Brief introduction to Insurance and Credit risk
Agenda

► Who we are
► Example of use of simulation techniques in insurance
► Brief introduction to credit risk modeling
Who we are
Who are we?

- Marius Fredheim
  Senior Manager
  - Marius is working as an actuary in our Financial Services.
  - He has long experience as an actuary in the Nordic market

- Lars Østhasse
  Consultant
  - Lars is a newly graduated actuary who joined our practice in August 2013
Ernst & Young Advisory Services is one of the largest Nordic consulting firms

Advisory services
- Ernst & Young Advisory Services is one of the largest Nordic consulting firms, with over 600 consultants

Financial services
- Financial Services deliver a global perspective. Aligned to key industry groups including asset management, banking and capital markets, insurance and private equity

Actuarial services
- Actuaries supports the audit function, profitability improvement projects, pricing, reserving and capital modeling. Often related to Solvency II

We work with the leading Nordic financial institutions:
- Swedbank
- Nordea
- Handelsbanken
- SEB
- Danske Bank
- DnB Nor
- Vital
- Carnegie
- OP-Pohjola
- Folksam
- Skandia
- Gjensidige
- SpareBank 1
- Lånsförsäkringar
- If...

We leverage our global size...

... Together with our local knowledge
Our quantitative resources are working on a wide range of services, including:

**Actuarial function**
- Provide formal sign off of liability calculations
- Advice on pricing and product development
- Advise on regulatory and market movements

**Pricing**
- Burning cost calculations
- Review existing pricing mechanisms
- Risk factor coverage
- Cost of capital – economic vs. regulatory

**Reserving/reserving reviews**
- Review reserving methodologies against market practice
- Accuracy of implementation
- Use of reserving numbers through the business “single version of truth”

**Credit Risk**
- Advice on risk aggregation and design of simulation models
- Capital modelling
- Validation on the IRB-system

**Solvency II / Basel III**
- P&L attribution
- Standard formula implementation
- Capital modelling
- Validation
- IRB
Simulation techniques in insurance
Introduction to risk and capital
The economics of an insurance company

\[ \text{UW resultat} = \text{Premium} - \text{Claims} - \text{Costs} + \text{Investements} \]
The economics of an insurance company

P&L Account for 2014

-/- Net Premium Earned
-/- Net Claims Incurred
-/- Net AcqCost Incurred
-/- Expenses Incurred
+ Investment Income
-/- Tax Incurred
-/- Dividends
= Net Retained Earnings
Risk profile at policy level

Company’s need to assess different types of scenarios and always define “worst case” scenario

- **Worst case scenario**: 90,000 loss
- **Moderate loss scenario**: 30,000 loss
- **Break even scenario**: 10,000 loss

**Policy Premium = 10,000 NOK**
Potential loss and capital requirement

Company’s need to set aside capital to cover potential loss with 99.5% probability

Potential loss with 99.5% probability
Capital requirements under Solvency II

Starting BOF at T=0

Expected profit in year
Average change in economic capital from T=0 to T=1

Potential loss
Average change in economic capital from T=0 to T=1

SCR:
Change in BOF over the year in the stressed scenario (99.5th percentile BOF at time T=1 less the starting BOF at T=0)

Modelled stress to the 99.5th percentile

99.5th percentile BOF at T=1

T=0

T=1 Mean

T=1, 99.5th
Different risk categories and aggregation
Some risk categories for insurers

- **Premium risk**: Risk related to future claims being higher than expected.
- **Reserving risk**: Risk related to incurred claims being higher than expected.
- **Market risk**: The risk of economic losses resulting from deviations in the value of assets.
- **Counterparty risk**: The risk to each party of a contract that the counterparty will not live up to its contractual obligations.
Top financial risks insurers are facing

Categories of Risk:

► Insurance Risk
  — Underwriting Risk
  — Reserving Risk
► Market Risk
► Credit Risk
► Liquidity Risk
► Group Risk
► Operational Risk

- Insurance Risk, 68%
- Credit Risk, 8%
- Market Risk, 13%
- Operational Risk, 10%
- Liquidity Risk, 0%
- Group Risk, 1%
Many risk modules from the Solvency II standard formula are addressing risks that need to be covered within Non-Life risk models.
Total risk profile for the corporate

- UW risk
- Reserving risk
- Credit risk
- Market risk
- Operational

Corporate Risk Profile
UW riskmodels
2. Calibration/Design – Premium Risk

A common approach across different markets - dividing claims into three different types:

- **Attritional claims**
  - High frequency/low severity claims

- **Large Claims**
  - Low frequency/high severity claims, that exceed a certain threshold

- **Catastrophic Claims**
  - Accumulation claims caused by an catastrophe (natural or man made)
2. Calibration/Design – Premium Risk

<table>
<thead>
<tr>
<th>Attritional claims</th>
<th>Attritional claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Modelled as aggregate claims</td>
<td>▶ Adjustment of trends and inflation</td>
</tr>
<tr>
<td>▶ Separate parameterisation of frequency and severity or</td>
<td>▶ Excluding annuities for parameterisation (life risk)</td>
</tr>
<tr>
<td>▶ Parameterisation of aggregate loss distribution</td>
<td>▶ Excluding cat. claims data sometimes leads to issues due to missing cat. classification at single data level.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Large Claims</th>
<th>Catastrophic Claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Modelled as single large claims via frequency/severity approach</td>
<td>▶ Careful usage of external data needed as sometimes external data do not fit to the written business of the insurance company (e.g. due to unreasonable model assumptions)</td>
</tr>
<tr>
<td>▶ Exposure adjustments/Indexation</td>
<td>▶ Validation strongly required, e.g. comparison of average of external and internal data or internal discussion of size of tail events</td>
</tr>
<tr>
<td>▶ Impact of catastrophic events is modelled on current exposure set</td>
<td>▶ Often missing internal acceptance of model results if unreasonable tails are used</td>
</tr>
</tbody>
</table>

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Scientific models often used from external sources, but parametric approaches also used.

Impact of catastrophic events is modelled on current exposure set.

Threshold for large claims has to be smaller than the priority of non-proportional reinsurance treaty relevant for the modelled line of business.

Careful usage of external data needed as sometimes external data do not fit to the written business of the insurance company (e.g. due to unreasonable model assumptions).

Validation strongly required, e.g. comparison of average of external and internal data or internal discussion of size of tail events.

Often missing internal acceptance of model results if unreasonable tails are used.
2. Calibration/Design – Premium Risk

- Gross Result components
- Earned premium
- Costs
- Simulated Claims
Underwriting risk

► Attritional claims: everyday claims

► Large claims: claims that are large enough to get individual attention

► Catastrophic claims: claims that are extremely large and usually caused by a single very severe event
Recap – Insurance Risk inc Underwriting Risk

- Insurance risk is the risk of loss arising from the occurrence, timing and amount of insurance claims.
- It includes current and prospective underwriting and the development of prior year reserves.
  - Underwriting Risk ≈ what you will write
    - Attritional and large claims
    - Catastrophe Risks
    - Underwriting Cycle
  - Reserving Risk ≈ what you have written
    - Possibility that prior year reserves are inadequate
    - Earned and unearned reserves

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equities, Bonds, Cash</td>
<td>Technical Provisions</td>
</tr>
<tr>
<td>Property</td>
<td>UPR</td>
</tr>
<tr>
<td>DAC Provision</td>
<td>Other Provisions</td>
</tr>
<tr>
<td>Debtors</td>
<td>Creditors</td>
</tr>
<tr>
<td>Shareholder’s Capital</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P&amp;L Account</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Premium Earned</td>
</tr>
<tr>
<td>-/- Net Claims Incurred</td>
</tr>
<tr>
<td>-/- Net AcqCost Incurred</td>
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<td>-/- Expenses Incurred</td>
</tr>
<tr>
<td>+ Investment Income</td>
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<tr>
<td>-/- Tax Incurred</td>
</tr>
<tr>
<td>-/- Dividends</td>
</tr>
<tr>
<td>= Net Retained Earnings</td>
</tr>
</tbody>
</table>
Brief introduction to credit risk modeling
### Setting the Scene

**Why is credit important?**

#### The Firm(s)

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assets</td>
<td>Debt</td>
</tr>
<tr>
<td></td>
<td>Equity</td>
</tr>
</tbody>
</table>

#### The Bank

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans</td>
<td>Deposits</td>
</tr>
</tbody>
</table>

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*Basel III leverage ratio requirement of more than 3%*
What is Credit Risk?

**Definition of Credit Risk**

Credit risk is most simply defined as the potential that a borrower will fail to meet his obligations in accordance with agreed terms.

**Definition of Default**

The failure to pay interest or principal when due.

A contract is said to be in default 90 days after due. The bank has to report and establish the loss.
How can we assess the losses associated with Credit Risk?

**Unexpected Loss (UL)**
- The risk that losses exceed EL within a year.

**Individual losses**

**Expected Loss (EL)**
- The average value of losses over a year.

**Stochastic simulation**

**Historical Data**

**Models**

Unexplained Risk (UL): The risk that losses exceed EL within a year.
How to cover the losses associated with Credit Risk?
Mathematical definition of Expected Losses

What drives Expected Loss?

\[ \text{Expected Loss} = \text{PD} \times \text{EAD} \times \text{LGD} \]

- **Rating**
- **Exposure**
- **Loss percentage**

Customers will always have an Expected Loss – even good customers!

A statistical method for estimating future losses based on historical data.
What’s the probability of the customer going into default on the loan(s)?

Expresses the probability of the customer defaulting within a year.
EAD – Exposure at Default

What is ‘at stake’?

Exposure at Default (EaD)

- Time of estimation
  - Unused
  - Drawn

- Time of default
  - Unused
  - Increased drawing up to default (CCF)
  - Drawn

Expected utilisation at the time of default
LGD – Loss Given Default

How big a proportion do we expect to lose?

Loss Given Default (LGD):

0% 100% 0% Coll. LGD 100% Coll. Min. LGD

Degree of collateralization

Expected proportion of exposure that will be lost in case of default
PD-modeling
There are three fundamentally models used for PD modeling:

1. **Hybrid rating models**
2. **Option models**
3. **Structural models**
4. **Simulation models**
5. **Rating forms**
6. **Expert judgement**
7. **Qualitative model**

**Statistical scoring model**
- Regression models
- Neural networks
- Discrimination analysis

Purely statistical approach based on historically data:

<table>
<thead>
<tr>
<th>Wealth</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fra</td>
<td>Til</td>
</tr>
<tr>
<td>0</td>
<td>0,5</td>
</tr>
<tr>
<td>0,5</td>
<td>200 000</td>
</tr>
<tr>
<td>200 000</td>
<td>750 000</td>
</tr>
<tr>
<td>750 000</td>
<td>2 000 000</td>
</tr>
<tr>
<td>2 000 000</td>
<td>5 000 000</td>
</tr>
<tr>
<td>5 000 000</td>
<td>7,5</td>
</tr>
</tbody>
</table>

**Economic models**
- Option models
- Cash flow models
- Simulation models

**Structural models**
- Structured qualitative approach by little data

**Qualitative model**
- Expert judgement
- Rating forms

*Wealth*:
- Fra (fraction)
- Til (total)
- Score

*Side 37*
Regression analysis of historical data

Today (2013)

“Good” loans

“Bad” loans

Upon credit approval (2012)

Retrospective

Question

Using the customer data we now have, can we construct a model that would have enabled us to identify the bad customers at the time of initial credit screening?
Credit Risk analysis using Logistic Regression Modeling

850 past and prospective customers to execute a Logistic Regression Analysis

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Sample:</td>
<td>513</td>
<td>Random mix of good and bad loans</td>
</tr>
<tr>
<td>Validation Sample:</td>
<td>204</td>
<td>Random mix of good and bad loans</td>
</tr>
<tr>
<td>Prospective Sample:</td>
<td>133</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

**Customer information:**
Age, Sex, Income, Debt-to-income ratio, Change of Address, Education level, Amount of credit card debt

- Construct the model
- Validate the model
- Use the model
Different predictors are used depending on whether you are a new or existing customer

<table>
<thead>
<tr>
<th>New Customer</th>
<th>Existing Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>New customer will be assigned an average PD based on age, sex, residence, income, assets etc</td>
<td>Existing customer will have a history which will be included in the PD estimation (in addition to the usual parameters). Such as overdrafts days and income-to-consumption ratio.</td>
</tr>
</tbody>
</table>

![Calibration curve](image-url)

- **Grade 1 (‘AAA’)**
- **Grade n**
- **Grade N (‘D’)**
- **Score**

**Probability of default (PD)**
Credit Scoring with Logistic Regression

Factors
- Background info
- Liquidity
- Solvency
- Behaviour

Weight of Evidence
- $w_1$
- ...
- $w_n$

Coefficient
- 0 - 10
- ...
- 0 - 10

PD
- Default
- ...
- Default

Rating class
- A
- ...
- ...

$PD(Score) = \frac{1}{1 + e^{-\left(\frac{\text{SCORE} - 200}{20 \ln(50)}\right)}}$

Scores
- 0 - 10
- ...
- 0 - 10

Score
- 0
- ...
- ...

Default Rating class
- Depends on the desired rating scale structure

Expert judgement, univariate analysis and regression
Transformation
Logistic regression-analysis
The ultimate goal of any rating model is to predict the probability of defaults for new applicants.

PDs are either produced by the model or obtained via mapping of internal grades to external default experience.

The accuracy of these estimates needs to be validated.

Realized default rates will deviate from estimated ones. Validation procedures need to examine whether the deviation is substantial and should lead to a review of the model or can be attributed to statistical noise. Focus:

- Significance of deviations
- Monotony of PDs with regards to ‘risk’
The binomial test determines the probability of observing the realized default rate under the hypothesis that the estimated value is correct.

The probability to get $n$ or less defaults given $N$ non-defaulted borrowers and probability of default $PD$ is given by:

$$P(\text{defaults} \leq n) = \sum_{i=0}^{n} \binom{N}{i} PD^i (1 - PD)^{N-i}$$

The binomial test with 95% double-sided confidence level amounts to:

- $P(\text{defaults} \leq n) > 97.5\%$ means that with this PD one should have gotten less defaults than realized and the PD is underestimated.
- $P(\text{defaults} \leq n) < 2.5\%$ means that with this PD one should have gotten more defaults than realized and the PD is overestimated.

Typically the test is carried out for each risk class.
Thank you for your attention!

Feel free to contact us for any and all questions on this material!

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