurer and policyholder to make a number of estimates and/or appraisals of possible future conditions in order to appreciate the level of premium relative to the level of benefits. Some of these appraisals concern the time value of money, as reflected in the measurement of ALM and credit risk discussed in the previous chapters, as well as business risks such as lapse risk and expense risk to be discussed in chapter 6. The remainder of this chapter focuses on mortality risk and morbidity risk.

Although each of the above risks can affect the life insurer’s financial position, it is the combined impact that matters. Adverse experience in one part of the life insurance portfolio may well be compensated by favourable experience in another. The long-term nature provides the insurer some ability to smooth adverse experience over a number of years instead of being forced to account for annual achievements. Implied guarantees remain, however, so very few (if any) profit sharing systems can cope with a truly prolonged period with extremely low interest rates, such as currently in Japan.

3.2 Mortality risk

Definition and risk drivers
Mortality risk is the risk of deviations in timing and amounts of the cash flows (premium and benefits) due to the incidence or non-incidence of death. Both in traditional business as well as in non-traditional business, insurers sell products that either provide a benefit in the case of death or a benefit in the case of being alive at some maturity date or both. As a result insurers are influenced by both upward and downward deviations of mortality risk, particularly when the upward trend impacts another age group than the downward trend.

The main risk drivers are mortality and longevity expectancy. Longevity is affected by the continuous improvement of medical support, quality of life and environment, safety precautions, and a more health-oriented focus of lifestyle. Insurers are further exposed to adverse selection as policyholders may have greater knowledge on specific issues concerning mortality than insurers do.
Measurement approaches

Insurance companies measure exposure to mortality risk through the use of basic probabilities of death over a fixed time period such as one year. These probabilities (called mortality rates) depend on a number of variables (covariates). Normally actuaries use the gender of the person, the age and type of insurance. Other variables may include number of years since issue date, smoking/non-smoking and some medical issues. The mortality rates are estimated from historical data. The rates are usually presented in the form of mortality tables.

The process of modelling future mortality generally starts with using historical data to develop an expected current level of mortality. Since historical observations may not always be relevant for in-force as well as newly issued life insurance contracts, it is important that trends in mortality rates are taken into account. Owing to the pace of ongoing developments in nutrition, medical and genetic science, human mortality rates have decreased considerably over the past centuries; a process that is expected to continue in the near future.

When calculating expected mortality rates for a certain class of persons (insured lives, annuitants, pensioners) the specific characteristics of the insurance policies should be considered, particularly when products include guaranteed rates over a long period such as a whole life guaranteed annuity. Depending on the goal and the available data, several models can be applied to predict future mortality based on information about recent trends in mortality improvement or deterioration. This central projection for the future expected mortality is surrounded by a) volatility risk and b) uncertainty risk. In addition, c) extreme events may significantly impact the expected mortality.

a) Volatility risk
Volatility risk (or fluctuation risk) results from the random nature of mortality and the variation across insurance policies of the sum-at-risk in case of death of the insured person. In addition to the normal random fluctuations, additional volatility can result from external causes such as (extreme) cold winters or an unexpected number of influenza epidemics in a year. These can be considered as systematic fluctuations in the underlying mortality probability model. In general, the expected value of the volatility process is zero with fluctuations being either positive or negative.

Modelling volatility risk usually starts with the simplifying assumption that individual claims are mutually independent so that the number of deaths can be drawn from a binomial distribution. This assumption does not hold when people are exposed to the same risk factors. Examples include more than one person in a car-accident or plane-crash, cold winters or small epidemics. In order to account for this, fatter-tailed distributions are recommended, which are more difficult to model. An example of such a distribution around the number of claims would be a Poisson distribution.

b) Uncertainty risk
Several elements of uncertainty risk can be considered separately. First, the level of uncertainty relates to the fact that best estimates are typically derived from population or industry data. Such estimates may need to be adjusted when the insured population differs from the population in general, different products attract different groups (for example annuities or term insurance), or company specific underwriting has to be considered. Sometimes mortality rates are directly estimated using observations in
similar product lines in the insurer’s own portfolio or in (part of) the industry. Second, as the risk is a deviation from future expected mortality, the uncertainty with respect to the trend is important. The same models used in developing best estimate mortality assumptions can be used to measure their uncertainty.

c) Extreme event (or catastrophe) risk
Extreme event risk is the risk of a one-time claim level of extreme proportions due to a certain event. This event will not change the parameters directly but it can be seen as a one-off shock. This kind of risk is difficult to model as there is insufficient information (a very limited number of observations). Although analyzing the available information may be of help, expert judgement is typically required to assess this risk.

Risk mitigation tools
Instruments used to diminish possible adverse deviations are:

- **Reinsurance**: this can be used to improve the level of homogeneity in the portfolio measured in terms of sums at risk. Reinsurance narrows the range of sums at risk. The more homogeneous the portfolio, the less volatile adverse deviations.
- **Product type ~ policy conditions**: products can be re-designed to provide the policyholder with less guarantees on future levels of mortality. As an example, with unit-linked business often yearly-renewable term covers are used.

3.3 Morbidity risk

*Definition and risk drivers*
Morbidity risk is the risk of deviations in timing and amount of the cash flows (such as claims) due to incident or non-incident of disability and sickness. Risk drivers are morbidity and disability expectancy. Morbidity risk exists in both the life and non-life lines of business (chapter 4). A wide variety of policy classes are subject to morbidity risk, including disability, accidental death & disability, accelerated death benefits, workers compensation, medical insurance, and long-term care insurance.

In classifying morbidity risk, one has to distinguish between independent morbidity policies and supplementary morbidity clauses that accompany many life insurance policies. While independent morbidity policies are covered by the non-life business lines in Dutch insurance companies, the majority of the business actually takes place in the form of supplementary clauses (‘riders’) to life insurance policies. Wherever the risk is classified and managed, the essential risk characteristics are identical.

*Measurement approaches*
Best-estimate morbidity rates are based on expected levels in the insured population/underwriting classes relative to population or industry experience and future trends. In addition to ordinary volatility in morbidity experience around the expected rates, there is uncertainty about the level and trend of future morbidity. Similarly to the case of mortality risk, calamity levels of morbidity might not be included in available statistical data. Models to measure economic capital for morbidity risks are similar to those used in measuring life risk or non-life risk or a combination of the two. Some models are specifically developed to measure the risk in disability income business.
4. Non-life or P&C risk

**Definition and risk drivers**

P&C risk comprises the risk of loss due to unforeseen increase in size and frequency of claims and time-to-payment of future claims, development of outstanding claims, and allocated loss adjustment expenses (ALAE) for P&C product lines. Non-life or P&C risk is subdivided into extreme event or catastrophe (such as hurricanes or earthquakes) and non-catastrophe risk (such as car accidents and fires). While it is difficult to identify specific risk drivers, changes in legislation, technology, and the social and economic environment impact the relative frequency and severity of claims within each product line.

**Measurement approaches**

The measurement approaches relate to the sources of risk. Sources of P&C insurance risk are as idiosyncratic as the nature of P&C insurance products. Various P&C insurance products present almost every combination of low/high frequency and size of loss. For example, in homeowners insurance, natural phenomena such as hurricanes are a low frequency/high severity source of risk. Another example of low frequency/high severity risk is the risk that a single product insured under products liability is later found to generate life-threatening injuries for a widespread group of product users, resulting in significant insurance costs. An example of a high frequency/low severity risk for property coverage would be losses from the theft of radios and stereo equipment covered by automobile insurance.

Non-life insurance entities generally include various lines of business like fire insurance, motor insurance etc. This variety implies some diversification benefit, which may limit the overall risk for the entity. However, diversification is mitigated where several lines may be impacted by the same event. A windstorm for example affects insured houses (fire line of business) as well cars (motor line of business).

The risk to be reflected in the economic capital is that actual variability for the future deviates from the expectations based on best estimates of the future. The total variability needs to be split between a) the volatility of the claims process and b) the uncertainty about claims-parameter estimation. Additionally, particularly property claims can be split into ‘normal’ and c) catastrophic or extreme event claims.

a) Volatility risk

Volatility risk is the risk that, given the probability distribution of total claims, the actual amount of claims will differ from its expected value. It is caused by the randomness of frequency, severity, and time-to-payment of claims and related expenses. Volatility risk of a portfolio increases with the range of insured amounts, as more variability in insured amounts leads to a higher degree of randomness in the severity of individual claims. Also heterogeneity in policyholder characteristics (such as kilometres driven each year, alcohol consumption patterns etc.) contributes to volatility. On the other hand, volatility risk relative to the portfolio size decreases when the size of a portfolio is increased.

Modelling the total amount of claims can be done in various ways. One possibility is to estimate probability distributions for the frequency and severity of claims by the individual policyholders and combine them to find a distribution for the total liability.
Alternatively, it is possible to estimate a distribution function for the total liabilities directly without considering the underlying frequency and severity distributions of individual policyholders. A distinction is normally made between new claims and claims incurred in prior accident years. For incurred and reported claims, the frequency is already known, and only the severity and time to payment risk contribute to volatility. For incurred but not reported (IBNR) claims, there are both frequency and a severity elements in the volatility. The estimation of the distribution of liabilities resulting from claims incurred in prior accident years, both reported and unreported, is usually performed at a portfolio level directly, with a segmentation into product type and/or coverage. This type of modelling is more commonly used in business lines with relatively homogeneous portfolios, such as personal lines automobile, than for lines with more heterogeneity such as commercial lines liability.

Modelling should take into account the correlation between different clients. If there is such a correlation, it will cause additional volatility of the total claims liability. If volatility is modelled on an aggregate level, no explicit assumption needs to be made for this correlation. In estimating a distribution of the total claims liability based on past observations, such correlations are implicitly taken into account. Possible distributions to model the claims liability on an aggregate level include the normal, log-normal, Pareto, gamma and inverse Gaussian probability distributions. The Pareto especially takes into account the possibility of extreme events outside of the observed range by virtue of its fat tail.

b) Uncertainty risk
The uncertainty risk in the P&C-claims process can be subdivided into three parts. Firstly, the parameters of the distributions used are prone to misestimation. Such misestimation can be quantified using statistical theory. Secondly, as already discussed in the previous subsection, the parameters driving the claims process are not constant over time. They fluctuate as a result of changes in the environment such as legislation, weather and climate conditions, rising expenses etc. For instance, in a dry summer, there will be an increased frequency of fire incidents. The fluctuation of parameters over time can be observed in evidence of a number of a few past years. However, modelling such fluctuations ranges from straightforward to very complex. For instance, weather conditions can often be modelled reasonably well, but changes in a legal system can not. Finally, model risk is the risk that the chosen distribution and other model assumptions are not correct. Although it is not easy to further quantify model risk (another model would be needed for it), it can be said that some risks can be better modelled than others. Hence there is more model risk for risks that can not be modelled well (e.g. the changes in a legal system as mentioned above).

c) Extreme event (or catastrophe) risk
Extreme events are events occurring with a low frequency and a high severity. Due to the low frequency of catastrophes, catastrophe risk cannot be estimated on the basis of

24 Techniques to model volatility as combined frequency and severity risk of individual policyholders are translated gamma/normal power distribution; Panjer recursion; and Esscher approximation.
25 The fluctuation of parameters for the insured individuals over time can also regarded as a part of volatility risk, depending on the kind of model used. This part of the volatility can not be diversified away by increasing the size of the portfolio, as it affects all insured individuals in the portfolio simultaneously.
statistical evidence dating back only a few years. It should therefore be recognized as a separate category. Estimation of natural catastrophe risk is extremely difficult, as detailed and specific knowledge about the stochastic nature of such catastrophes is in most cases unknown. Important, but almost always unknown information is the dependency structure between the individual risks. Due to the scarcity of experience data, the parameter uncertainty and model risk are typically large.

In modelling extreme events a wide variety of software is currently available. These models calculate the probable maximum loss (PML) as a result of defined events given a repetition time (of 1 in 100 years to usually up to 1 in 500 years). These models make use of experience data based on the occurrence of the events as defined. Because there are few data points corresponding to extremely large losses and because of the impact these losses, it may be desirable to analyze large losses separately. The body of statistical/actuarial theory known as extreme value theory (EVT) provides the theoretical justification for the ‘shape’ of the extreme tail of the distribution of losses. The theory shows that in most situations, the distribution of losses in excess of some threshold follows a generalized Pareto distribution.

Risk mitigation tools
Instruments used to diminish possible adverse deviations are:

- **Reinsurance**: Catastrophe reinsurance may particularly limit the impact of extreme events, such as windstorms and earthquakes. Also, this can be used to improve the homogeneity of the portfolio measured in terms of insured amounts.
- **Product type ~ policy conditions**: products can be re-designed to include less risk or to a lower extent. Examples include the introduction of a requirement for safety measures in household policies, or the application of deductibles in policies covering windstorm.
5. Operational risk

Definition and risk drivers
The new capital adequacy framework for banks (Basel II) defines operational risk as the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. Legal risk is included in the definition; strategic and reputational risks are not. While developments in the insurance industry generally mimic those in Basel, many insurance companies separately model external event risk. Main risk drivers are the quality of control and the volume of cash flows or other business measures.

Measurement approaches
Currently used or known methods to measure operational risk are based on the use of simplistic business scalars (such as revenues, funds under management), through external benchmarks, to causal modelling. Most banks, however opt for a combination of two techniques:

a) Loss distribution approach, which applies statistical analysis to historical loss data; and

b) Scorecard approach, which focuses on the quality of the risk control measures a specific institution has taken.

These two techniques appear to supplement each other well: While the statistical analysis of historical losses is backward looking and quantitative of nature, the scorecard approach is composed of forward-looking and qualitative indicators.

a) Loss distribution approach (LDA)

The main objective of the LDA approach is to derive an objective capital number based on the size and the risk appetite of an institution and its business units. The loss distribution approach estimates the likely (fat-tailed) distribution of operational risk losses over some future horizon for each combination of business line and loss event type. Basel II, for example, distinguishes 7 such loss event types: internal fraud; external fraud; employment practices and workplace safety; clients, products and business practices; damage to physical assets, business disruption and system failures; and execution, delivery and process management. The main characteristic of the LDA is the explicit derivation of a loss distribution, which is based on separate distributions for event frequency and severity.

The event frequency is the number of events arising from losses over some time horizon. The Poisson distribution is commonly used to model the distribution of frequency. To test whether data come from a Poisson distribution, a quantile-quantile (qq) plot can be used. An additional parameter in modeling the distribution of frequency is the time horizon chosen for the analysis (bucketing or holding period). The choice of the time horizon may depend on a range of aspects, such as the length

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of a bad ‘storm’ period typical for a particular loss event type, or the amount of data available over a particular time horizon.

The event severity denotes the amount that a financial institution looses in case of an event. The distribution of event severity is often fat-tailed. Unlike event frequency, event severity can normally be modelled as a continuous random variable. To accommodate the fat-tail, the severity data can be fitted to non-normal distribution.\footnote{For example the lognormal, Weibull or gamma distribution.} A more robust, but also more complex way for generating fat-tail estimates (than only adjust for skewness), is to combine two distributions, typically one standard distribution and one extreme value distribution. The standard distribution then describes the bulk of events below an upper threshold; it mainly captures expected losses. The extreme value distribution can be a fat-tailed but flexible parametric distribution; it accounts for the truly unexpected loss.

One advantage of the LDA approach is that it can be applied to both an institution as a whole and its business units.

On the other hand the LDA still suffers from the poor quality and quantity of data internally available to banks. As the approach relies on historical losses, it does not reflect recent changes in risk profiles (rear-view mirror vision). Internal data also does not reflect the full distribution of possible events. They particularly miss out on low-frequency-high-severity (fat-tail) losses. And if one then uses external data (incidents of other institutions), these data might not be relevant to the institution or might need to undergo a difficult scaling process.

Another drawback of the LDA is that, as a pure statistical model, it does not provide staff with tools on how to reduce the risk. Business units can not change external data and if they change the risk profile, this affects the internal loss data only very slowly. To overcome this difficulty, the inclusion of a forward-looking control element in the calculation is essential. In this context, scorecards may be a useful complement.

b) Scorecard approach\footnote{M. Lawrence (2000), Marking the Cards at ANZ, Risk, November.}

The widest known operational risk management and measurement scorecard system is that developed by and implemented at Australia New Zealand bank (ANZ). The development of a scorecard system follows a multi-step procedure.

First of all, the content of the individual scorecards (one for each event category) composed of forward-looking risk indicators needs to be developed. Usually an expert panel identifies the drivers of each risk category. These are then used to derive questions that could be put on the scorecards. The questions ask for quantitative data (e.g. staff turnover rates), for qualitative judgements (e.g. the rate of change in different businesses) or simple yes/no questions (e.g. indicating compliance with certain group policies). They should cover drivers of the probability and impact of operational events, as well as the actions that the bank has taken to mitigate them. After pilot-testing the scorecards, they are rolled out and completed by all business units using self-assessment.
The strength of the scorecard approach is found in the creation of behavioural incentives to business units to manage and control their risks as a way to reduce their operational risk and to improve their risk scores. As a consequence, reduced risks will be reflected in lower economic capital allocations.

A major shortcoming, however, is that the scorecard approach as such does not give an indication of the required capital. It basically results in a relative risk comparison of the different activities. The approach requires a quantitative anchor and that is where the LDA is a good complement. The resulting capital numbers for each business units and/or risk category can then be reallocated or adjusted on the basis of the scorecard results obtained for that particular business unit and/or category.

Another shortcoming of the scorecard approach is the danger of gaming. A promising way of mitigating this problem is to focus the scorecards on quality of the risk management processes themselves.
6. Business or strategic risk

Definition and risk drivers
Business risk is the risk underlying the business a company conducts, to the extent that it includes all residual risk not covered by the market/ALM, credit/transfer, life, non-life and operational risk categories. Defined more precisely, it is the exposure to loss of value due to fluctuations in volumes, margins, and costs stemming from decreased demand, competitive pressure, operational efficiency, changes in regulation, etc. These fluctuations can occur because of internal, industry, or wider market factors. In one of its simplest forms business risk is regarded as the risk that due to changes in margins and volumes, earnings will fall below the fixed cost base.

Business risk can be seen as a result of management strategy and internal efficiency:

- **Strategic risk** is directly linked to strategic management decisions. For example, in order to realize sustainable revenue growth, management can decide to enter a new market or a new country. The corresponding risk is that the move is not successful, for example when the new business volumes will be much lower than expected. Another example is the decision of management not to adjust client rates in order to preserve client volume. Risks related to mergers, acquisitions and divestitures are also part of strategic risk;

- **Lapse risk** is the risk arising from the possibility that clients may choose to terminate contracts at any time, adversely impacting upon the company’s financial position. An example of lapse risk is the loss of savings accounts or mortgage loans due to changes in the competitive environment;

- **Efficiency risk** is predominantly triggered by the internal organisation. If a company, for example, is unable to manage its costs well, this may result in unanticipated losses if economic circumstances change (inflexibility).

- **Expense risk** is the risk that actual expenses adversely deviate from expected expenses. For insurance companies this risk is non-trivial, given the long-term nature of many contracts (unexpected inflation!).

Measurement approaches
Business risk capital can be calculated either a) top-down or b) bottom-up.

a) Top-down approach

The top-down approach mostly combines peer-group and earnings volatility analysis to capitalize for business risks. The approach is mainly applied in (some) banking institutions. Peer-group analysis attempts to define the capital level and structure required to maintain a target rating by reference to other firms in the same business. The earnings volatility analysis is based on historical cash flows.

The basic calculation framework is driven by the volatility in the P&L and a capital multiple that determines how much capital should eventually be hold for a given level of confidence. In addition one can adjust for the level of (un)certainty with respect to

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31 As explained in section 1.3, lapses that can be modelled as a direct consequence of movements in financial market factors, such as interest rates, are included in ALM rather than business risk. After all, this risk can be priced and is therefore tradeable and hedgeable. Lapse risk refers to lapses induced by all other (often more idiosyncratic) risk drivers, including general supply and demand factors.
the volatility. For the calculation of the volatility a P&L time series can be used that needs to be cleansed for other risk events (market, credit, etc). The capital multiple can be derived from so-called analogue companies. These are companies with similar activities, but without market/ALM, credit/transfer, life, non-life or operational risk. The assumption is that the actual available equity of these companies is a proxy for the business risk capital, as this is in general the requirement of the market. As the (P&L) volatility of those companies is known as well, one can determine the capital multiple to be used to scale the P&L volatility to the appropriate amount of business risk capital, taking into account peer companies’ ratings.

A limitation of the top-down approach is that it does not clearly indicate how to manage and control the economic capital. It may also proof difficult to find enough peers with a comparable business mix.

b) Bottom-up approach
Where distinct causes of residual volatility can be identified (for example in insurance businesses), these can be modelled bottom-up, particularly for businesses that include net present values of future margins in their earnings. The bottom-up approach relies upon a detailed model that projects the future cash flows of the business unit based on frequency and severity rates affecting those cash flows. For a business unit the (existing) embedded value model can be used, and the bottom-up approach would specifically model subcategories such as (maintenance) expense risk, lapse (or in force business persistency) risk, profit margin risk, and new business volume risk.

The ideal bottom-up methodology would be to simulate a probability distribution of the present value of cash flows, based on a full stochastic model of the company, using a large collection of scenarios based on coherent responses of the underlying sales, expense, and persistency levels to the fundamental risk drivers. Then one could derive the economic capital from the tail of the distribution, and calculate the fair value of the business by applying some valuation function to the full distribution.

In practice, a fully-fledged multifactor model is rather complex. Consequently, a shortcut is often taken by working with point-estimates of the value distributions made by running the embedded value models at both best estimate and ‘shocked’ values for the assumptions. Where possible, the shocked values are derived from historical analysis based on comparable internal or external data.

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32 There will be some element of capital held against operational risk by the analogue companies. The capital multiple should adjust for this.
33 Because of changes in market conditions and business mixes, the accuracy of the probability distributions can be problematic. Qualitative scenario-analysis will therefore be a useful addition to stochastic simulations.