Workers Compensation Loss Development Tail

Evidence from Large Workers Compensation Triangles

CAS Spring Meeting
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Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

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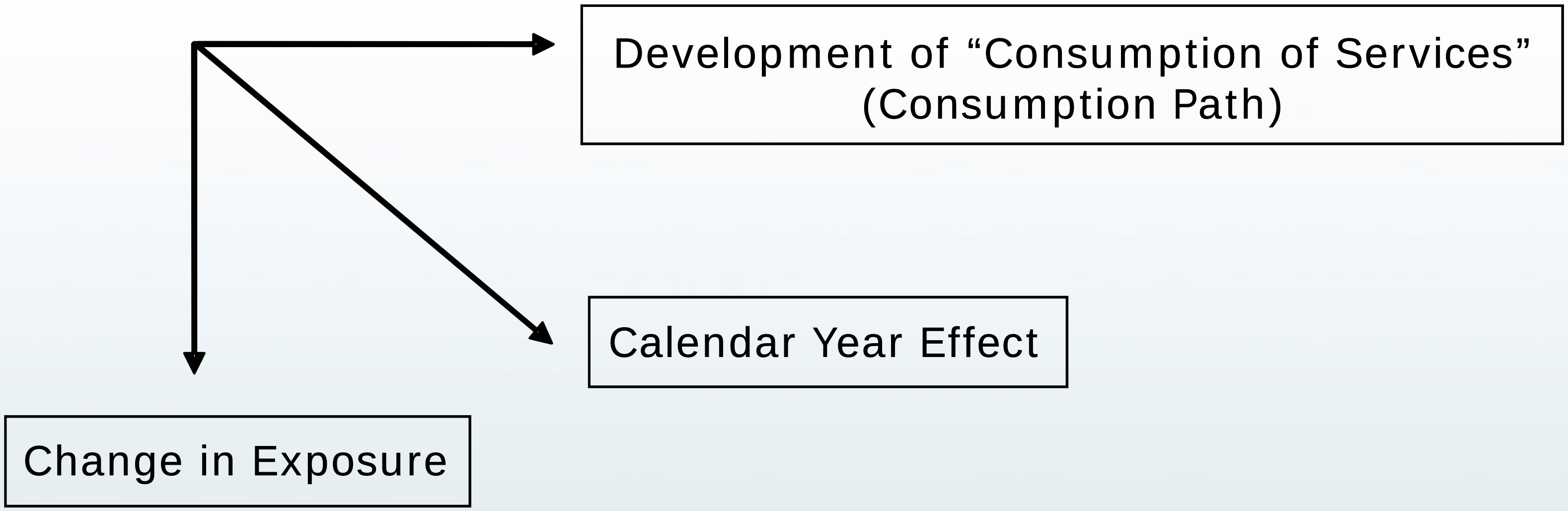
Large Indemnity and Medical Triangles

- Studying the payment pattern of workers compensation claims until closure requires triangles that comprise many decades of accident years—only very few such triangles are available for research purposes
- In what follows we present findings for a set of large indemnity and medical triangles
  - The SCF (State Compensation Fund) Arizona indemnity triangle comprises 74 years of development; the accident years range from 1930 through 2003. Due to a dearth of data for accident years 1930-1937, these eight years are excluded from the analysis, thus reducing the triangle to 66 development years
  - The SAIF Corporation (State Accident Insurance Fund Corporation, Oregon) triangle comprises the medical component of permanent disability claims; the accident years run from 1926 through 2005. Due to the sparseness of the data, the first nine accident years (1926-1934) are discarded, thus reducing the triangle to 71 development years

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

Triangle Dynamics



For this architecture of triangle analysis, see Glen Barnett and Ben Zehnwirth, “Best Estimates for Reserves,” Casualty Actuarial Society Proceedings Vol. 37, No. 167, pp. 245-321, 2000, http://www.casact.org/pubs/proceed/proceed00/00245.pdf

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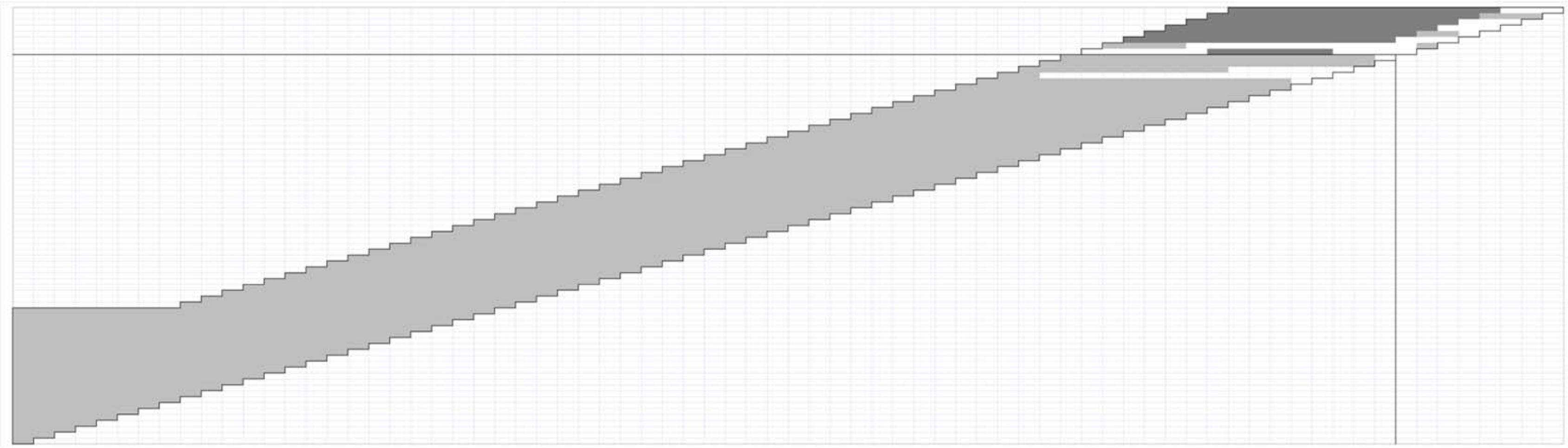
The SCF Arizona Indemnity Triangle

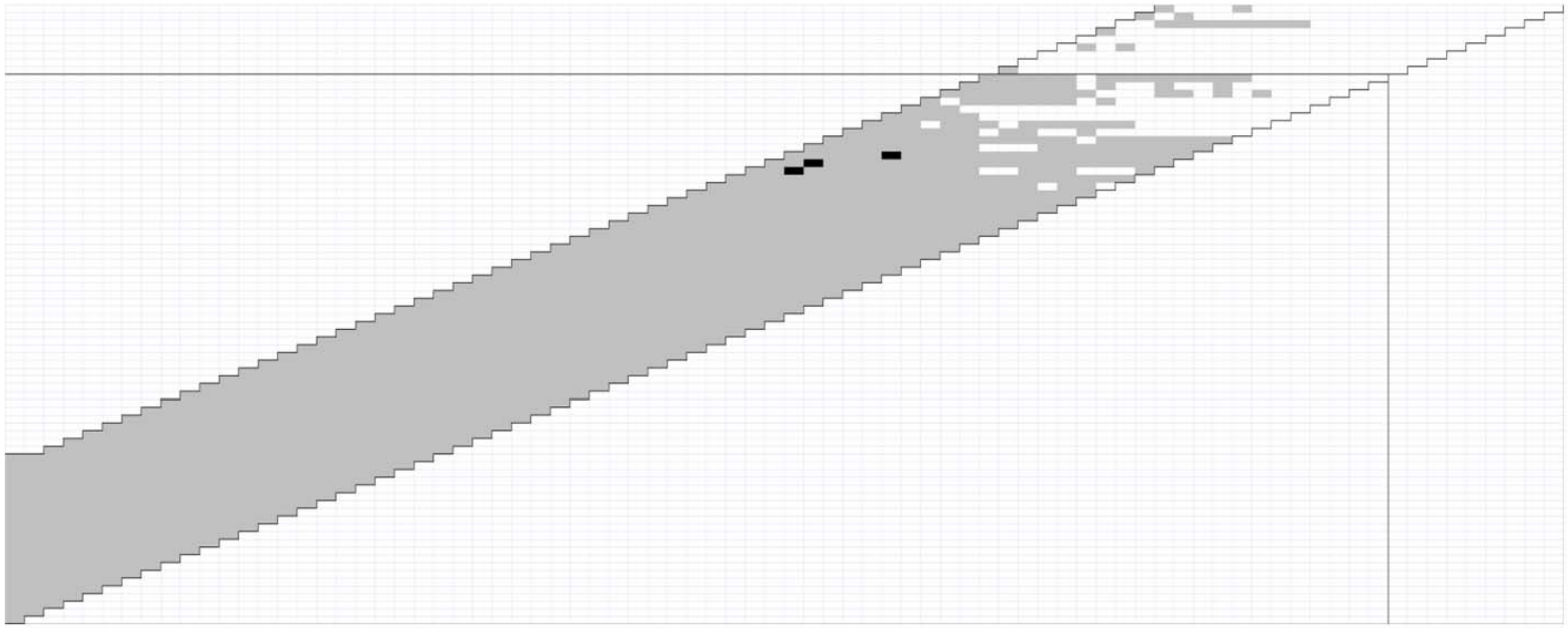


Positive incremental payments are shaded light gray, and incremental payments at zero amounts are left white; there are no negative incremental payments. For the cells shaded dark gray, no payment information is available. In the analysis, only the triangle within the rectangular box (accident years 1938-2003; 66 development years) is used.

Data source: Arizona State Compensation Fund

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

The SAIF Corporation PTD Medical Triangle



Incremental payments at positive amounts are shaded gray, incremental payments at negative amounts are marked black, and incremental payments at zero amounts are left white. In the analysis, only the triangle within the rectangular box (accident years 1935-2005; 71 development years) is used.

Data source: State Accident Insurance Fund Corporation, Oregon

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

Main Features of the Statistical Model (1/3)

- The model is Bayesian and estimated using MCMC (Markov-chain Monte Carlo simulation)
- The model fits to the logarithmic incremental payments
- The likelihood is a *t*-distribution, which is implemented as a scale mixture of normal distributions
  - The degrees of freedom of the *t*-distribution are determined within the model. The lower the degrees of freedom are, the heavier the tails of the distribution are. By allowing for heavy tails, the model is robust to outliers
  - Using a second-order random walk smoother, the scale parameter of the *t*-distribution is allowed to vary in development time (that is, is allowed to vary by development year)
- A Bernoulli distribution (the parameter of which varies on a Gompertz curve in development time) accounts for the variation in the probability of observing a payment in a given column

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

Main Features of the Statistical Model (2/3)

- The model uses reversible jump MCMC for determining the optimal degree of smoothing of the path of the consumption of services (as measured by the exposure-adjusted and calendar year effect-adjusted logarithmic incremental payments)
  - Reversible jump MCMC is a concept of Bayesian model averaging; this way, the estimation process accounts for model uncertainty
- Due to reforms in Oregon in 1990, the model allows for a structural break in the consumption path of medical services
  - Generally, the location of the breakpoint is determined by the model within a provided interval of exposure years. Due to the sparseness of the data and the knowledge regarding the timing of the reform, the interval comprises a single accident year only, making 1991 the first post-reform year

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

Main Features of the Statistical Model (3/3)

- The calendar year effect is modeled as a normal distribution around an expert prior for the rate of inflation (which is zero for indemnity, as there is no cost of living adjustment in Arizona, and equals the M-CPI rate of inflation for medical)
- The rate of exposure growth is modeled as a draw from a normal distribution; using a second-order random walk smoother, the scale parameter of the normal is allowed to vary in development time (that is, is allowed to vary by accident year); this is to control for heteroskedasticity
- For the medical triangle, future rates of inflation are simulated using a discrete Ornstein-Uhlenbeck process that has been calibrated to annual data of the M-CPI rate of inflation—in this first-order autoregressive process, the rate of inflation reverts to its historical mean at the rate embodied in the history of available data

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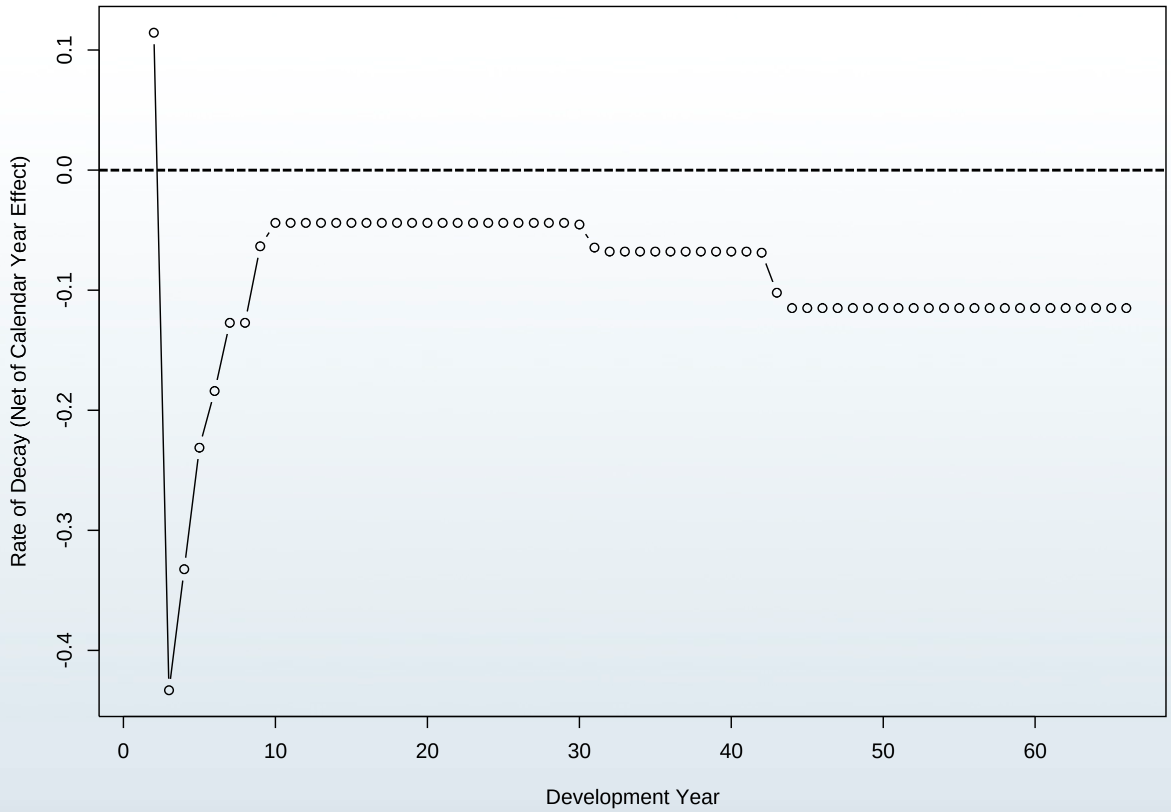
R package *lossDev*

- A model akin to the one applied here has been bundled into the R package *lossDev*
  - The R package *lossDev* runs on Microsoft Windows (32 bit) and Linux platforms and is available for download at http://cran.r-project.org/web/packages/lossDev/index.html
    - There is a vignette with two worked examples
    - We are in the process of building a 64 bit MS Windows version of *lossDev*
  - For an introduction to the model and the R package, see the session "An Introduction to Monte Carlo Markov Chain (MCMC) Methods for Bayesian Analysis" at this CAS Spring Meeting, moderated by Glenn Meyers
  - A working paper, entitled "Robust Loss Development Using MCMC," provides a detailed description of the model and is available at http://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=101739

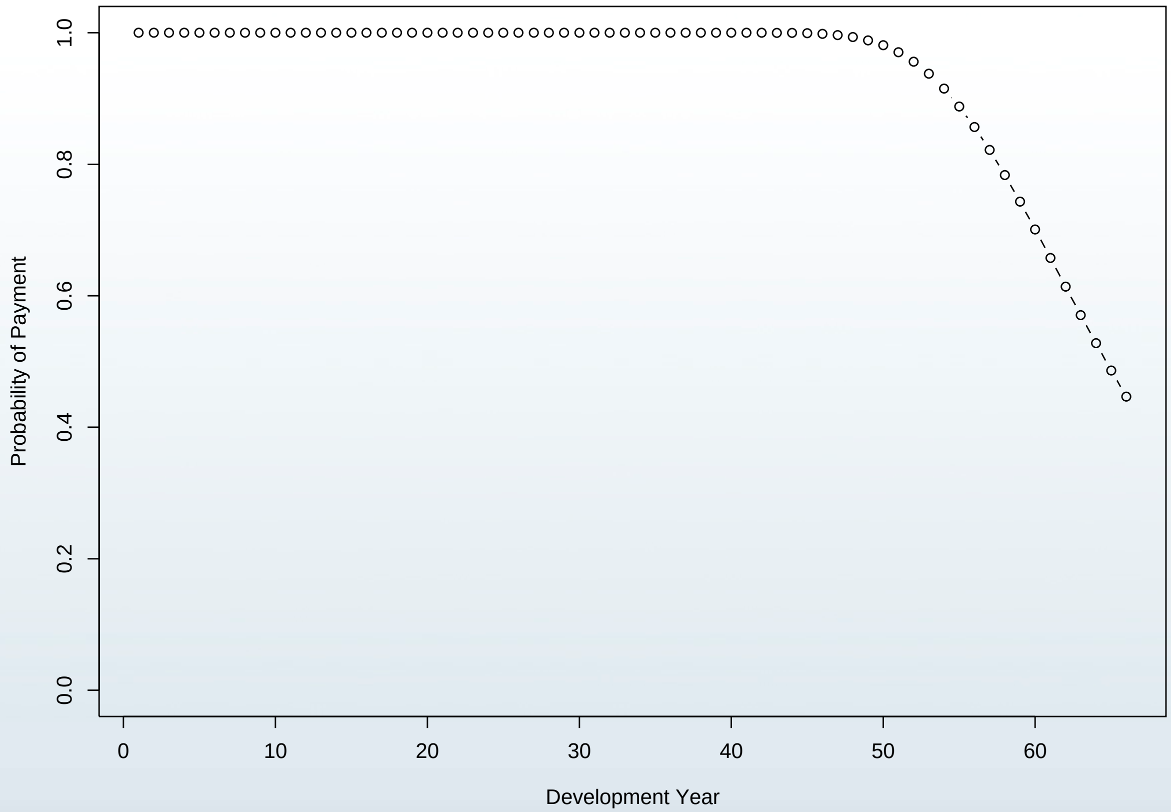
Development of Indemnity Consumption



- The chart displays the rate of change in the consumption (per development year) of indemnity benefits
- Consumption is defined as indemnity payments, adjusted for calendar year effects (which, where applicable, include cost of living adjustments)
- The decline of consumption quickens, following the rate of mortality of the cohort of injured claimants

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

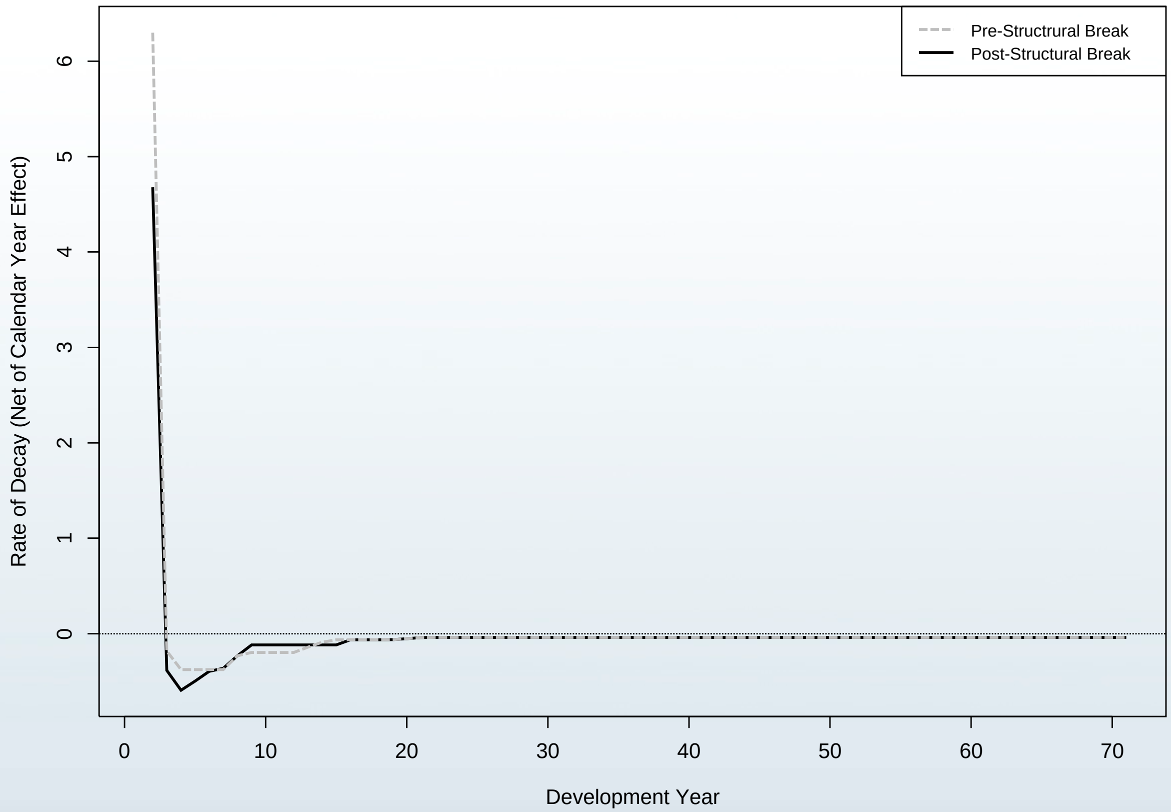
Probability of Observing an Indemnity Payment



- The chart displays the probability of observing a nonzero incremental payment
- The trajectory of this probability is estimated using a Gompertz curve
- The trajectory was treated as uniform across accident years (although increased exposure may increase the probability of observing a payment, all else equal)
- Assuming that longevity improves with exposure years, the trajectory has to be shifted to the right when simulating ultimate losses

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

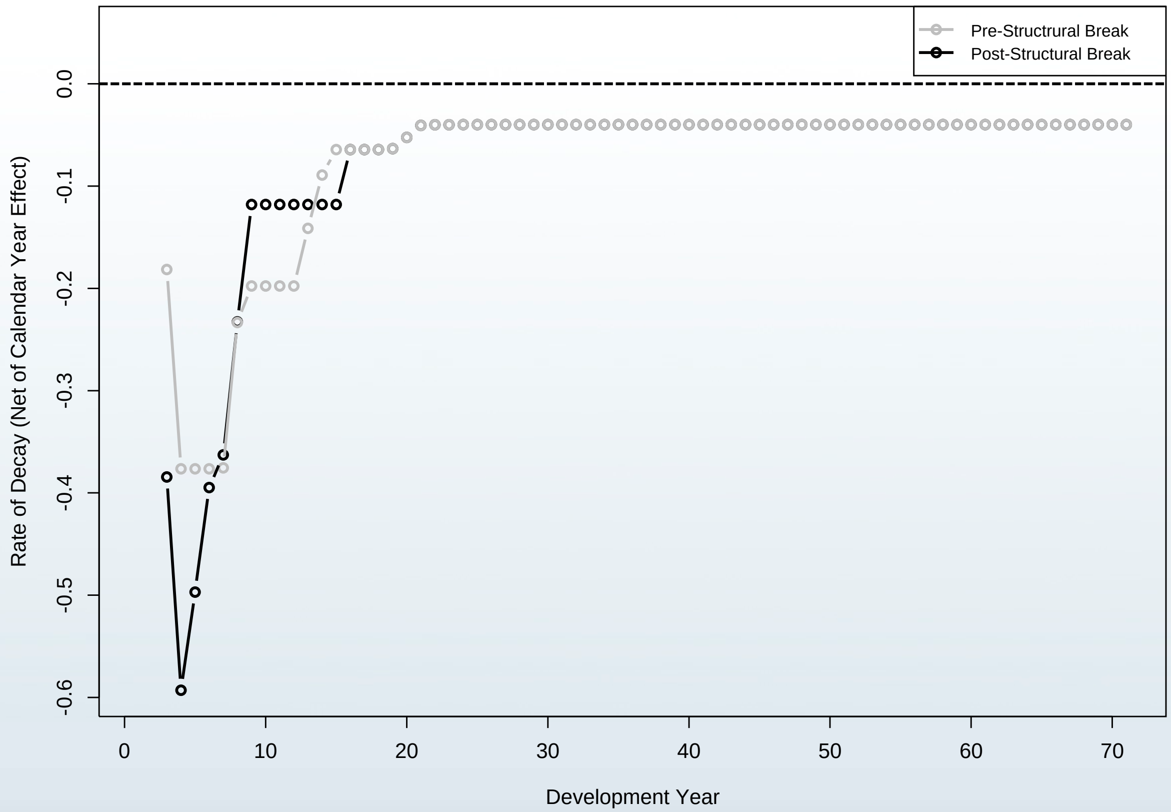
Development of Medical Consumption (1/2)



- The chart displays the rate of change in the consumption (per development year) of medical benefits
- Consumption (per development year) is defined as incremental medical payments adjusted for calendar year effects (which include inflation)
- There is a structural break in consumption, which is related to cost containment reforms in Oregon in 1990

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

Development of Medical Consumption (2/2)



- The chart details the rate of change in the consumption of medical benefits by leaving out the first two development years
- The rate of decline of consumption stabilizes around development year 20, which implies that from then on, the increase in the rate of mortality is partially (and at constant proportion) offset by an increase in the rate at which consumption of medical services grows among the remaining claimants
- The cost containment reform of 1990 has lead to an accelerated run-off during the first couple of development years

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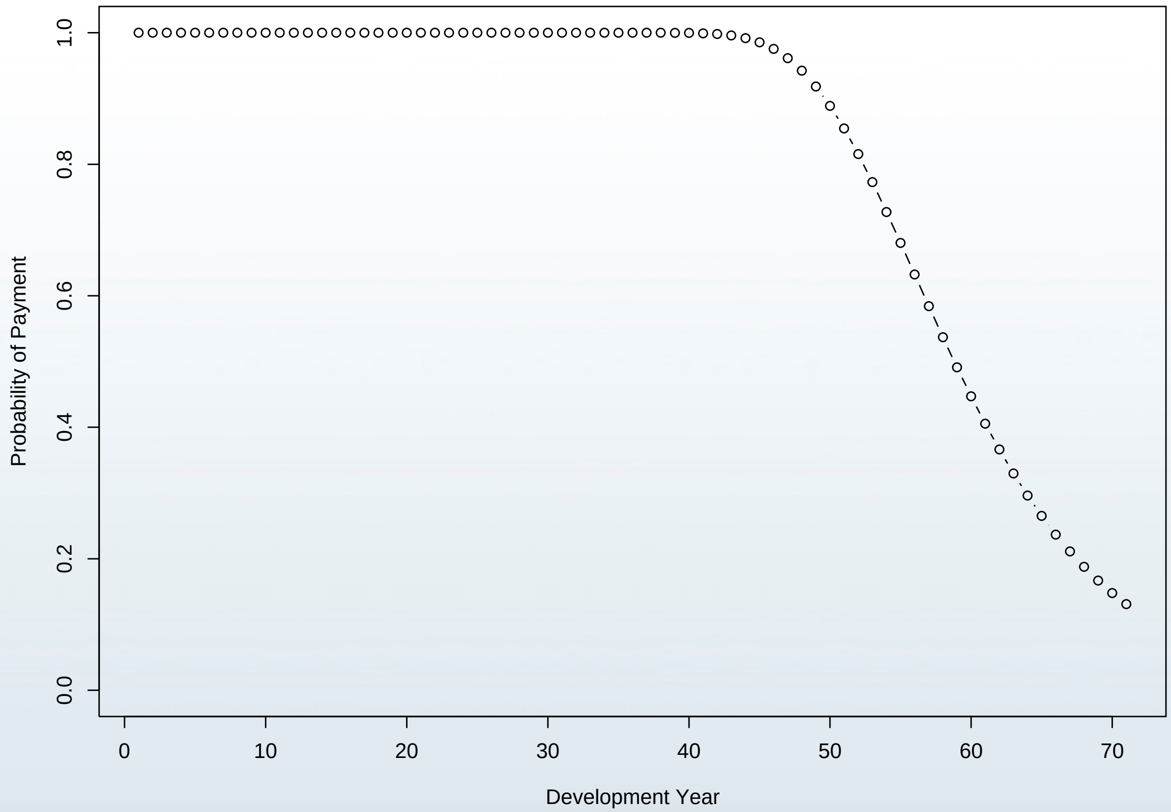
Probability of Observing a Medical Payment



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- The trajectory was treated as uniform across accident years (although increased exposure may increase the probability of observing a payment, all else equal)
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Simulating Medical Losses

- The rate of decay in the consumption of medical services assumes a stationary (negative) value after about 20 development years
  - This implies that, as a cohort of claimants of a given exposure year ages, the acceleration of mortality is offset partially and at a constant proportion by an acceleration of consumption of medical services on the part of the survivors
  - Further, a stationary rate of decay of medical consumption allows for straightforward simulation of ultimate losses where the age distribution of the injured cohort is available (or can be approximated)
  - Future rates of medical inflation may be simulated using a discrete Ornstein-Uhlenbeck process that has been calibrated to the rate of M-CPI inflation
    - Note that any systematic difference between the (logarithmic) rate of M-CPI inflation and the actual and unobservable (logarithmic) rate of inflation for medical workers compensation services factors into the (logarithmic) rate of decay of consumption of medical services and, hence, is of no concern
- Legislative reforms, such as the 1990 cost containment reforms in Oregon, may accelerate the decay in the consumption of medical services

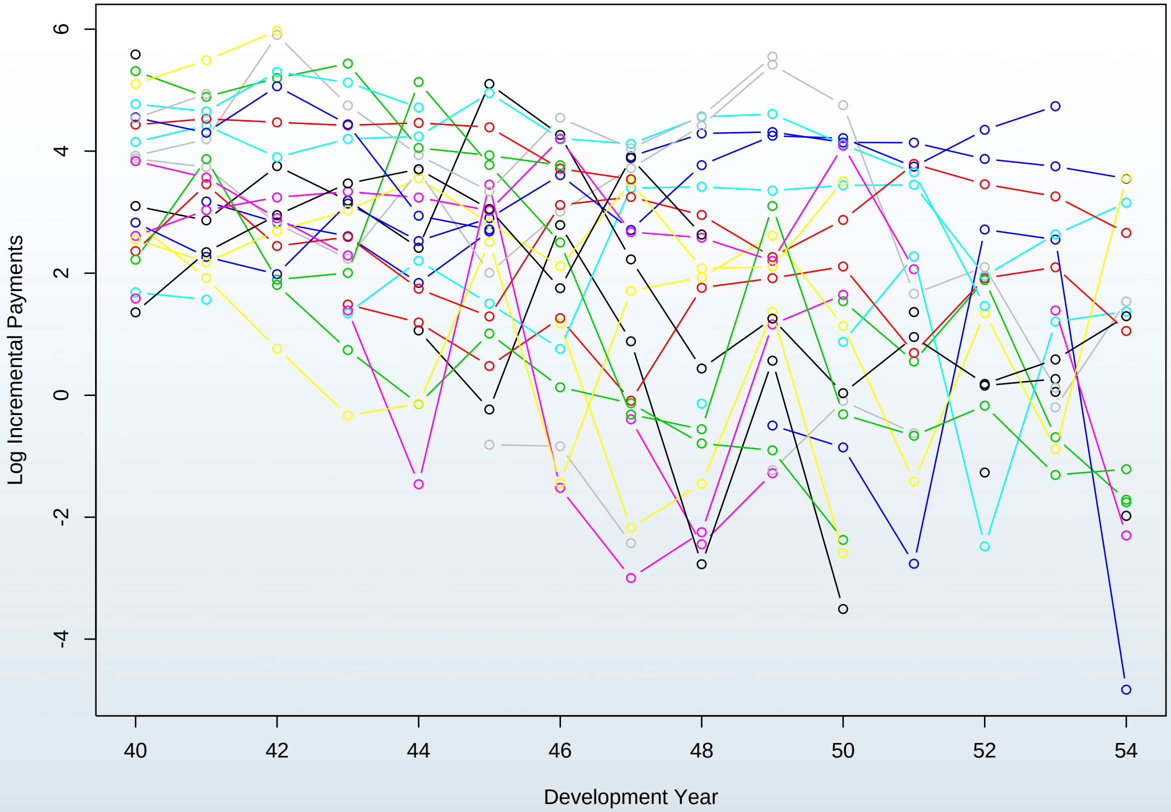
Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

Discussion

- The finding of a stationary rate of decay of medical consumption (after about 20 development years) differs from earlier findings by Richard E. Sherman and Gordon F. Diss ("Estimating the Workers' Compensation Tail"), who discover a bulge in incremental payments between development years 40 and 52, approximately
  - Note that Sherman and Diss analyzed the same triangle, except that their accident years run through 2002 (instead of 2005), and they do not discard accident years 1926-1934 (which comprise a total of 16 payments)
- Sherman and Diss posit that such bulge in payments is due to "added costs of caring for the elderly"
  - An alternative explanation for the bulge in payments is a spike in volume caused by accident year 1945 and, to a lesser degree, accident year 1946—these payments start in development years 41 (accident year 1945) and 40
  - For instance, the volume of payments (summed up within the window of observed development years) in 1945 (1946) is 17.4 (6.5) times as high as in 1944, and 11.4 (4.2) times as high as in 1947

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

Raw Incremental Payments on the Log Scale

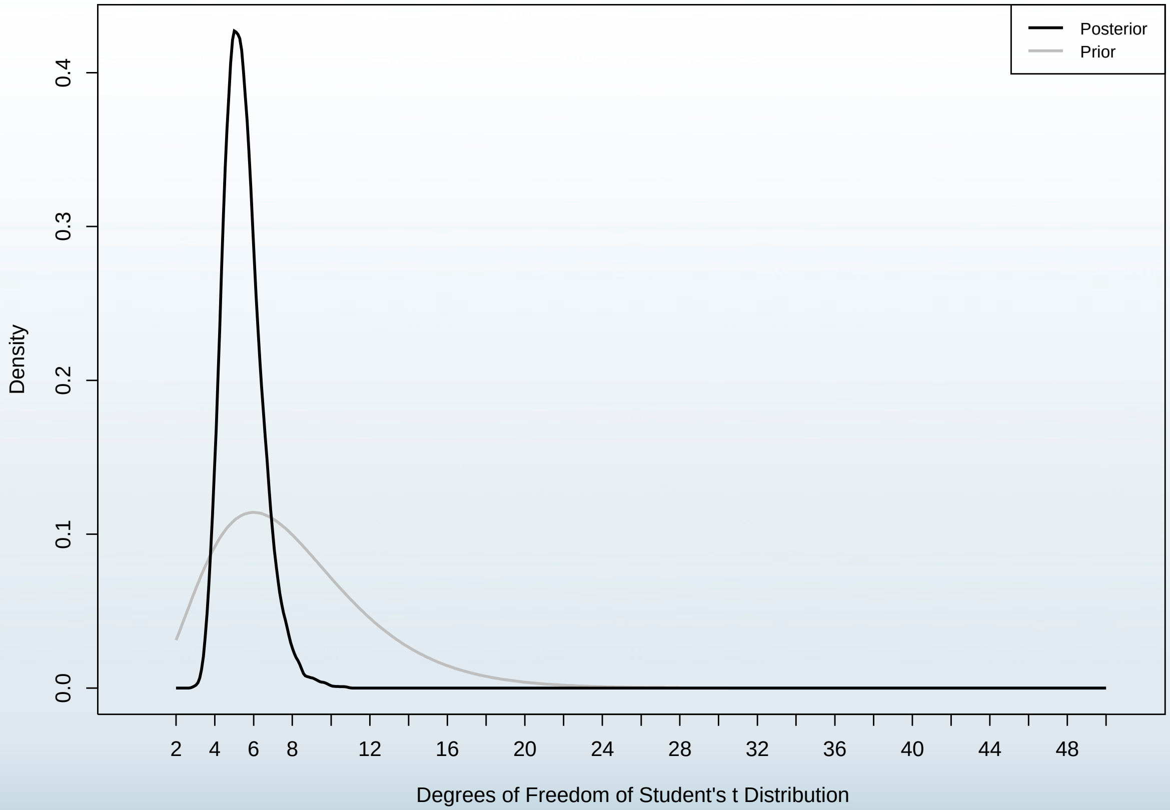


- The chart displays the incremental payments (expressed as natural logarithms) between (and inclusive of) development years 40 and 54
- There are missing values due to payments being at zero or negative amounts
- Lines that start farther to the right tend to be associated with older accident years (and, hence, lower levels of payments), thus giving the (potentially erroneous) impression that the incremental payments are declining as losses develop

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

Appendix

Degrees of Freedom of Student's *t*: Indemnity

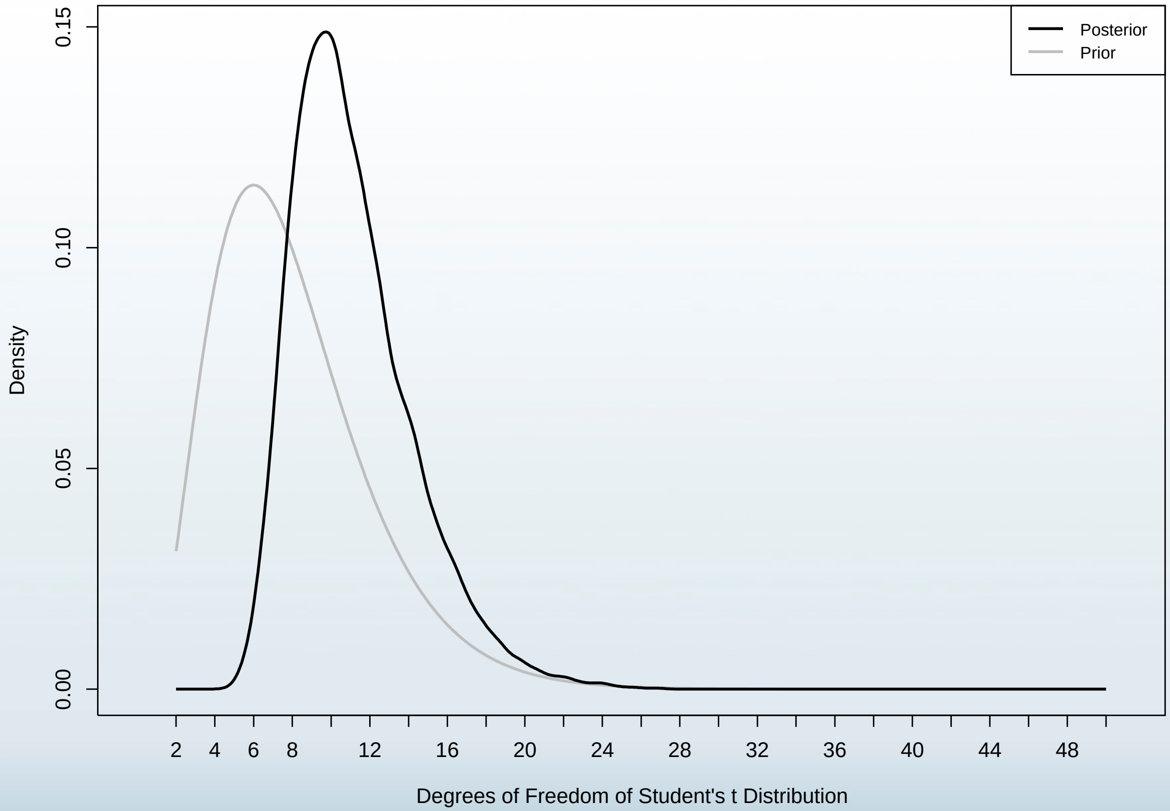


- The chart displays the prior distribution and a kernel density estimates of the posterior distribution of the degrees of freedom
- The estimated degrees of freedom indicate that incremental indemnity payments have heavy tails

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

Appendix

Degrees of Freedom of Student's *t*: Medical



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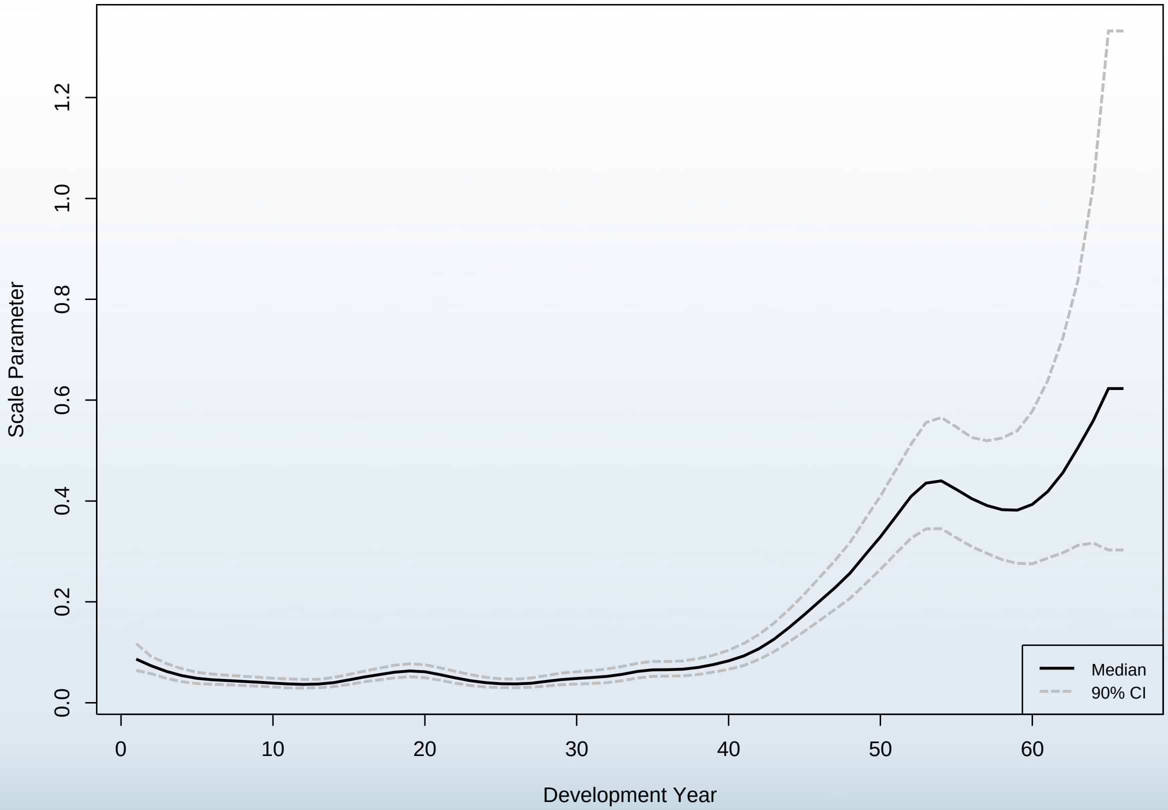
Appendix

Scale Parameter of Student's *t*: Indemnity



- The chart displays the scale parameter of Student' *t* distribution
- The (log of the square of the) scale parameter was smoothed using a second-order random walk with an inverse gamma(5,0.5) prior for the innovation variance
- The dashed lines indicate 90 percent credible intervals—these intervals are reflective of the degree of smoothing

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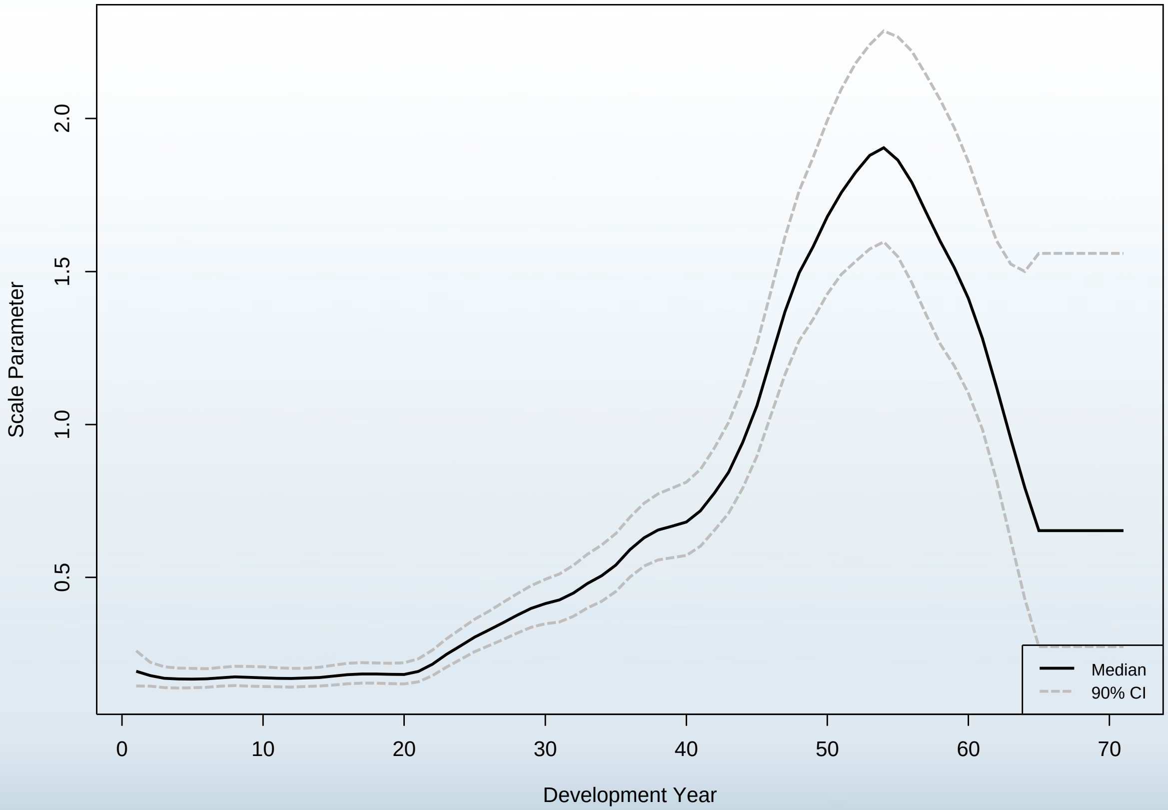
Appendix

Scale Parameter of Student's *t*: Medical



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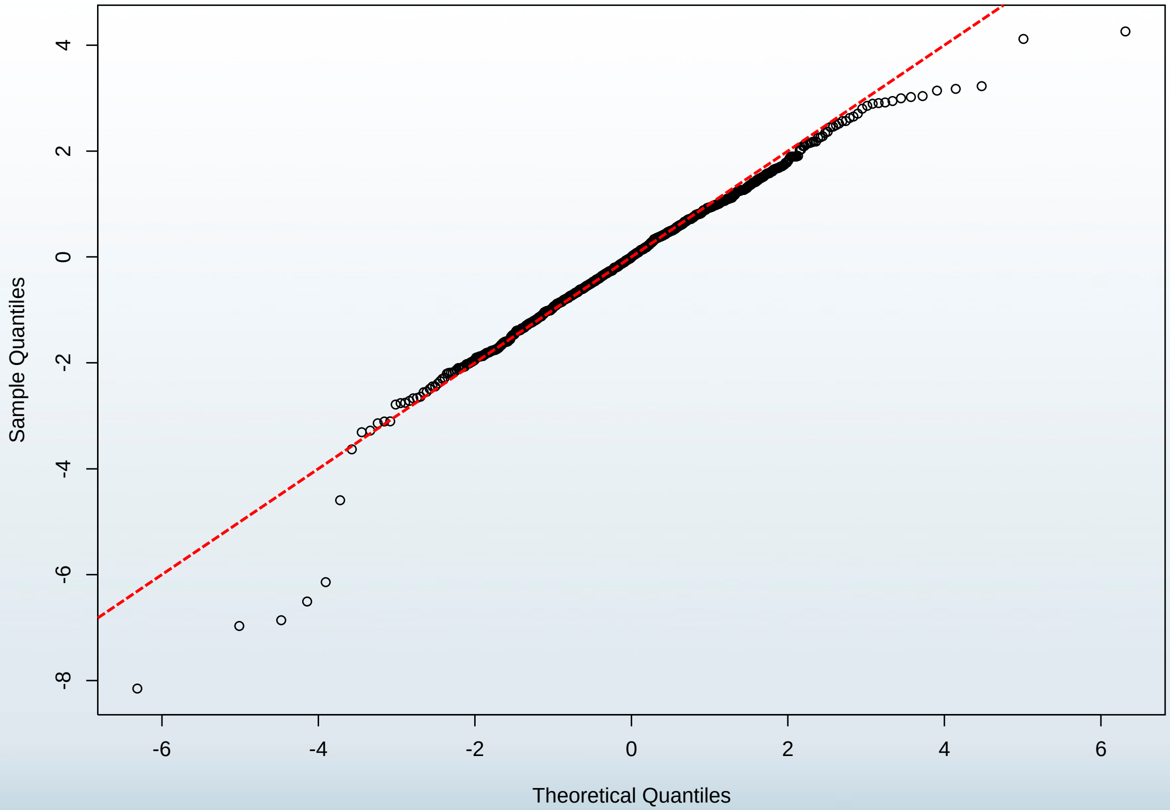
Appendix

QQ Plot of Standardized Residuals: Indemnity



- The chart displays a QQ plot for the standard-*t* distribution with degrees of freedom equal to the estimated mean
- The residuals shown in the chart were normalized by the scale parameter of the *t* distribution, "draw by draw"
- The chart displays a mild degree of skewness in the residuals

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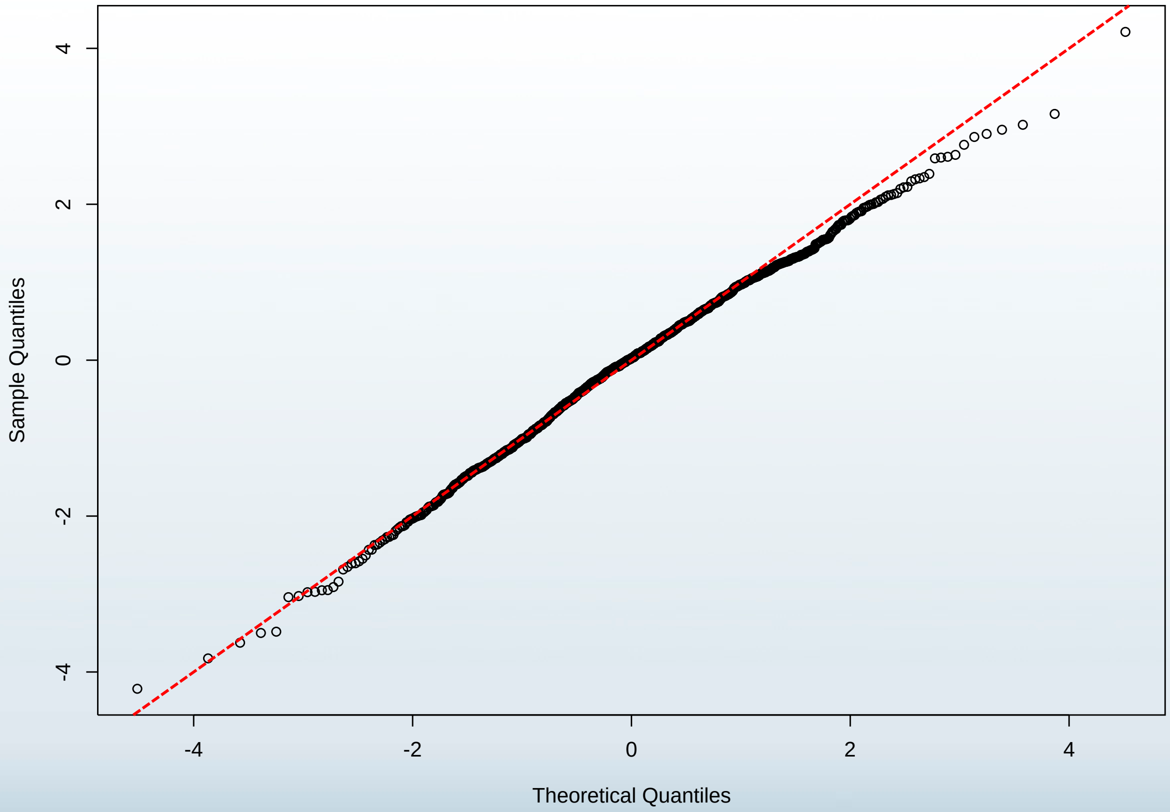
Appendix

QQ Plot of Standardized Residuals: Medical

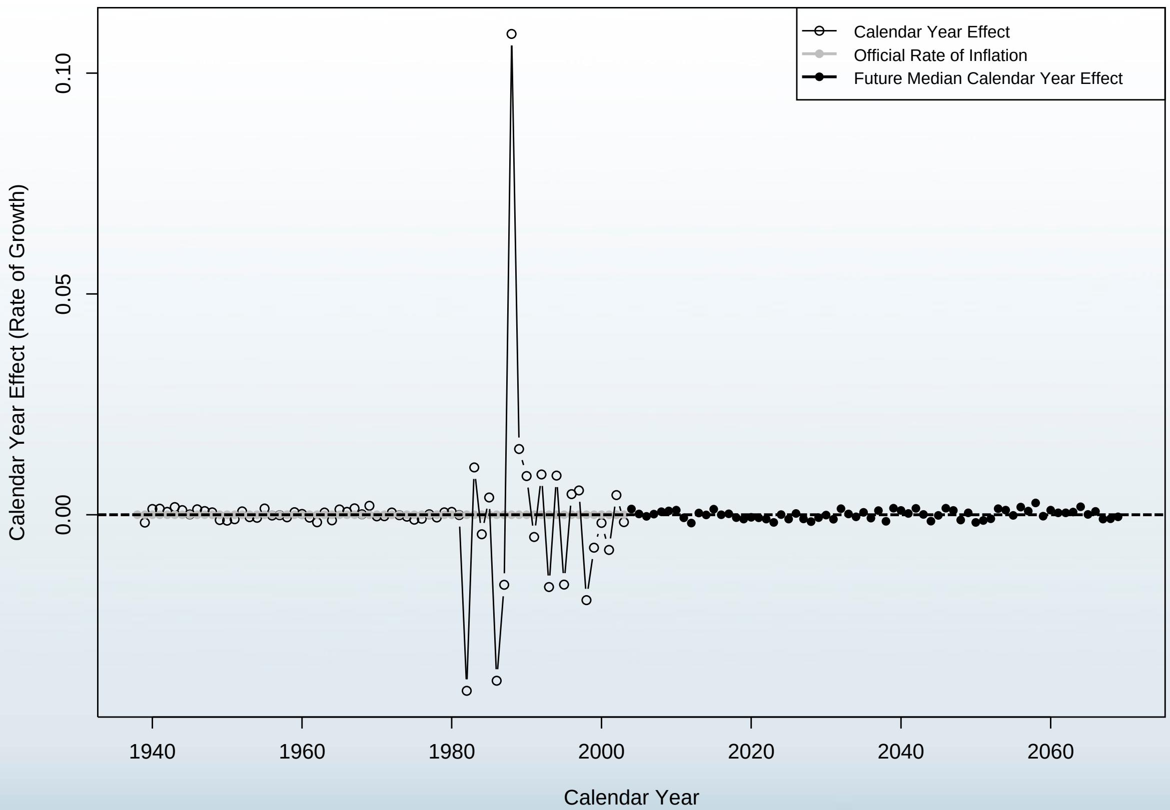


- The chart displays a QQ plot for the standard-*t* distribution with degrees of freedom equal to the estimated mean
- The residuals shown in the chart were normalized by the scale parameter of the *t* distribution, "draw by draw"
- The chart shows that Student's *t* distribution is appropriate for modeling the log incremental medical payments

Source: Schmid, Frank A. (2009) *The Workers Compensation Tail Revisited*, First Draft: January 2009; Revised: September 2009, http://www.ncci.com/documents/CASJournal-Schmid.pdf

Appendix

Calendar Year Effect: Indemnity



- The chart displays the calendar year effect
- Arizona has no cost of living adjustment for indemnity claims
- The first 43 diagonals of the SCF Arizona triangle are not populated (and another 7 diagonals are populated only in the first couple of development years)—thus, in the early calendar years, the means of the posteriors for the calendar year effects equal the expert priors (net of sampling errors)

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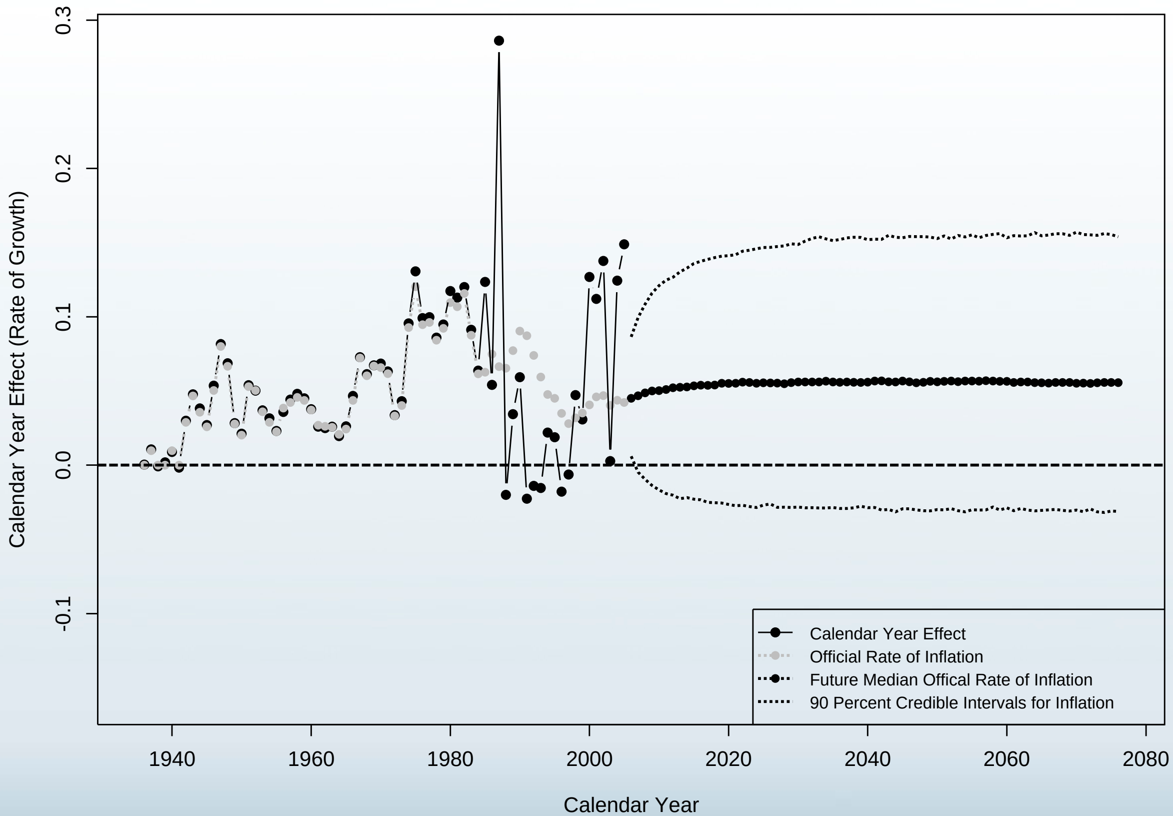
Appendix

Calendar Year Effect: Medical



- The chart displays the calendar year effect, inclusive of the simulated future rates of inflation
- The first 49 diagonals of the SAIF Corporation triangle are not populated (and the first populated diagonal has only one incremental payment)—thus, in the early calendar years, the means of the posteriors for the calendar year effect equal the expert priors (net of sampling errors)

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