The impact of changing economic conditions on reserve variability

2013 Casualty loss reserve seminar

Thomas P. Conway, principal

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Agenda

1. Sources of reserve variability
2. Why model impacts of economic changes to loss reserves?
3. Why are loss reserves sensitive to inflation?
4. Incorporating inflation variability using regression modeling
5. Case study
6. Potential application and use of our approach
7. Other approaches to modeling economic impacts

What are the sources of reserve variability?

1. **Independent intrinsic risk drivers** – includes risks inherent in the underwriting process involving:
   - Claim frequency
   - Timing of claims
   - Claim severity

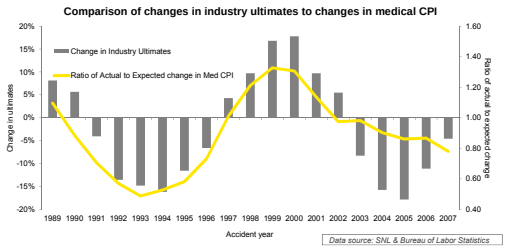
2. **External systematic risk drivers** – includes external effects such as:
   - General inflation - Consumer Price Index (CPI)
   - Wage rate inflation
   - Medical inflation
   - Medical utilization
   - Workers compensation (WC) reform
   - Legislative/Judicial changes
   - Changes in public sentiment
   - Insurance market cycle

3. **Internal management risk drivers –** includes internal effects such as:
   - Changes in claims handling/case reserving/claims payment
   - Changes in claims verification processes
   - Changes in legal representation/settlement procedures
   - Changes in underwriting/mix of business/rate adequacy

Why model inflationary impacts?

1. Two key drivers are random variation in claim size and unexpected changes in economic conditions
2. Appropriate modeling requires separating these two risk drivers
3. Changes in economic conditions have been shown to drive adverse loss reserve development
4. A quality model can be derived for economic inflationary risk drivers

Historical adverse development in WC



- Change in ultimates: percentage change in the estimate of industry ultimate loss and allocated loss adjustment expense (ALAE) from the first evaluation to the fifth evaluation
- Change in medical CPI: ratio of actual change to expected change in medical CPI (Average of prior four years/Average of next four years)

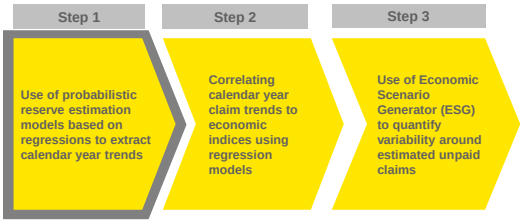
Characteristics of P&C loss reserves

1. Linkages to inflation are both direct and indirect
2. Various lines of business show different relations to inflation
3. Long tail lines are especially exposed to inflation
4. Payments are composed of multiple components which have different levels of inflation sensitivity
5. Economic impacts which drive only claim frequency are less relevant to reserve variability since the number of claims incurred is reasonably well known

Components of loss reserve payouts

Line of business	Components of claim payments	Relevant economic driver
Workers' compensation	Short- and long-term wage replacement Short- and long-term medical care	1. Wage inflation 2. Unemployment 3. Medical CPI
Auto liability **General liability** **Professional liability**	Economic and non-economic damage, composed of current and future medical, wage loss, pain and suffering, etc.	1. General CPI 2. Medical CPI 3. Property value
Homeowners **Auto physical damage**	Replacement or repair of damaged property	1. Property value 2. Automobile value

Our approach to modeling inflation impacts

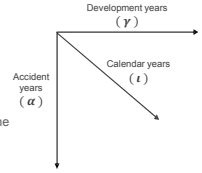


Step 1: Reserving model of choice
Probabilistic trend family

- The shortcomings of traditional link ratio methods, such as chain ladder method, have been explained in a number of actuarial literatures
- Application of the link ratio methods to statistical modeling framework may be based on implicit assumptions that are inconsistent with real-world scenarios
- Barnett and Zehnwirth developed a probabilistic modeling structure called probabilistic trend family (PTF) that provides substantial improvement
  - The PTF model can be understood as a model that consists of multiple simultaneous regressions
  - Barnett, Glen and Zehnwirth, Ben, "Best Estimates for Reserves" *Proceedings of the CAS, Volume LXXXVII, 2000.*

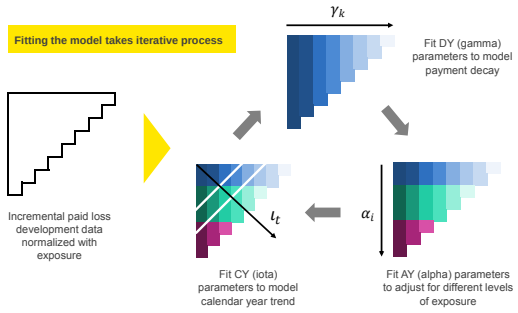
Step 1: PTF modeling of claim payments

- Goal of PTF modeling is to build a model that captures the trends and variability in the logarithms of the incremental data that show linear trends
- Data used
  - Incremental claim payment triangle
  - Exposure base
- Modeling framework
  1. Accident year (AY or alpha) trends – describes the level of losses within one accident year after adjusting for exposures
  2. Development year (DY or gamma) trends – describes the timing and magnitude of loss emergence for a given AY
  3. Calendar year (CY or iota) trends – describes the inflationary trend in the data
  4. Log-normal distribution (i.e., normal distribution on a log-scale) is fit to the variability of each cell

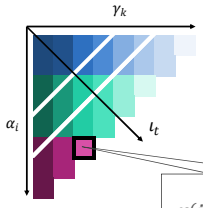


Step 1: Example of a PTF model building

Fitting the model takes iterative process



Step 1: Example of a PTF model



- Each cell in triangle is represented by a combination of α, γ and ι parameters as a series of simultaneous regression models
- Model generates a "fitted incremental paid triangle"

$$y(i,j) = \alpha_i + \sum_{k=1}^{j} \gamma_k + \sum_{t=1}^{i+j} \iota_t + \varepsilon_{i,j}$$

Ln (incremental loss in AY *i* and DY *j* per exposure)

AY loss level

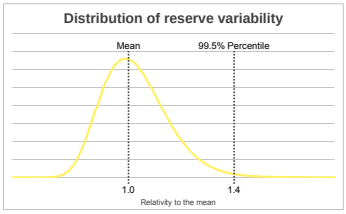
DY trend

CY trend

Error term

Step 1: Reserve variability distribution from PTF model output

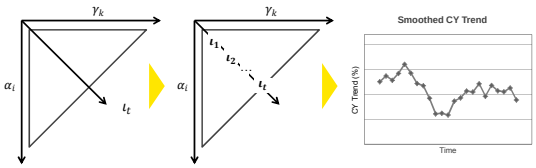
- The underlying data may not have sufficient history to capture the full spectrum of variability in the observable history
- The observable history itself may not be adequate to illustrate the variability under all potential future economic scenarios that may arise



Line of business	WC medical claims
Region	Countrywide
Reserve size	> $1bn
Number of simulations	10,000
Coefficient of variation	13%

Step 1: Extracting smoothed (five-year MA) annual calendar year trends

Fitted Model | **Saturate CY parameter** | **Imbedded annual calendar year trend**

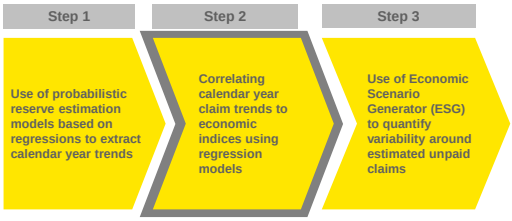


$$y(i,j) = \alpha_i + \sum_{k=1}^{j} \gamma_k + \sum_{t=1}^{i+j} \iota_t + \varepsilon_{ij}$$

- Fix AY (alpha) and DY (gamma) parameters, and saturate the model by inserting CY (iota) parameter for every year
- Model is refitted to extract annual CY trend for each year

- Value of CY parameters represent annual inflationary trend
- Smoothed through five-year moving average due to high volatility of single-year trend

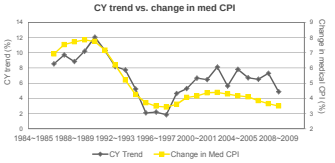
Our approach to modeling inflation impacts



Step 2: Correlating CY claim trends to economic indices

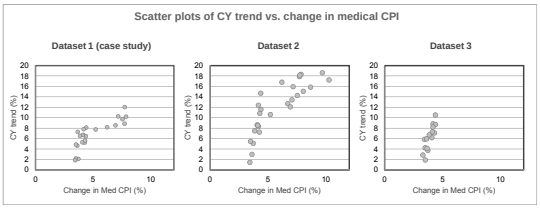
Approach:

1. Hypothesize that WC medical CY claim trends may be correlated with medical CPI
2. Take five-year moving averages of the CY trends extracted from the PTF model (this smoothes out the observed CY trends)
3. Take five-year moving averages of the year-over-year changes in medical CPI
4. Observed 82% correlation between CY trends and changes in medical CPI



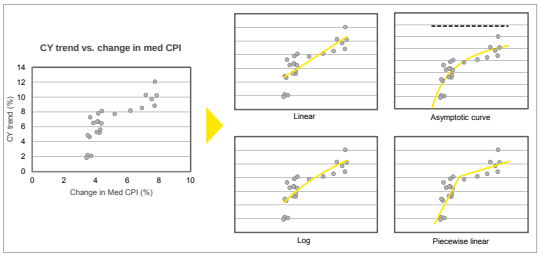
Step 2: Correlating CY claim trends to economic indices

- Multiple datasets exhibit similar patterns – the relationship levels off as the change in medical CPI increases
- Some datasets do not have enough history to capture the relationship under the high-inflationary environment



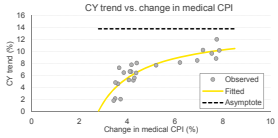
Step 2: Correlating CY claim trends to economic indices

- The relationship between CY trends and change in medical CPI can be modeled using various regression models depending on the underlying data



Step 2: Correlating CY claim trends to economic indices

- The relationship between CY trends and change in medical CPI can be modeled by $Y = A - B/(X-C) + \varepsilon$, where Y is CY trend, subject to a minimum of 0, X is medical CPI and ε is the error term
- Reason for this model:
  - Observed that CY trends increase at a decreasing rate as changes in medical CPI increases
- Asymptotic feature of the model:
  - The "A" parameter represents the horizontal asymptote, i.e., a maximum for the CY trend



Fitted equation

$$Y = 0.1381 - \frac{0.0025}{X - 0.01}$$

Our approach to modeling inflation impacts

Step 1	Step 2	Step 3
Use of probabilistic reserve estimation models based on regressions to extract calendar year trends	Correlating calendar year claim trends to economic indices using regression models	Use of Economic Scenario Generator (ESG) to quantify variability around estimated unpaid claims

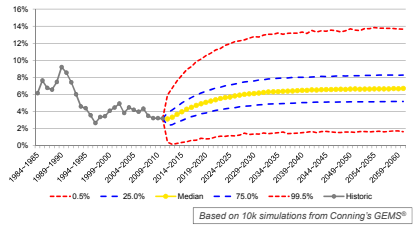
Step 3: Translating ESG simulated variability to CY trend variability

Correlate	Scale CY trends	Generate distribution
Use the regression formula to calculate the simulated future CY trends based on the ESG simulated outputs for future changes in Medical CPI.	Scale the calculated future CY trends so the mean value matches the selected long-term CY trend from the PTF model. This creates a distribution of future CY trends.	Apply the scaled CY trends to the future incremental claim payments forecasted by the PTF model. This creates a distribution of unpaid loss estimates.

Step 3: Use of ESG to simulate variability in future medical CPI

- ESG can provide a wide range of probabilistic future inflation scenarios
- Replace the CY trend variability in the model with the variability in the simulated future inflation scenarios from ESG

Historical and simulated change in medical CPI

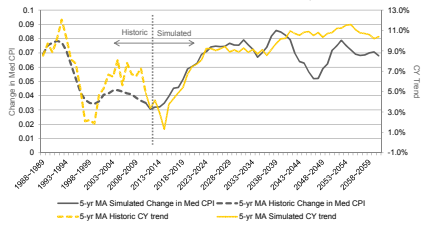


Based on 10k simulations from Conning's GEMS®

Step 3: Generate CY trend distribution

- Resulting CY trend is applied to the reserve model producing a distribution of reserve variability that incorporates ESG output

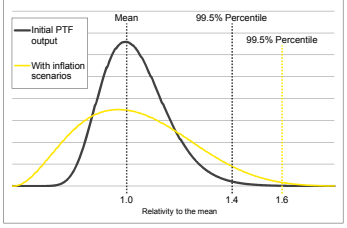
Modeled CY trend based on one simulated path



Step 3: Reserve variability distribution with ESG variability

- The variability of the unpaid claims has increased after incorporating the variability of future inflation scenarios from ESG

Distribution of reserve variability



Coefficient of variation	
Initial PTF output	With inflation scenarios
13%	22%

Potential applications and uses of our approach

- Other lines of business
  - Personal auto liability
  - Commercial auto liability
  - General liability
- Economic capital modeling
  - Allows for fully integrated modeling with inflation as the common risk driver between lines
- Scenario testing
  - Common request for stress testing models is to illustrate the impact of high-inflationary environment
- Loss reserve ranges
  - Financial reporting which truly incorporates an explicit level of inflation

Other approaches to modeling economic impacts

- Richard, William F., "Evaluating the Impact of Inflation on Loss Reserves," *Casualty Actuarial Society Discussion Paper, Program Casualty Actuarial Society,* Arlington, Virginia, May 1981.
- Butsic, Robert, "The Effect of Inflation on Losses and Premiums for Property-Liability Insurers," *Casualty Actuarial Society Discussion Paper Program, Casualty Actuarial Society,* Arlington, Virginia, May 1981.
- Schmid, Frank A., "The Workers Compensation Tails," *Variance, Volume 6, Issue 1, Casualty Actuarial Society,* Arlington, Virginia, 2012.

Q & A