Micro–level stochastic loss reserving

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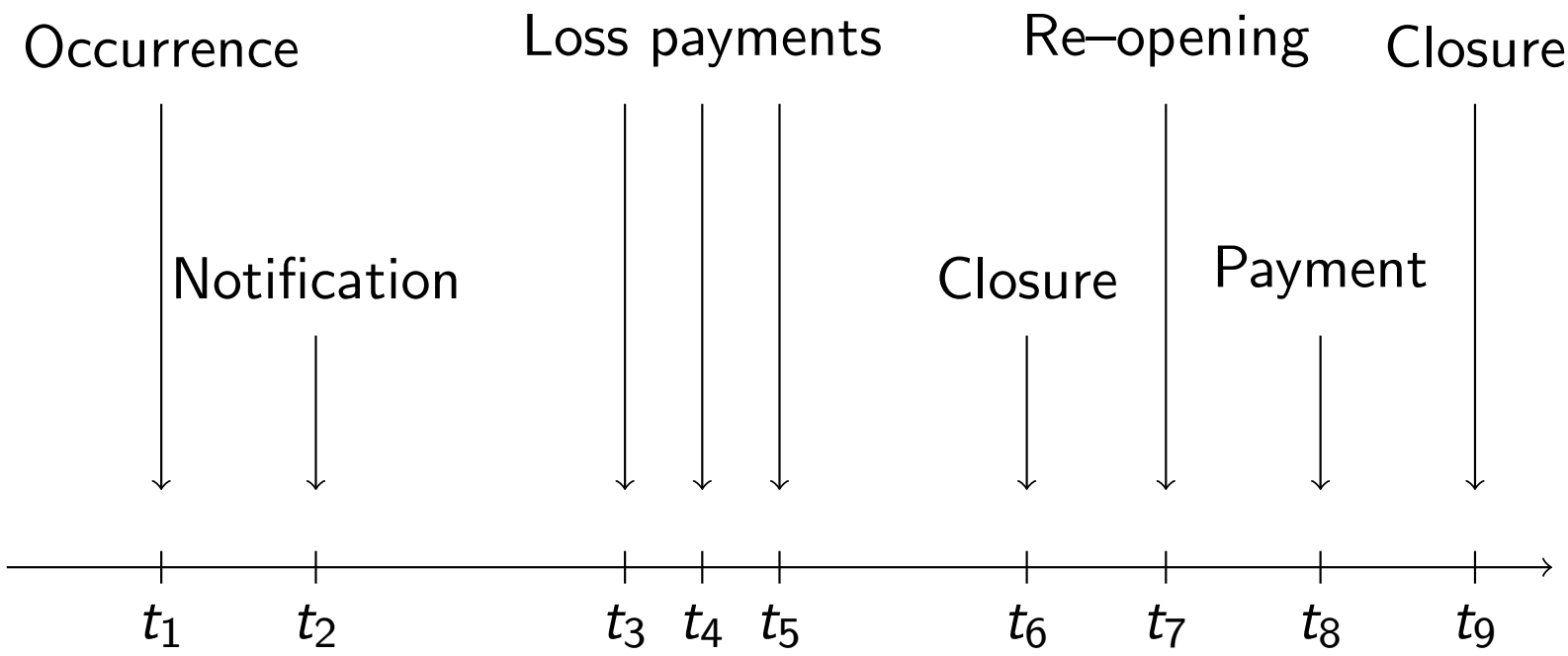
Context

- Consider the claims reserving problem for a branch of insurance products known as **non–life insurance** (Europe), **general insurance** (UK) and **property and casualty insurance** (USA).
- Examples of **LoBs**: motor insurance, property (e.g. against fire), liability insurance, ...
- Insured receives financial coverage against the random occurrence of well–specified events, in return for paying a premium to the insurance company.
- For consistent financial statements: all claims with accident year 'xx' have to be matched to premium earned in 'xx'.

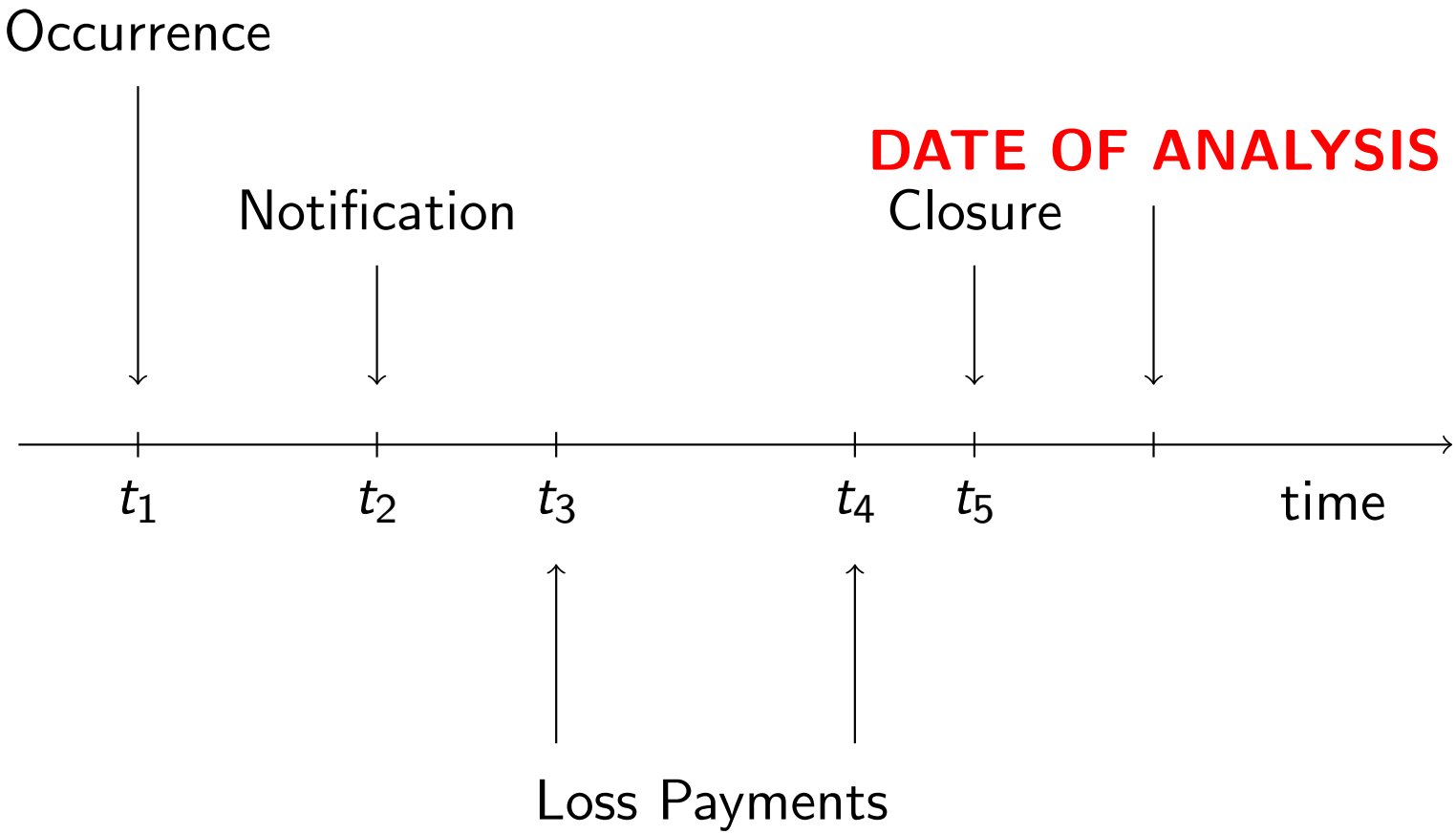
Dynamics of claims reserving

Run–off process of a **non–life claim**



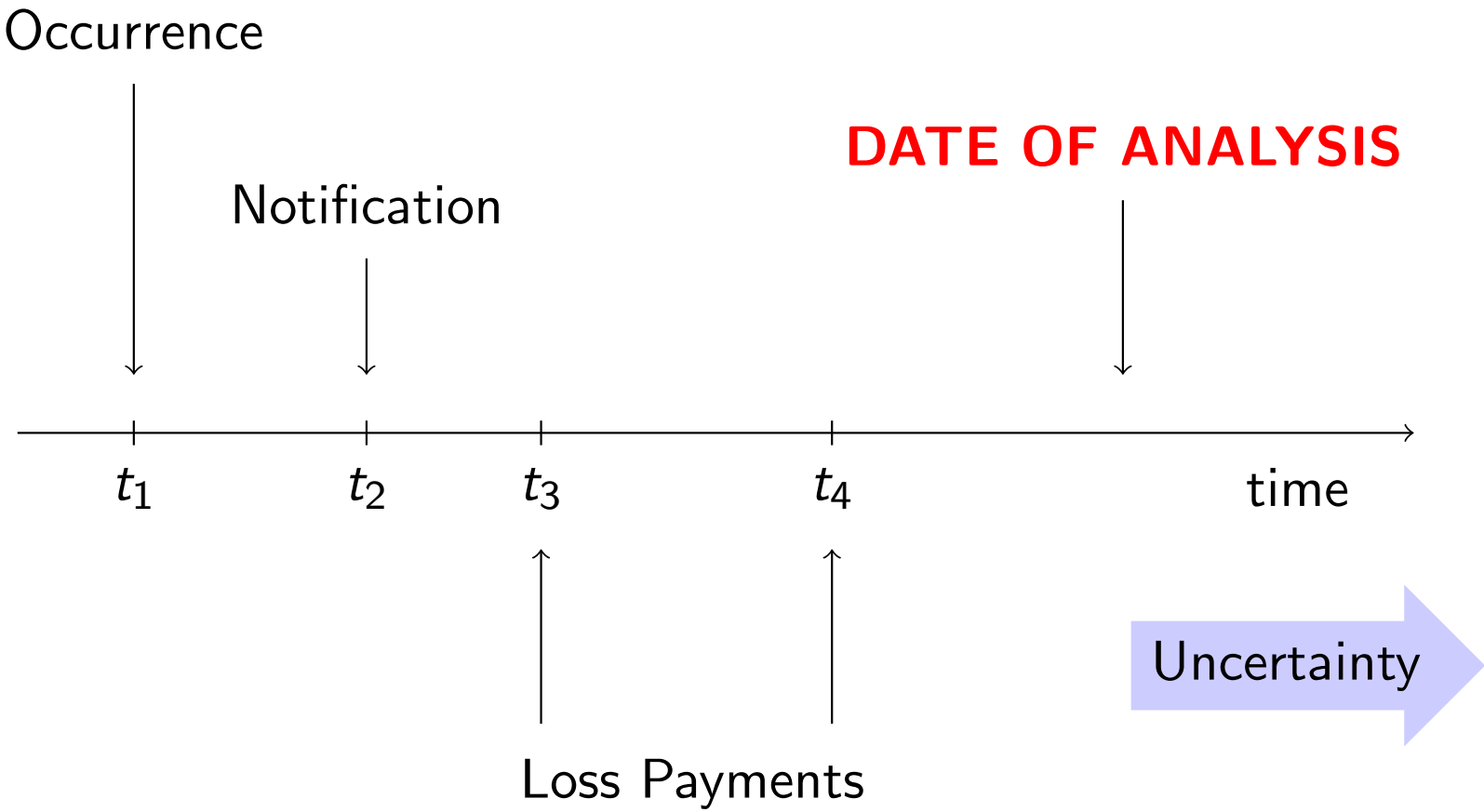
Dynamics of claims reserving

Closed claim



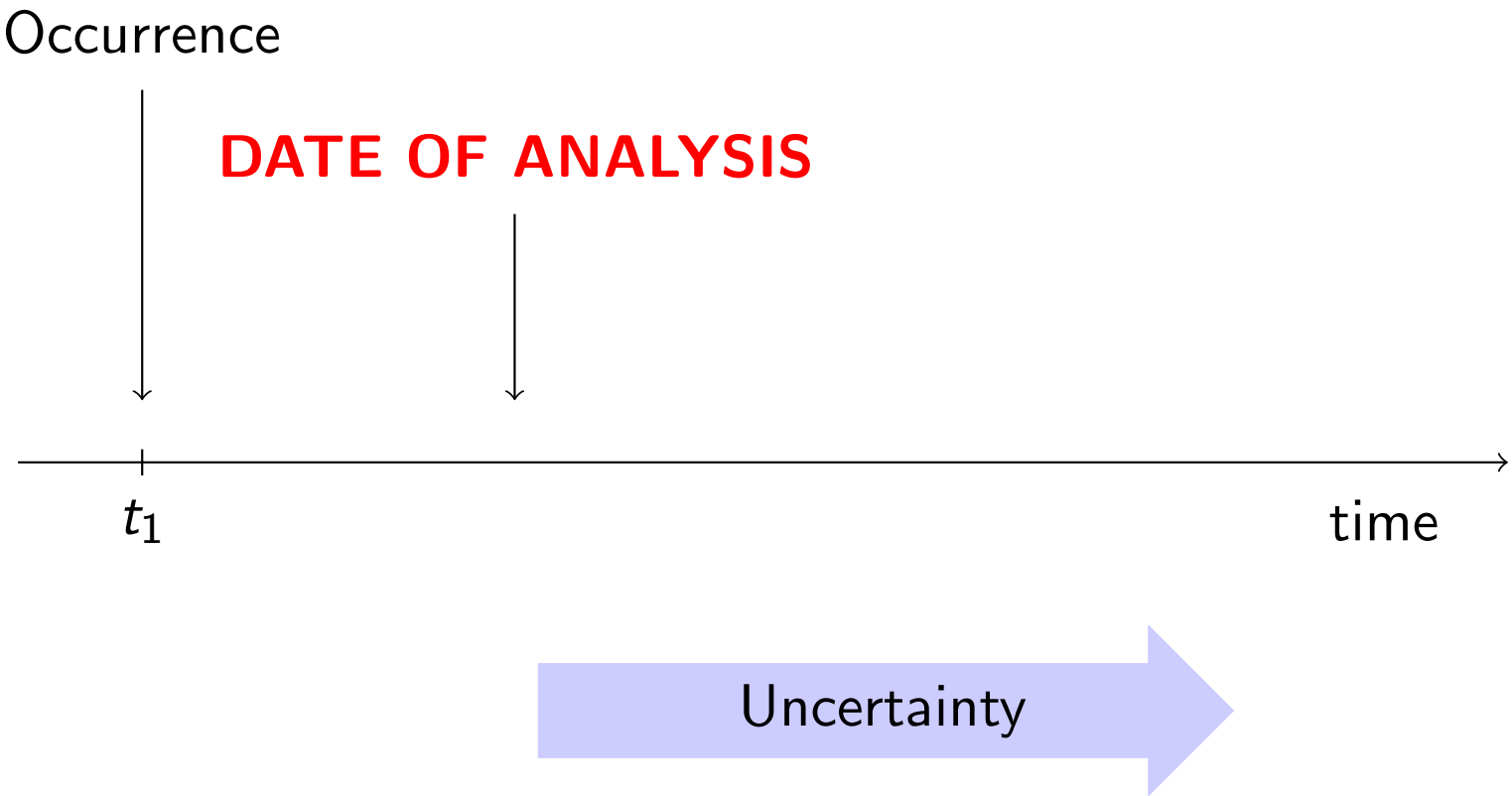
Dynamics of claims reserving

RBNS claim



Dynamics of claims reserving

IBNR claim



Claims reserving: aims

- Two types of incomplete claims:
  - **IBNR**: Incurred But Not Reported;
  - **RBNS**: Reported But Not Settled.
- Predict the unknown development of these claims.
- Not just a point estimate of outstanding amount, but real interest is in predictive distribution.
- The measurement of **future cash–flows and their uncertainty** becomes more and more important: see Solvency 2 (in 2012) and IFRS 4 Phase 2 (in 2013).

Micro–level run–off data

- Non–life insurance companies have **data** bases with detailed information:
  - exposure measure;
  - information about the claim event, the policy (holder) (eg policy limit) and the reporting delay;
  - payments: date and severity, type;
  - explanatory variables (eg case estimates by experts).

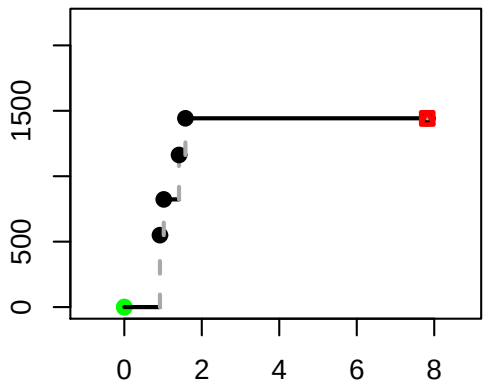
Micro–level run–off data: example

- European **general liability insurance portfolio**: **bodily injury** claims and **material damage** claims.
- Observation period is Jan. 1997 – August 2009.
- File consists of 1,525,376 records corresponding with 474,634 claims.
- Structure of the data:
  - **Policy file**: exposure per month from January 2000 till August 2009.
  - **Claims file**: accident date + details, open/closed.
  - **Payments file**: each payment made during observation period.

Micro–level run–off data: example

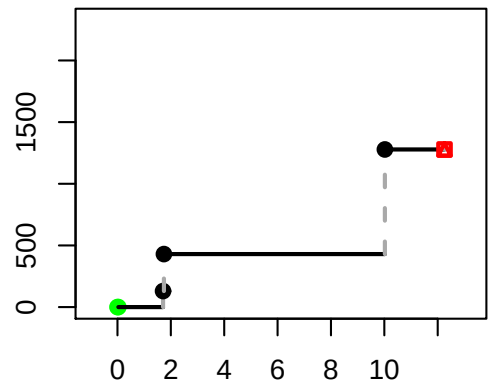
Development of 4 random **material** claims:

Development of claim 327002



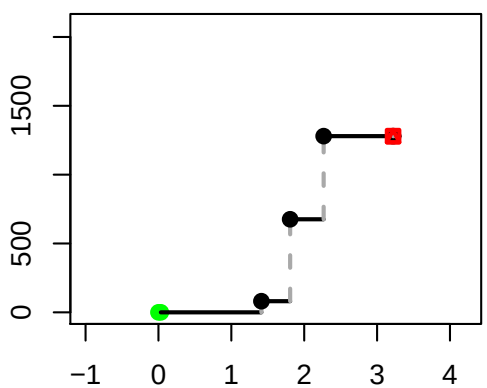
time since origin of claim (in months)
Acc. Date 15/03/2006

Development of claim 331481



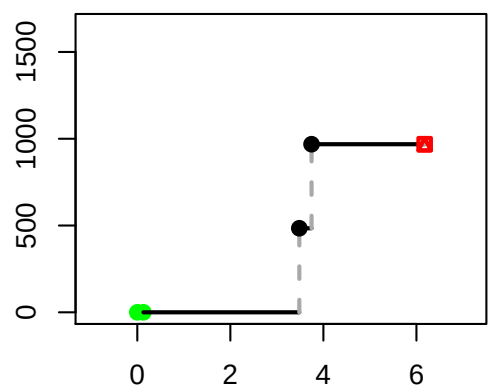
time since origin of claim (in months)
Acc. Date 24/04/2006

Development of claim 434833



time since origin of claim (in months)
Acc. Date 01/10/2008

Development of claim 34127

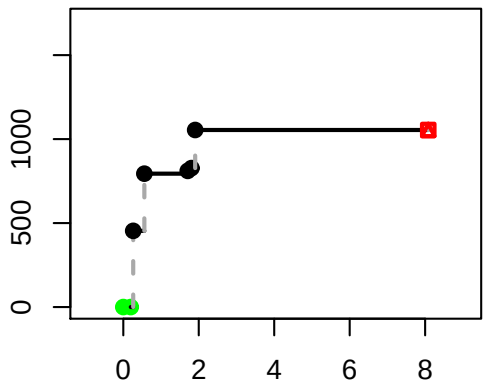


time since origin of claim (in months)
Acc. Date 02/04/1998

Micro–level run–off data: example

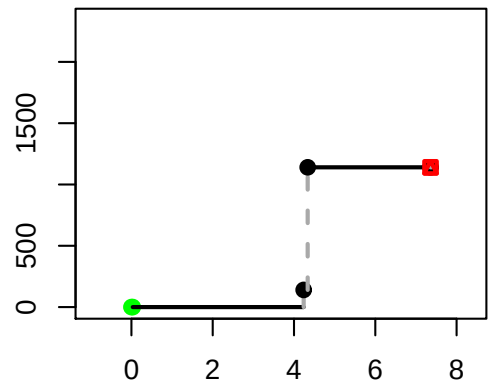
Development of 4 random **injury** claims:

Development of claim 12



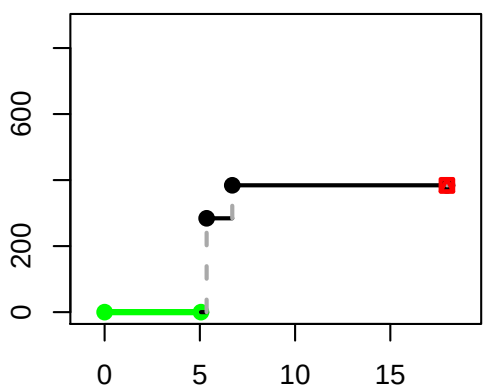
time since origin of claim (in months)
Acc. Date 01/01/1997

Development of claim 173876



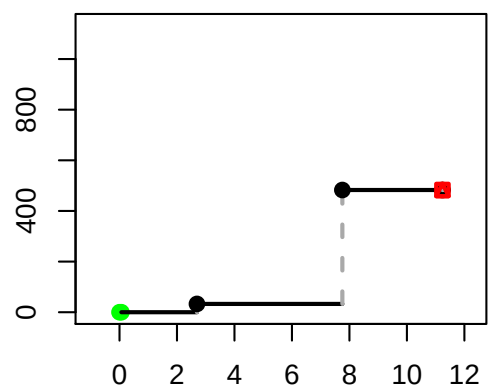
time since origin of claim (in months)
Acc. Date 19/06/2002

Development of claim 216542



time since origin of claim (in months)
Acc. Date 05/02/2003

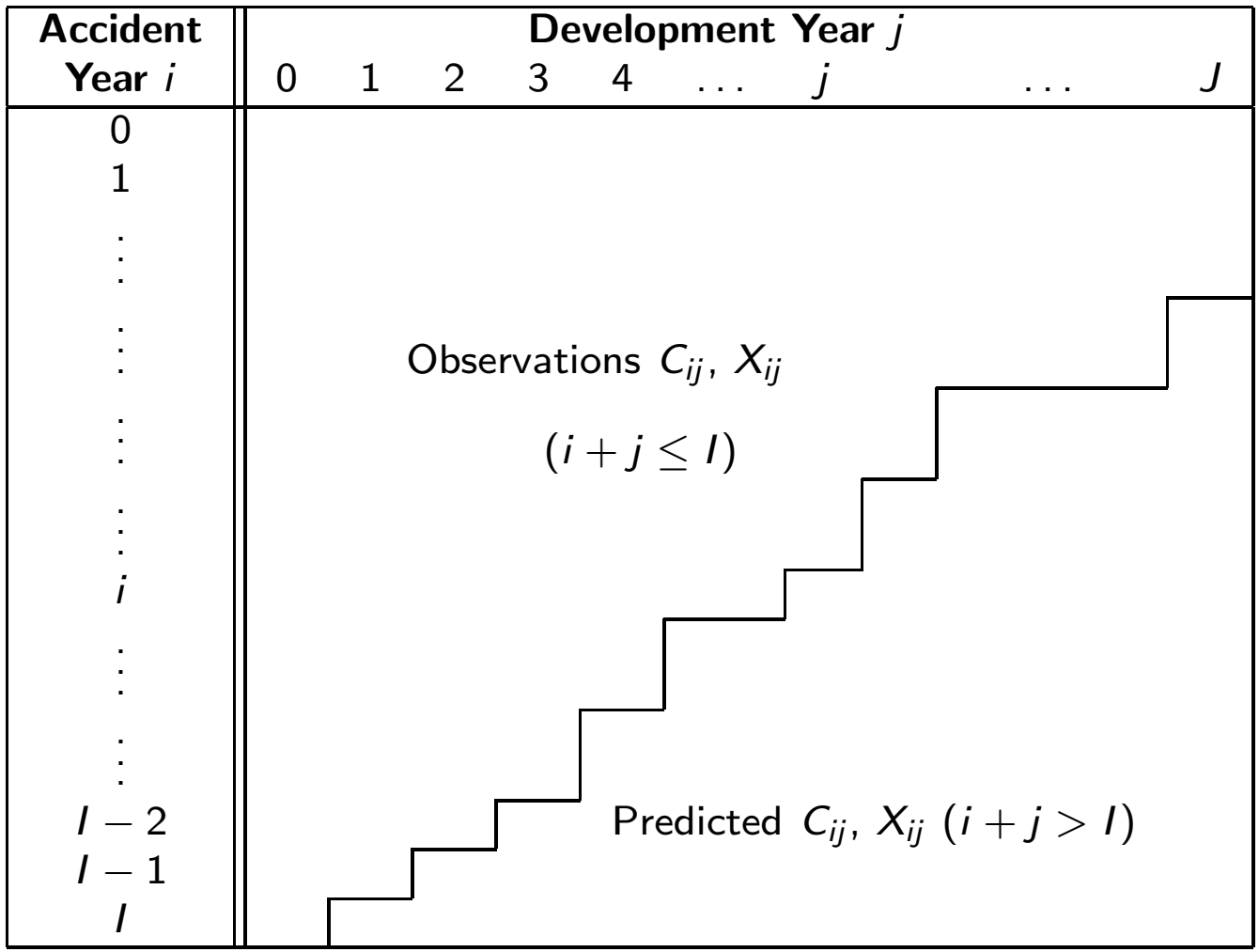
Development of claim 349176



time since origin of claim (in months)
Acc. Date 17/09/2006

Traditional actuarial display

- Actuarial techniques for claims reserving are based on **data aggregated** in run–off triangles.



Traditional actuarial display

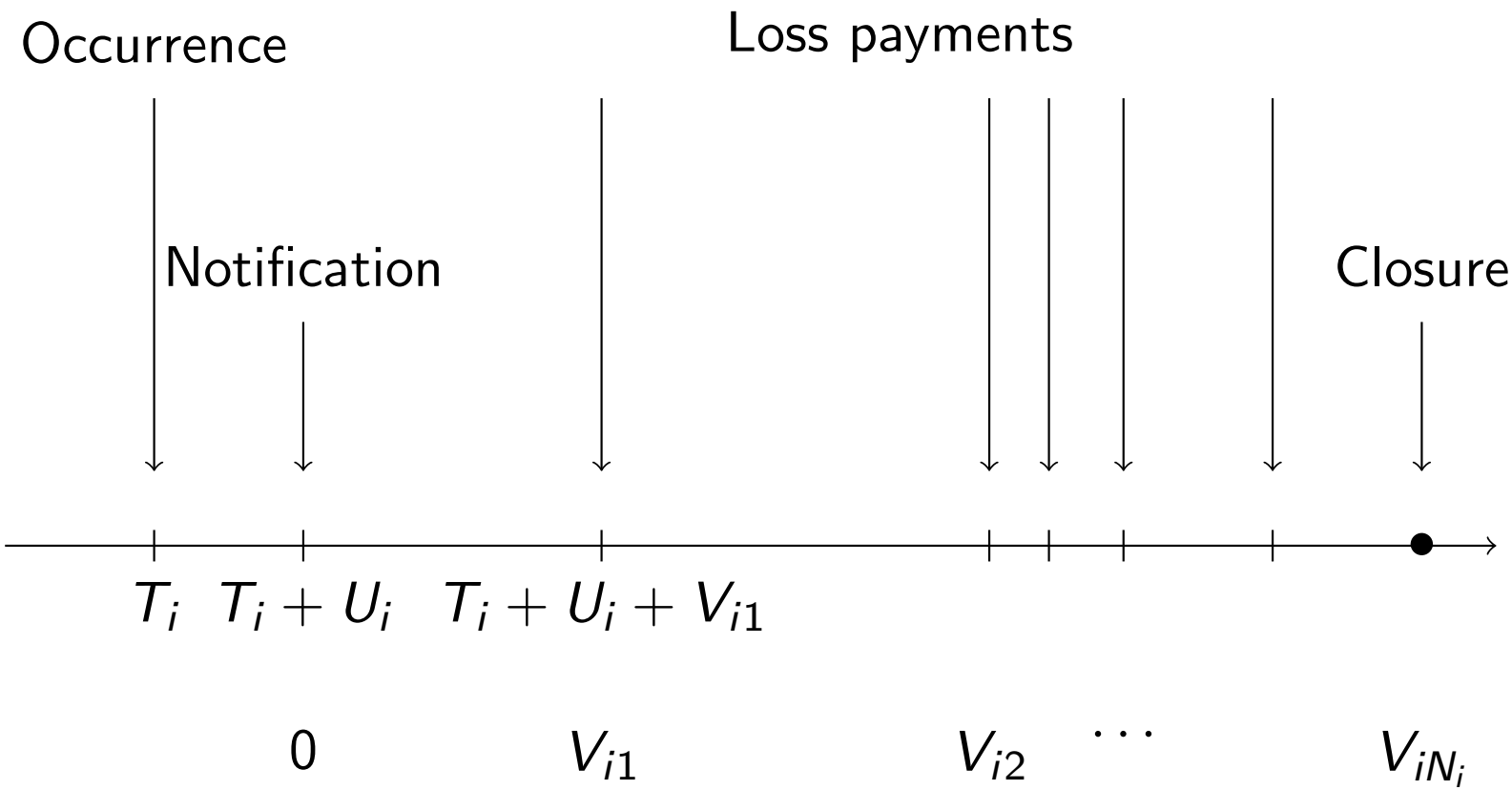
- Actuarial techniques for claims reserving are based on **data aggregated** in run–off triangles.
- Drawbacks/Questions:
  - useful information at individual claim and policy level is ignored;
  - limited amount of data is analyzed;
  - how to distinguish IBNR and RBNS claims?
  - how to distinguish small and large claims?
  - zero cells, negative cells, how to combine paid and incurred data?
  - how should reinsurance companies approach the reserving problem?

Micro–level loss reserving model

- A **claim** i is a combination of
  - an accident date T_i;
  - a reporting delay U_i;
  - a set of covariates $\mathbf{C}_i$;
  - a development process $\mathbf{X}_i$: $\mathbf{X}_i = (\{E_i(v), P_i(v)\})_{v \in [0, V_{iN_i}]}$;
- In the **development process** we use:
  - $E_i(v_{ij}) := E_{ij}$ the type of the jth event in development of claim i;
  - occurs at time v_{ij}, in months after notification date;
  - corresponding payment vector $P_i(v_{ij}) := P_{ij}$.

Micro–level loss reserving model

- Run–off process of a non–life claim on a time axis



Micro–level loss reserving model

- Say outstanding liabilities are to be predicted at calendar time τ.
- **Observed data**: development up to time τ of claims reported before τ.

$$(T_i^o, U_i^o, X_i^o)_{i\geq 1}.$$

- Development of claim i is **censored** $\tau - T_i^o - U_i^o$ time units after notification.
- Likelihood of the observed claim development process:

$$\begin{aligned}\Lambda(obs) &\propto \left\{\prod_{i\geq 1}\lambda(T_i^o)P_{U|t}(\tau-T_i^o)\right\}\exp\left(-\int_0^\tau w(t)\lambda(t)P_{U|t}(\tau-t)dt\right)\\ &\times \left\{\prod_{i\geq 1}\frac{P_{U|t}(dU_i^o)}{P_{U|t}(\tau-T_i^o)}\right\}\times\prod_{i\geq 1}P_{X|t,u}^{\tau-T_i^o-U_i^o}(dX_i^o).\end{aligned}$$

Micro–level loss reserving model

- Building blocks in the model used in Antonio & Plat, following Norberg (1993, 1999):
  - a distribution for the reporting delay;
  - a filtered Poisson process driving the occurrence of claims (IBNR + RBNS);
  - the claims development process: recurrent events and payment severities;
    - (recurrent) events?

      $\Rightarrow$ settlement with payment, settlement without payment, intermediate payment.

Micro–level loss reserving model

- Likelihood uses the following building blocks:

(1) the **reporting delay**: $\prod_{i\geq 1} \frac{P_{U|t}(dU_i^o)}{P_{U|t}(\tau - T_i^o)}$;

(2) the **occurrence times** (given the reporting delay distribution):

$$\left\{ \prod_{i\geq 1} \lambda(T_i^o) P_{U|t}(\tau - T_i^o) \right\} \exp\left(- \int_0^\tau w(t)\lambda(t) P_{U|t}(\tau - t) dt \right);$$

(3) the **development process – event** part:

$$\prod_{i\geq 1} \left\{ \prod_{j=1}^{N_i} \left(h_{se}^{\delta_{ij1}}(V_{ij}) \right\} \times h_{sep}^{\delta_{ij2}}(V_{ij}) \times h_p^{\delta_{ij3}}(V_{ij}) \right) \exp\left(- \int_0^{\tau_i} (h_{se}(u) + h_{sep}(u) + h_p(u)) du \right);$$

(4) the **development process – severity** part:

$$\prod_{i\geq 1} \prod_{j} P_p(dV_{ij}).$$

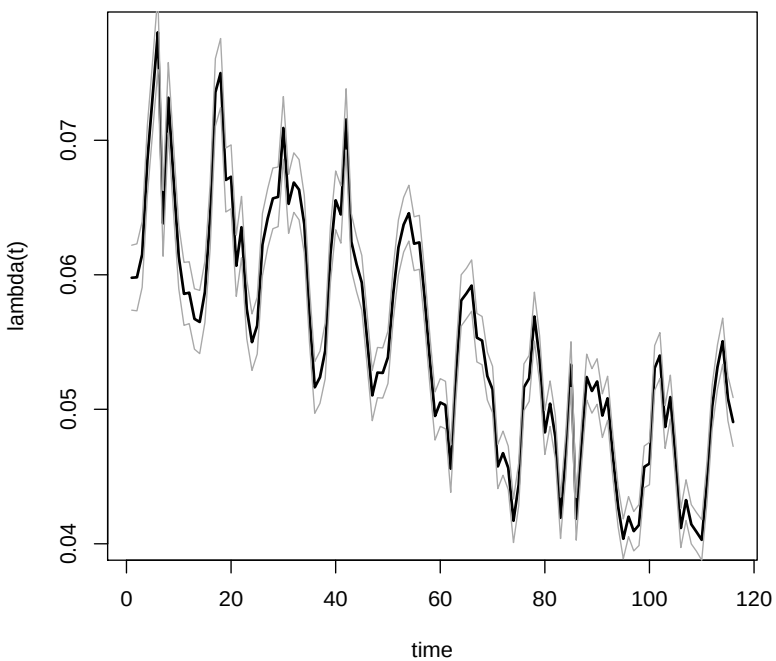
Calibration: reporting delay

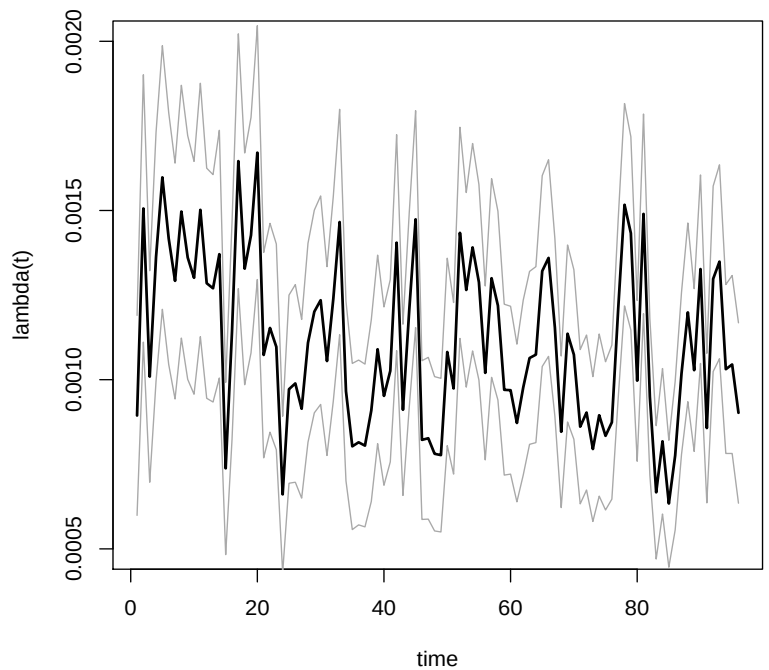
- **Reporting delay** distribution.
- Combine a Weibull distribution with degenerate components at 0 days delay, 1 day delay, . . . , 8 days delay:

$$\sum_{k=0}^{8} p_k I_{U=k} + (1 - \sum_{k} p_k) f_{U|U>8}(u).$$

Calibration: occurrence of claims

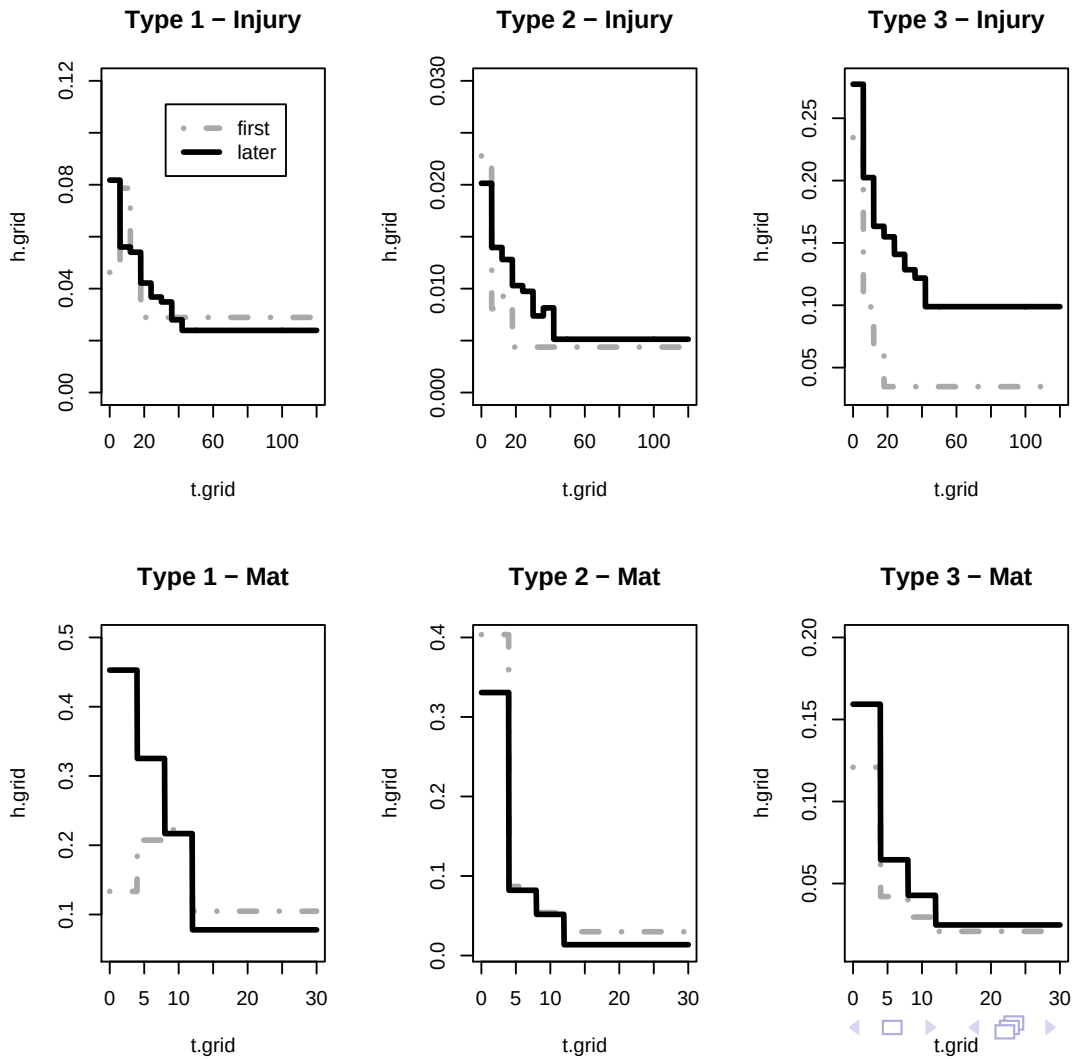
- **Poisson process** driving the occurrence of claims.
- A piecewise constant specification for the occurrence rate $\lambda(t)$.
- Material damage (left) and injury (right) claims:





Calibration: development of claims

- **Claims development**: occurrence and type of events.
- Piecewise constant specification of the hazard rates.

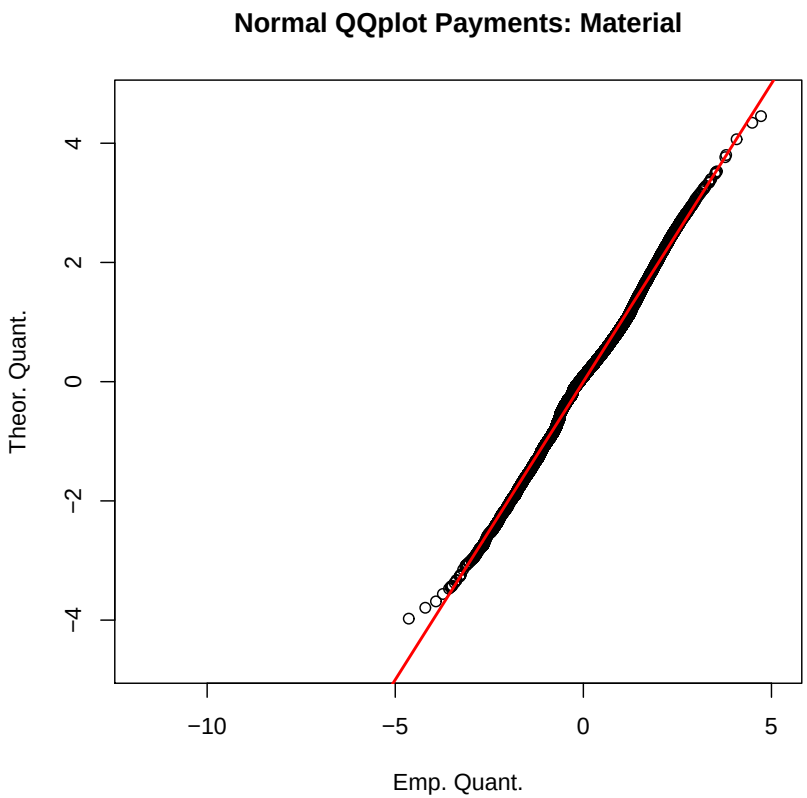


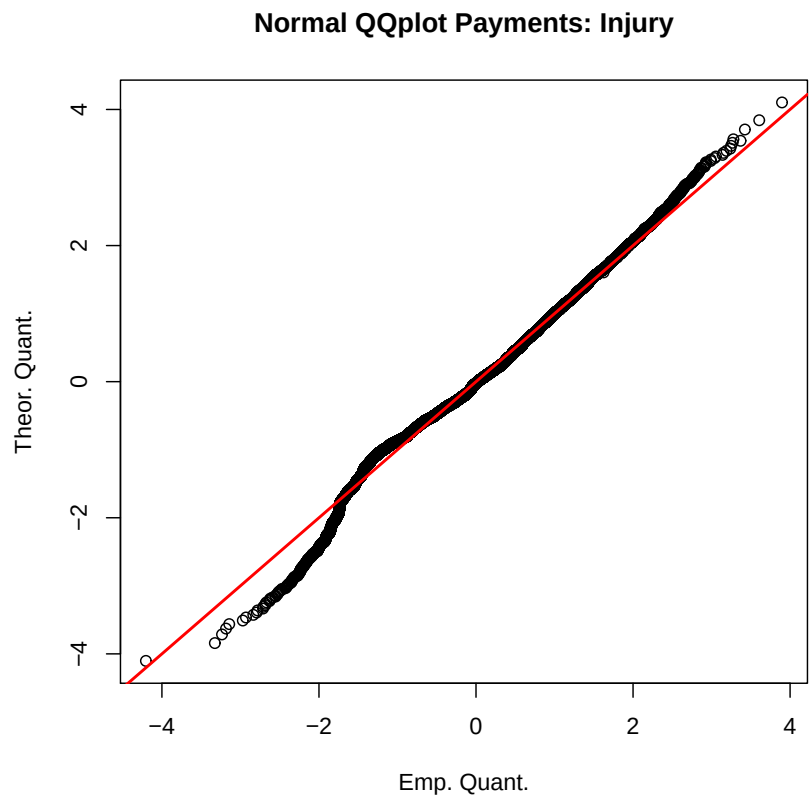
Calibration: severities

- **Severities** distribution.
- Lognormal distributions with μ and σ depending on:
  - the development period: 0-12 months after notification, 12-24 months . . . (for injury) and 0-4 months, 4-8 months . . . (for material);
  - the initial reserve (set by company experts): categorized.
- Policy limit of 2,500,000 euro is implemented.

Calibration: severities

- **Severities** distribution: material damage (left) and injury (right).





Forecasting

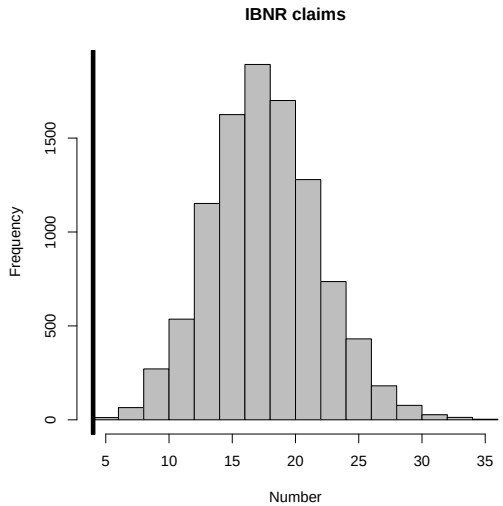
- Using these building blocks we can easily:
  - simulate the time to a next event, the corresponding type and severity for an RBNS claim;
  - simulate the number of IBNR claims that will show up, their occurrence time and their development.

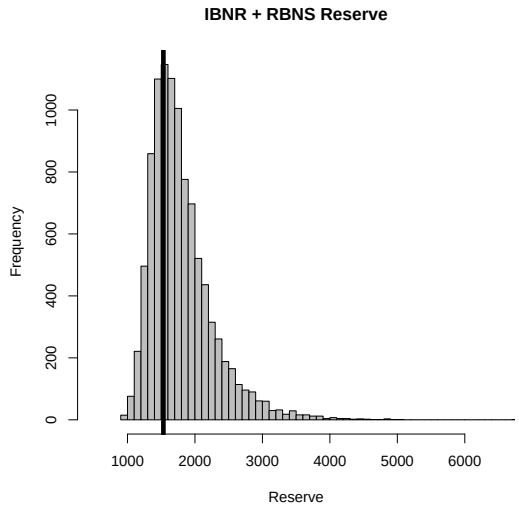
Results

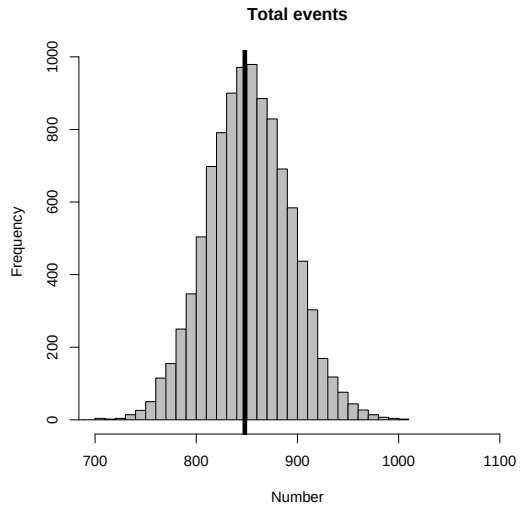
- Example of a **back–test**: fit model to data 1/1/1997 till 1/1/2004 and compare predictions with real outcomes.
- Results obtained with micro–model are compared with those from traditional techniques (i.e. overdispersed Poisson and lognormal regression model with chain–ladder structure).

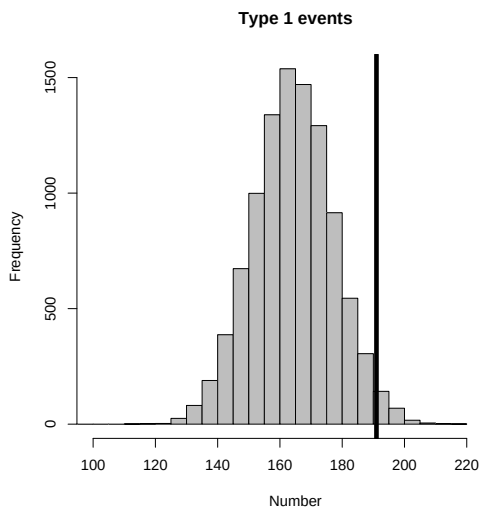
Results

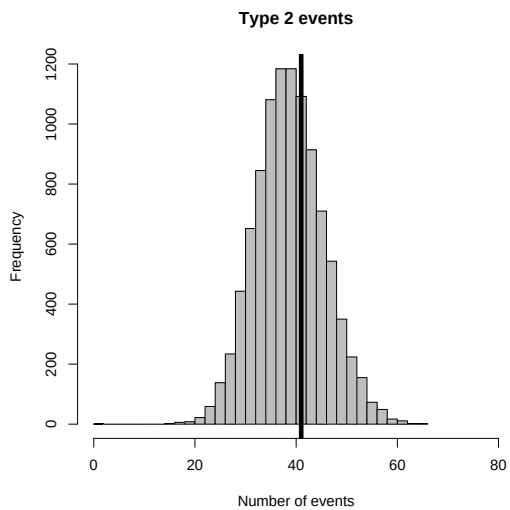
Injury claims, results for calendar year 2006.

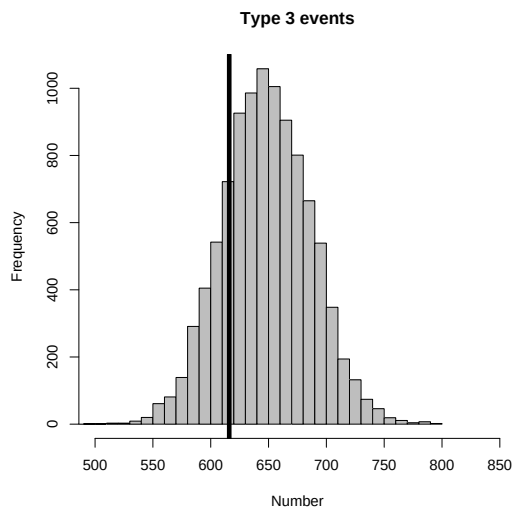






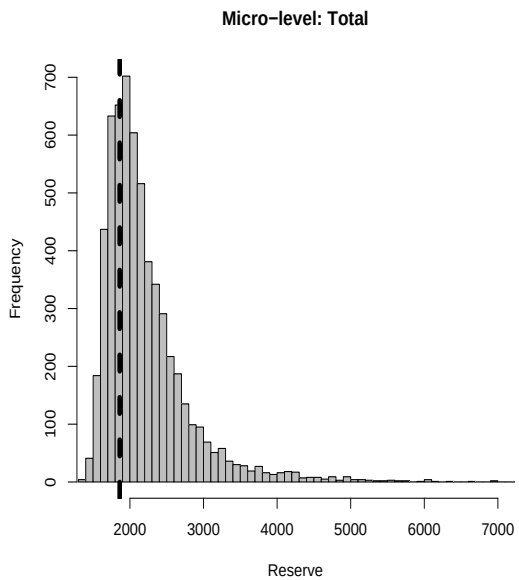


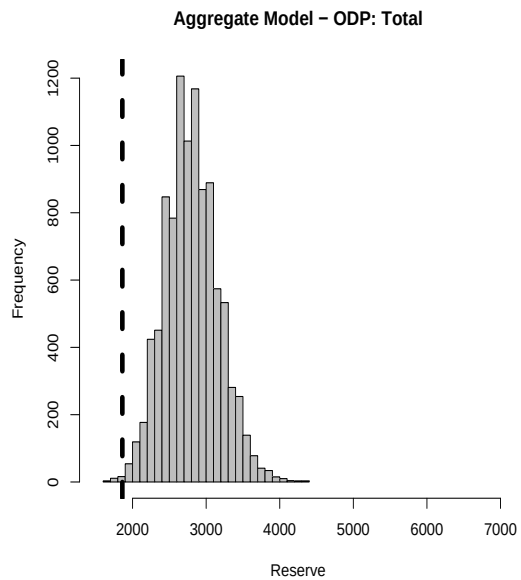


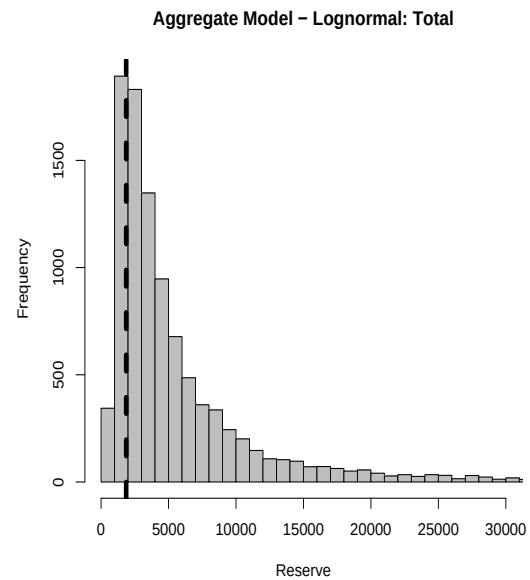


Results

Material damage claims, total reserve: micro–level, overdispersed Poisson (triangle), lognormal (triangle) model.







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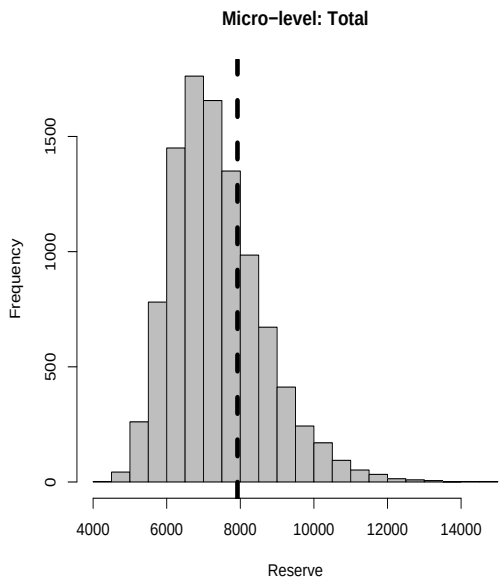

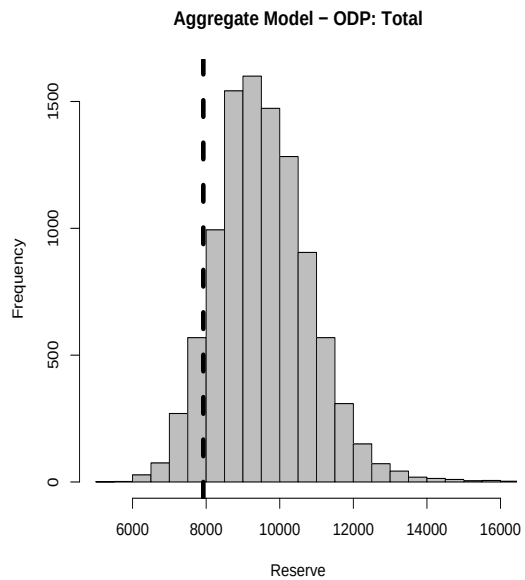

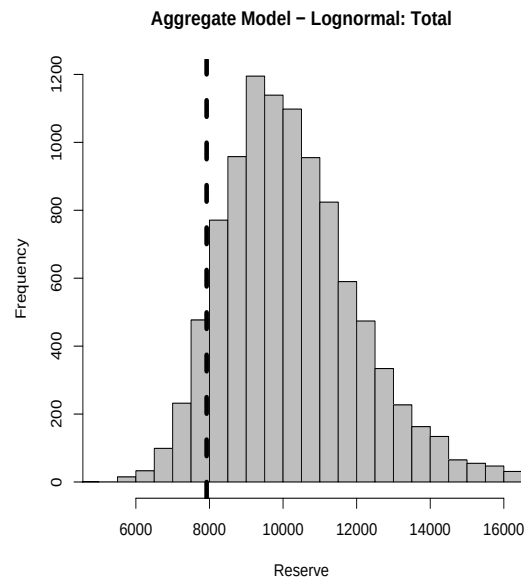

Conclusion and outlook

- Development of a micro–model for claims reserving in non–life insurance, including:
  - calibration to a realistic data base from practice;
  - forecasting;
  - back–testing, in comparison with results from traditional techniques.
- On–going work:
  - aggregate data $\ll \gg$ individual data with development aggregated in cells of e.g. one year $\ll \gg$ micro–level data in continuous time;
  - the reinsurance point of view;
  - combination with extreme value statistics.