Dynamic Risk Modeling Handbook

Pricing Risk

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Use of dynamic risk modeling for pricing analysis:

In simple form:

- Estimate the impact of policy features such as deductibles, limits and variable commissions on prices and profitability.

In advanced form:

- Measure the volatility of underwriting results.

Use of dynamic risk modeling for pricing analysis:

In advanced form:

Requires implementation of assumptions regarding:

- the amount of premium to be written, earned and/or collected
- the fixed and variable expenses associated with the portfolio
- the aggregate distribution of losses
- the timing of the premium, expense and loss cash flows
- an appropriate rate to discount the cash flows
- the correlations or dependencies between lines of business
- the impact of or interaction with other economic variables

Outline of the modeling approach (Structure of the chapter):

A. Fitting and parameterization of loss distributions

B. Choice of modeling timeframe

C. Loss segmentation for modeling

D. Treatment of correlation effects in modeling

A. Fitting and parameterization of loss distributions

- Why?

To characterize the loss generating process underlying the sample data that is being analyzed.

- How?

Commonly used distributions are:

For severity: normal/log, gamma/log, pareto and gamma

For frequency: poisson, negative binomial

A. Fitting and parameterization of loss distributions

Affected results:

- Reduces the effect of sampling variation in the data, and replaces an empirical distribution with a more smoothed distribution.
- Allows for the estimation of tail probabilities outside the range of the original data.

A. Fitting and parameterization of loss distributions

Must avoid excessive use of parameters, due to:

- costs of maintaining and monitoring each parameter used,
- potential of loss in simplicity without gains in accuracy (Occam's razor),
- need to keep the model scope aligned with business considerations, and ensure understandability and acceptability by the intended audience.

A. Fitting and parameterization of loss distributions

Some major considerations are:

1. Data sources
2. Treatment of policy features
3. Parameter uncertainty
4. Choice of discount rate
5. Treatment of loss trend effects

A. Fitting and parameterization of loss distributions

Consideration: Data Sources

a. Company data

- Used for dynamic elements that are influenced by management decision-making, such as exposure and expense growth.
- Captures the effects of: insured base, policy/coverage features, claims-handling operations.

b. Industry data

- For factors outside company influence, such as interest rates, inflation and judiciary trends.

A combination of the two types can be used in certain instances. For example, we may adopt baseline industry payment patterns, and then construct their variability on company information.

A. Fitting and parameterization of loss distributions

Consideration: Treatment of policy features

- Treat them as truncation/censoring of data, and use maximum likelihood estimation to obtain the parameters.
- Use variability of policy features by line of business as guide to determine appropriate data segmentation for modeling.

Examples of line-specific features:

** Personal Lines generally have lower limits/deductibles. Deductible payments generally erode policy limits.*

** Limits on policies with self-insured retentions are generally not eroded by losses within the self-insured retention.*

A. Fitting and parameterization of loss distributions

Consideration: Parameter uncertainty

- Price is determined before the loss event, so the risk is greatest at policy inception, and declines as claims are known.
- Multiple sets of parameters can re-produce the actual data, and it's hard to determine which one truly represents the underlying distribution.
- To reduce sampling uncertainty, incorporate the error structure into the estimated parameters. Set a tolerance level for the probability that the parameter value falls in a certain range, and this way, capture all relevant info from the sample.

A. Fitting and parameterization of loss distributions

Consideration: Choice of discount rate

- To measure future underwriting performance, we need to make an assumption on investment income earned on future underwriting cashflows.
- Uncertainties with this are: timing of future cashflows, size of future yields.
- Reasonable solutions: use treasury spot rates for the expected timing of payments; assume funds will be reinvested at the prevailing risk-free T-bill rates.

A. Fitting and parameterization of loss distributions

Consideration: Impact of loss trend

- Loss trend is comprised of frequency, severity and exposure trends.
- Continuity of historical trends should be reviewed periodically.
- Relationship of trend with claim size must be observed.

For example: an increase in the frequency of small claims can give the impression that the increase in the severity of claims is more muted than may actually be the case.

B. Choice of timeframe

Choice of time horizon depends on intended use:

- one-year: for needs of regulator, rating agency, securities analysts
- longer: run-off lines
- longer: more ambitious: modeling of correlation between market conditions and management actions

B. Choice of timeframe

Forecasting beyond 12 months will add to uncertainty with regard to:

- the amount of premium that will be written
- underlying rate adequacy
- changes in the underlying loss costs.

C. Loss segmentation for modeling

- Individual large losses: for when one or few large losses can have significant impact on line results.
- Aggregate losses: for when modeled line is high-frequency, low-severity (e.g. personal auto)
- Clash/catastrophe losses: assume the probability of occurrence of a defined event; estimate the loss to firm after policy features are applied; also model the contagion from such an event within the insurer's portfolio.

<u>Caution:</u>

In selecting risk segments for fitting, must strike balance between homogeneity and credibility.

D. Correlation between Lines

Factors that have influence over price levels may be internal or external.

External:

- - Competitive environment in the insurance marketplace
- - Prospects of investment income
- - Judicial and regulatory environments

Internal:

- - Desired rate of return
- - Appetite for growth
- - Operational changes

D. Correlation between Lines

Factors affecting price levels will have a tendency to affect multiple lines simultaneously:

- a new market entrant, leading to multi-line price competition
- change in expected inflation, leading to change in prospective loss costs for multiple lines
- changes in company operations, leading to changes in prospective costs of some lines, while leaving those of others unchanged.

A realistic dynamic risk model must reflect this tendency for prices to move together.

D. Correlation between Lines

Measures commonly used for assessing linear correlation among two or more variables:

- Pearson's correlation coefficient
- Spearman's rank correlation coefficient
- Kendall tau rank correlation

D. Correlation between Lines

Spearman's rank correlation

- Uses the same formula as the Pearson coefficient, but replaces values of the variable outcomes with their ranks:

Kendall tau rank correlation

- Uses a formula which depends on how many of the ranks are in the same order:

Kendall'sTau = where

C = Number of pairs that are concordant.

D = Number of pairs that are not concordant

D. Correlation between Lines

Pearson's correlation coefficient:

$$r = \frac{\sum_{i=1}^{n}\left(X_i - \bar{X}\right)\left(Y_i - \bar{Y}\right)}{(n-1)S_X S_Y}$$

- No correlation: r = 0
- Positive correlation: r = (0,1]
- Negative correlation: r = [-1,0)

Certain underlying assumptions that may not be met by insurance company operations are:

- Relationship between variables are assumed to be linear.
- All distributions are assumed to be normal with a constant variance.
- Correlation is highly affected by outliers.

D. Correlation between Lines

Considerations for DRM:

- Serial correlation across years, when forecasting for more than one year.
- Association of movements in insurance variables (premium, ELR, expense ratio, etc) with macroeconomic variables (GDP growth, inflation, interest rates, etc).
- Correlation of insurance variables among business lines, due to catastrophe events, shifts in macro variables, simultaneous moves in rate adequacy, etc.
- Correlation of reserve adequacy and future underwriting profitability, observed in the insurance market cycles. (Need to reflect in DRM model the cyclical trend of falling profitability and ensuing weakening in reserve adequacy in the soft market, leading to increasing rates and strengthening of reserves in the hard market.)

Overview

Essential elements of DRM:

- Fitting and parameterization of loss distributions
- Choice of modeling timeframe
- Loss segmentation for modeling
- Treatment of correlation effects in modeling

Thank you.

Q&A