Customizing the Public Access Model Using Publicly Available Data

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Abstract

Dynamic Financial Analysis is an extremely powerful tool for all aspects of the insurance operation. With the constantly increasing amounts of information available to the public, DFA models can be better customized to fit the needs of the end user. This paper will examine several areas in which a publicly available model can be customized to fit a company's specific management structure and risk management priorities. Specific approaches to these customizations will be provided along with possible data sources, reasonableness checks, and potential advantages and disadvantages of each approach. Where possible the paper will use publicly available data in order to provide the reader with available sources for developing DFA applications like this one.

Introduction

This paper will discuss specific areas to consider for customization in a DFA model, alternative approaches to take in performing such a customization, available sources of data to aid in the changing of the parameters, and advantages and disadvantages of the tactics presented. We will provide general commentary on the area of customization and then specific examples using the workers compensation line as an example.

We will discuss four general areas of model parameterization: Interest Rate and Economic Condition Modeling, Premium Modeling, Loss Modeling, and Other Modeling Considerations. First, we will briefly describe the model.

About DynaMo

The model used in this analysis is DynaMo by MRH&T[1]. Dynamo is a publicly available model, which allows DFA users to learn about DFA in a forum which proprietary systems do not allow. It is intended to be a learning tool for the public and to help generate ideas on DFA. It has been developed using Excel to facilitate real-time run times and ease of use. DynaMo is completely open so as to help in the understanding of the intricacies in developing and running a DFA model. This includes the formulas for assets, liabilities, and interest rate models. All parameters are readily accessible and can be easily changed. Since every company is different and some parameters may not be appropriate, it is recommended that the users review these parameters prior to using the model.

The model can be thought of as a combination of interactive asset and underwriting cashflow generators. As new money becomes available, either from investments or premiums, underwriting and tax cashflows are generated and any remaining monies are reinvested. Should the outflows exceed the inflows, assets are sold to cover the difference. These cashflow generators are tied together by the workhorse variable -- the interest rate. Exhibit 1 displays a general schematic of the data flows within the model.

The model contains a number of inputs, including company specific historical data and model parameters. Much of the historical data inputs can be taken directly from the company's year-end actuarial report and Annual Statement. In addition to these inputs, economic and underwriting cycle parameters are required. These parameters, combined with some of the company specific input, are used to stochastically generate the following variables:

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[1] DynaMo can be downloaded free at www.mrht.com.

1. Underwriting Frequencies	6. Yield Curve
2. Underwriting Severities	7. Claims Inflation by Line of Business
3. Loss and LAE Payment Patterns	8. Equity Returns
4. Catastrophic Losses	9. Underwriting Cycle Positions
5. Short Term Interest Rates	

These variables are used to quantify the following risk categories to which companies are exposed:

1. Pricing
2. Loss Reserve Development
3. Catastrophe
4. Investment

The model generates cashflows at an exposure level basis to aid in the quantification of the impact of the variables listed above. In particular the loss ratio is not modeled in total but calculated as the result of its components.

Future premiums are generated by the following two step process: 1) adjust the previous periods average rate per exposure to reflect inflation, company rate changes, jurisdictional, and underwriting cycle (competitive) impacts, and 2) multiply the adjusted average rate per exposure by the future exposures. For example, the starting average rate may be $100, the modeled rate change 6%, and estimated exposures of 1,000. This would lead to written premium of $106,000.

A-priori ultimate losses for future years are generated by multiplying the exposures by the stochastically generated frequencies and severities. These frequencies and severities are adjusted to reflect inflation and underwriting cycle impacts. For example, inflation may force the average severity upwards and the underwriting cycle may indicate that the market is softening thus bringing riskier business into the company and higher frequency of loss. By breaking the loss ratio into its pieces, we are able to adjust each of its components to reflect the changing economic and competitive environment. It is particularly useful to model the components of the loss ratio when considering the impact of inflation and unemployment.

Two previous papers by this DFA research team provide additional information about the development and application of DFA models generally and this model specifically. The general approach used in this model, the key risks of U.S. property-liability insurers subject to modeling, the parameters incorporated in the financial aspects of the model and examples of the output are described in D'Arcy, Gorvett, et al. (1997)[2]. An application of an enhanced version of the original model to a multiline, multistate primary insurance company is described in D'Arcy, Gorvett, et al. (1998)[3]. This paper includes a case study examining several of the key features of the model, the process of parameterizing the model and refining the results, and the communication process with a company's management team.

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[2] D'Arcy, Stephen P., Richard W. Gorvett, Joseph A. Herbers, Thomas E. Hettinger, Steven G. Lehmann, and Michael J. Miller (1997) "Building a Public Access PC-Based DFA Model," Casualty Actuarial Society *Forum*, Summer 1997, Volume 2, pp. 1-40.
[3] D'Arcy, Stephen P., Richard W. Gorvett, Thomas E. Hettinger, Robert J. Walling III (1998) "Using the Public Access DFA Model: A Case Study," Casualty Actuarial Society *Forum*, Summer 1998 Edition, pp. 53-118.

INTEREST RATE AND ECONOMIC CONDITION GENERATION

Before discussing the modeling of the fundamental insurance variables, it is best to review the key economic drivers involved in the model. Particular discussion should be provided about the workhorse variable -- interest rates. The model utilizes generated interest rates to affect other relevant economic variables.

Cox-Ingersoll-Ross Interest Rate Generator

Recognizing that an interest rate model requires definition as to precisely what type of rate will be modeled, we chose short-term treasury rates as the base rate resulting from model generations. In particular, we will model 90-day treasury rates on an annual basis.

As discussed in D'Arcy et al. (1997), Cox-Ingersoll-Ross (CIR) provides a workable process for modeling interest rates. CIR offers a mean-reverting random walk, where interest rates are projected by modeling incremental movements in interest rates. These increments are the sum of mean-ward and purely random generated movements. We provide the formula on Exhibit 2. This process is advantageous in that it balances flexibility, simplicity, and intuitive appeal. CIR, by itself, is merely a parameter driven formula concept; it is not intended to be a completely comprehensive or universally accurate system of projection methodologies. Nonetheless, it appears to suit most DFA modeling purposes quite well.

Appropriate parameterization of interest rates demands that one study historical interest rate data as a method for assuring reasonableness. From links to the CAS DFA Web Site[4], a monthly time series was available as shown in Exhibit 3. Observing a graph of several decades of data, our parameter analysis ultimately focused on T-Bill rates observed since 1983. This choice was made to avoid reliance on the unusual economic conditions prevalent early in the 1980's, combined with the belief that future interest rates may remain relatively low in future years given the recent emergence of a balanced federal budget. The long term mean, b, we ultimately selected for the subject model was 6.0%.

CIR also demands that the user provide a mean reversion parameter, a. This was selected based on our judgment in consideration of the historical movements observed about the long-term mean. We selected .25 as the frequency of reversion parameter, a, indicating that we believe the rate should revert around b approximately every four years.

The random element discussed above is the last parameter to select. The standard deviation of the generated normal variate, s1, represents the volatility parameter of CIR. It is projected by observing the standard deviation of prior annual incremental movements in T-Bill rates. We have selected 1.40 as, s1, the volatility parameter.

How do we assure CIR is providing us with a reasonable interest rate result? We use two techniques to accomplish parameter validation: 1) descriptive statistic analysis, and 2) graphical validation. First, we observe the basic descriptive statistics of the historical data in comparison to the same measurements of the projected interest rates. For example, over the process of 100 CIR trials, the mean of the projected data should approximate b (adjusted to consider the impact of low initial rates), and the standard deviation of incremental movements should also approximate s1. Second, we utilized basic spreadsheet graphing

[4] http://www.stls.frb.org/fred/data/irates/gs3m is "hot-linked" to the CAS's website at http://www.casact.org/research/dfa/appendix1.htm

processes to analyze the graphical behavior of historical rates versus projected rates. This was accomplished by recalculating the random generation process several times and illustrating to our own eyes the graphical reasonableness of the projection range. Exhibit 3 shows a single iteration of this process.

Finally, CIR creates a term structure for longer-term treasury maturities. Due to the relatively long duration of assets and liabilities, we felt this property of the yield curve was a variable we should model directly. Therefore, using a slight departure from CIR's original term structure formula; we separately modeled a stochastic spread variable, p. Defined as the difference between 90-day T-Bills and 30 Years T-Bonds, p is projected by a normal random process, using selected mean and standard deviations based on historical spread observations. To project T-Bill rates at points between 90 day and 30 years we utilized an arctangent curve. This provided the proper first (increasing) and second (concave down) derivatives of a typical yield curve. We found that this form also accommodated an inverted yield curve. A graphical validation similar to the 90-day validation process is shown in Exhibit 4.

Inflation Models

Based on the expectation of a positive correlation between interest rates and general price inflation, we utilized a simple linear modeling process shown on Exhibit 5. The critical parameters to be analyzed, therefore, are the slope, m, and intercept, b, of the line as well as the volatility parameter, s2. CPI data[5] was obtained from the CAS DFA Web Site, and a linear regression was run between the 90-day T-Bill rates and the CPI data. We present the regression results on Exhibit 5. The graphical illustration of the fitted general inflation is shown on Exhibit 6.

General inflation should be distinguished from the inflation components affecting workers compensation premiums and loss. These components include wage inflation and medical inflation. Wage inflation[6] was also retrieved from public sources and was compared via its basic statistical properties to CPI data. Our basic observation was that wage inflation and general inflation rates did not differ materially. As a result we used the general inflation variable as representative of wage inflation rates.

Medical inflation rates, by contrast, have exhibited very unique historical behavior relative to general price inflation. Specifically, medical inflation has historically tended to be higher and more volatile. This is particularly evident for workers compensation medical costs during the early 1990's, which were unprotected from deductibles, limits, or benefit coordination. Workers compensation medical losses over these years often exhibited annual inflation levels in excess of 10%. More recently, however, major legislative reforms, combined with the impact of managed care initiatives, have reduced workers compensation medical inflation to levels lower than the CPI. Observing the graph on Exhibit 7 we can see the illustration of these historical rate movements.

As we did for inflation rates, we matched descriptive statistics between historical and projected data as well as the graphical validation of stochastic projections on Exhibit 7.

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[5] http://www.stls.frb.org/fred/data/cpi/cpiaucsl is "hot-linked" to the CAS's http://www.casact.org/research/dfa/appendix1.htm

[6] http://146.142.4.24/cgi-bin/surveymost?ee is a data page at the Bureau of Labor Statistics site at http://stats.bls.gov/blshome.htm

Unemployment Rate

Workers compensation loss costs are widely thought to be positively correlated with unemployment rates. Previously written CAS papers[7] have offered and supported that when unemployment (particularly involuntary unemployment) increases the average frequency of claims increases. This is apparently due, for the most part, to the lack of return to work prospects for an injured worker. Therefore, the unemployment rate is an important variable to be considered in a workers compensation DFA model as an indicator of general economic conditions and a specific driver of loss result trends.

One possible approach that can be considered for modeling unemployment rates is to use data from the Bureau of Labor Statistics Web Site[8]. This source provided data specifically from the single state where the subject company in this example writes its workers compensation business. When observing the graph of historical interest and unemployment rates, a correlation is not immediately evident. However, upon deeper analysis, we considered that a lagged effect of interest rates on unemployment rates was possible. We ran linear correlations on historical data using lagged unemployment rates as the dependent (affected) variable and 90 day T-bills as the independent (causal) variable. Specifically we ran correlations against unemployment rates with zero, one, two, and three year lags. The best R-Squared measures occurred using the two and three year lags. We further used the average of two and three year lagged unemployment and found the best fit. Therefore, a two-and-a-half year lag on unemployment rates appeared optimal. The lag concept also offers intuitive appeal in that observed higher interest rates generally lead to poorer economic conditions over a span of several months, which later lead to workforce reductions.

The results of our linear regression are shown on Exhibit 8. A linear slope, intercept, and error term were observed and ultimately selected in the same manner that we used to project medical inflation. To validate these selected parameters we again used the tools of descriptive statistical matching and graphical simulation. An example of the graphical validation can be seen in Exhibit 9.

PREMIUM MODELING

Jurisdictional Risk

We will define jurisdictional risk as the risk associated with judicial, legislative and/or regulatory actions that impact the operations of an insurance company. While it is clear that no DFA model could simulate all possible governmental interventions (nor should an efficient model need to), many states have jurisdictional climates that significantly influence operating results. The element of jurisdictional risk that we have chosen to focus on first in The model is in the area of underwriting. Specifically, jurisdictional risk's influence on underwriting results is modeled in two ways: rate change constraints (capping) and implementation lags.

First, proposed rate changes produced by a combination of prior underwriting results and future growth goals are required to stay within an "allowable range". This capping does not mean that rate level changes outside the reasonable range aren't possible. Rather, changes outside the reasonable range will require additional time and/or expense (additional analysis and filing preparation, consultants' fees, insurance department trips, etc.) for approval. Second, states have regulatory structures that range from allowing relatively rapid implementation of desired rates (e.g. open competition, use & file statutes) to structures that

[7] The reader is referred to Lommele, Jan A. and Sturgis, Robert W. (1977) "An Econometric Model of Workers Compensation," Proceedings of the Casualty Actuarial Society and Butler, Richard J. and Worrall, John D. (1982) "Workers' Compensation: Benefit and Injury Claim Rates in the Seventies," Review of Economics and Statistics for two relevant statistical analyses of this relationship between unemployment and workers compensation loss results.

[8] http://146.142.4.24/cgi-bin/surveymost?r5 is a data page at the Bureau of Labor Statistics site at http://stats.bls.gov/blshome.htm

almost assure a lengthy delay (prior approval statutes with lengthy waiting periods). This implementation lag phenomenon and its impact have been evaluated by a number of sources, including research done by the Virginia Bureau of Insurance in their study on alternate methods of rate regulation[9]. It should also be noted that a certain amount of lag in rate implementation exists purely due to data collection and analysis[10]. Intuitively, the capping and implementation lag factors create a maximum and minimum rate change that can be reasonably implemented and impose a delay on how quickly the capped rate change can be implemented[11].

The reason for customizing the jurisdictional risk parameters of This model is that for a given line of business, a number of factors may substantially increase or decrease the jurisdictional risk for an individual company. These factors include the size (e.g. large market share), target market (e.g. non-standard programs), state of domicile (e.g. domestic companies), and regulatory history (e.g. several previous filings going to hearing) of the company. The parameterization of the jurisdictional risk element of a DFA model should use actual company rate filing experience to the extent that the information is credible. The broadest use of company data would be to analyze historical rate levels filed versus those finally approved and delays in the effective dates of those filings to parameterize the rate caps and lags. However, a company's own filing experience may not have enough filings, particularly enough large increases and decreases, to be fully credible. Furthermore, a state can change its regulatory structure (e.g. a "use and file" state converting to prior approval or a change from an appointed commissioner to an elected one) thereby making a company's filing history less relevant.

As a proxy for meaningful filing history, the public access version of The model has been parameterized to represent a "typical" insurance company's jurisdictional risk based on the "1994 Property-Casualty Regulatory Survey" from Conning & Company. This report surveys insurance company executives for their assessment of each state's regulatory restrictiveness as related to reduced business writings, rate suppression, and freedom to manage personal and commercial lines business. The parameterization of the public access model also considers the type of filing statute that exists in an individual state (use & file, file & use, prior approval, state mandated rates), the type of insurance commissioner (appointed or elected), as well as any state specific requirements (Georgia's rate hearing requirement for filings over +9.9%). Data such as the Conning study, the filing statute, and the type of commissioner can serve as a valuable way to extrapolate a company's experience into new states and/or lines. For example, assume a company writes in State X and is considering expanding into State Y. If State X has a prior approval filing statute and an elected commissioner and State Y has a file and use statute, an appointed commissioner, and a more preferable ranking in the Conning study, a looser set of caps and a shorter jurisdictional lag may be appropriate for State Y.

The key to parameterizing the jurisdiction risk component of the underwriting cycle is the reasonableness check. Regardless of the blend of company data and industry experience that is used to parameterize the impact of jurisdictional risk, two questions need to be answered in the reasonableness assessment: "Do the factors seem reasonable to practitioners?" and "Do the jurisdictional risk parameters change the underwriting results in an intuitive way?" The answer to the first question depends on the skill and judgment of the practitioners. We used a number of actuaries and underwriters with filing experience in all states and a variety of backgrounds (different company sizes and a former regulator) to give our selections a

[9] Competition in the Property and Casualty Insurance Industry: An Evaluation of Alternative Methods of Rate Regulation. Bureau of Insurance, State Corporation Commission, January 1978.

[10] Daykin, C.D.; Pentikäinen, T.; and Pesonen, M., *Practical Risk Theory for Actuaries* (First Edition), 1994, p. 340. The combination of the rate review lag and the jurisdictional lag are described as follows: "Profitability and other relevant factors can only be ascertained after a certain delay and further time is required to implement corrective measures. If tariff bureaus and regulatory approval is involved, the process may take even longer. The total time delay is usually 1.5-2.5 years."

[11] It should be pointed out that the selected rates are capped first and then subjected to the lag. This approximates a realistic situation where the company prepares their filing proposing a capped rate change that is then subjected to jurisdictional lag.

peer review. To assess the impact of jurisdictional risk, we expected underwriting results to be impacted in two ways: 1) more disparity between indicated and implemented rate changes and 2) more variance in simulated loss ratios. Intuitively, if a company's ability to respond to rate inadequacies and redundancies is capped and lagged, loss ratios above a company's permissible loss ratio cannot be reduced completely (in severe circumstances) or immediately. Similarly, loss results better than permissible will not worsen to the permissible level as quickly, due to caps and lags on rate decreases. Exhibit 10 shows an example of what the differences in the implemented rate changes for a sample company might look like with and without jurisdictional risk. This example takes a typical selected rate level (a blend of market demand and indicated rate need) and subjects it to jurisdictional capping and lagging. As can be seen, the capping component limits any possibility for large rate changes and the lag component forces a portion of the rate level change to not be realized until the following calendar year. Exhibit 11 then demonstrates the impact on loss ratios for the next accident year. The model's random number reseed feature allows the user to run simulations with all randomly generated elements identical to a previous set of simulations. This allowed us to test the impact on loss ratios of introducing jurisdictional risk with otherwise identical parameters and simulated values. As you can see, there is both a higher variance in the simulated loss ratios and the mean loss ratio has increased.

Advantages and disadvantages of these methodologies are as follows:

Advantages

1. Adding jurisdictional components allows simulated premiums to more closely model reality
2. Allows the testing of changes in environment including:
   - Rate freezes
   - Changes in regulatory system
3. Increases accuracy of testing state entrance or exit implications
4. Takes advantage of a company's own filing experience to the extent that it is credible

Disadvantages

1. Tough to parameterize in a jurisdiction or line where the company has little or no experience
2. Modeler needs to know historical relationship between company and jurisdiction
3. Commissioners and regulatory systems change in sometimes unexpected ways

Impact of Rate Adequacy on Future Rate Levels

There are a number of ways a model can handle changes in rate adequacy[12]. We will propose five methods that can be used to parameterize the model to handle the issue of rate level adequacy. The first one is the simplest approach. It assumes the company's rates are adequate to begin with and only impacted by inflation. Method 2 assumes the company is only concerned about the competitiveness of its rates. Depending on the market position a supply/demand curve is used to determine the required rate change needed to obtain the desired exposure growth.

Method 3 allows the company to look at actual experience when developing the rate change. This becomes more complex as management intervention may result. The basis for this approach is to build into the model techniques similar to the company's actual rate review process. Past loss, premium, inflation, and investment experience are reviewed to determine the rate adequacy. Loss ratios are developed for the preceding time periods by using the a priori ultimate losses adjusted to reflect inflation as of time period t-1. These losses are then trended to the midpoint of period t using an average of claims inflation over the past three years. Premiums are adjusted to bring them to current level and to reflect inflation. The average loss

[12] Daykin, C.D; Pentikäinen, T.; and Pesonen, M., *Practical Risk Theory for Actuaries* (First Edition), 1994, p. 315-319

ratio adjusted to period t cost levels is compared to the company's permissible loss ratio, with an investment income offset (similar to the NAIC Calendar Year Investment Income Offset Approach[13]) to generate an indicated rate level change[14]. This rate level change would need to be capped based on management rules.

The next two methods are hybrids of preceding ones. Method 4 is a weighting between methods 1 and 2. Method 5 is a combination of 2 and 3. The combinations are heavily dependent upon management's views of how the company would handle each of these situations. The mixing of the different methods is intended to help approximate the reality that a company will not always follow the indicated trends but will go with competitive forces in some cases. At this point an example will be helpful.

Example 1

1. Claims inflation (CI) = +6%
2. Trended and adjusted loss ratio (ALR) = 0.75
3. Permissible loss ratio (PLR) = 0.75
4. Investment income offset (IO) = 0.05
5. Growth objective (G) = 10% exposures
6. Simplified supply/demand curve of RC = Gx+y, where RC is indicated rate change and G is growth objective.
7. Soft Market with x = -0.05 and y = -0.05
8. Assumes 50/50 weights are given in weighting together methods

Method 1	Method 2	Method 3	Method 4	Method 5
RC = CI	RC = Gx+y	RC = 1-ALR/(PLR + IO)	RC = .06(.5) + -.055(.5)	RC = -.0625(.5) + -.055(.5)
RC = 6%	RC = 10(-0.05)-0.05	RC = 1 - .75/.80	RC = 0.25%	RC = -5.9%
	RC = -5.5%	RC = -6.25%		

This same example can also be thought of in a graphical sense. The comparison of the implemented rate change to the actuarially indicated change for each method is shown as Exhibit 12.

Advantages and disadvantages of these methodologies are as follows:

Advantages

1. Allows pricing to be dynamic
2. Reflects inflationary pressures also put on losses
3. Method 1 is simple to implement and understand
4. Method 2 recognizes impact of the market conditions
5. Method 3 is consistent with company's current actuarial process
6. Methods 4 & 5 provide a way to balance these impacts on a more realistic way

Disadvantages

1. Requires management intervention to be built in, which may not always be predictable and which is not consistent within or between companies
2. Method 1 is an over simplification and may not be realistic

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[13] The model contains all of the necessary information to compute a provision for investment income from insurance operations using the NAIC calendar year investment income offset approach. The advantages and disadvantages of calculating investment income using this approach are beyond the scope of this paper. Other methods of calculating investment income and profit provisions (e.g. Discounted Cash Flows) are also easily computed using the information available in the model. The reader is referred to Robbin, Ira, "The Underwriting Profit Provision", 1992 for a detailed discussion of alternatives in this area.

[14] The approach to calculating indicated rate need is provided as an example. Advantages of this methodology and alternative methods to calculating rate need are beyond the scope of the paper. It should be pointed out however that given the data available in the model, a number of different approaches to indicated rate need could be customized into the underwriting module.

3. The supply/demand curves in Method 2 vary between companies, lines of business, and states.
4. Method 3 requires the user to select an actuarial methodology for adjusting rates, including trend selection, credibility issues and catastrophe loads

Once the method of rate change is chosen, it should be tested for reasonableness. This test of reasonableness should look at the following items over a number of simulations:

a. Inflation
b. Trended and developed loss ratio
c. Permissible loss ratio
d. Investment income offset
e. Rate change allowed by competition (This inherently means the supply demand curves have been checked for reasonableness)
f. Actual modeled change

If item f goes against management intuition given a through e, the weightings should be modified.

Impact of Exposure Trend on Premium Level

One of the fundamental properties of this model is that premiums are simulated based on projected exposures and average rates. This premise creates a need for care to be exercised when estimating projected exposure growth so that real exposure growth and inflationary pressure are both reflected in the exposure growth estimate. Several commonly used exposure bases are inflation sensitive. These include property value (used in homeowners), sales (used in general liability), and payroll (used in workers compensation). We have used wage inflation for this workers compensation application; however, the approaches presented could easily be applied to other inflation sensitive exposure bases.

For workers compensation, wage inflation affects premiums through the payroll exposure base. Wage inflation is projected through the random process described earlier and the effect on payroll is calculated. Normally, this is thought to be a fairly instantaneous relationship. Careful consideration should be given to the impact of unionization involving long-term wage agreements and their potential to delay the impact on payroll inflation. For a recent customization project, it appeared from our analysis of the company's own data that such a lag was not material. Therefore, we chose not to build in a wage inflation lag.

Payroll data was projected using audited payroll estimates in order to avoid the concern of estimating subsequent premiums due to audits.

LOSS MODEL PARAMETERIZATION

Impact of Wage and Medical Inflation

Workers compensation benefits include indemnity and medical payments. Loss adjustment expenses (LAE) will also be modeled as a percentage of the sum of the two benefit components. Indemnity losses are typically a direct function of injured worker wages. Therefore, wage inflation is a natural and direct driver of indemnity inflation through its influence on the average replaced wages under the workers compensation statute. However, in addition to the amount of the payment, the average time duration of disability payments should also be considered in the modeling process. Thus, a duration trend element was also necessary to project indemnity inflation.

To develop an indemnity duration trend parameter, in a recent customization project, we analyzed a company's actual indemnity loss experience relative to actual wage inflation. A fairly constant additive increment of 2.0% over wage inflation appeared evident through most statistical indications. Therefore, the formula for indemnity inflation was set at wage inflation + 2.0%.

Having previously modeled medical inflation, we used a percentage mix of benefits to develop a total loss inflation. Historical data for the subject company and others in its market indicate a fairly steady observation of two-thirds indemnity to one-third medical. By calculating annual loss costs through the projection period we could rebalance these weights. Through this apportionment of benefits, a total loss trend can be modeled which offers an analytical basis of inflation through its components.

Unemployment's Effect on Frequency

As discussed earlier, changes in unemployment rates are thought to have an effect on claim frequencies. For the subject company in a recent customization and other companies writing in its jurisdiction, we have analyzed the historical unemployment time series we used above in comparison to the change in reported claims per unit payroll for these companies. We ran a linear regression on these frequency measures versus unemployment rates and found the relationship to be nearly direct. That is, for each point (1.0%) change in the unemployment rate, the claim frequency changed approximately one point as well. As a result, we utilized a formula that increased the frequency per $100 payroll, one point for each point the modeled annual unemployment rate changed.

OTHER PARAMETERIZATION ISSUES

Collateralized Mortgage Obligations

The model has the ability to model different types of bonds. Bonds are segregated based upon their class and maturity. The maturity groupings are 1) Less than 1 Year, 2) Over 1 Year through 5 Years, 3) Over 5 Years through 10 Years, 4) Over 10 Years through 20 Years, and 5) Over 20 Years. The model then uses the same underlying methodology to develop the appropriate cashflows. This methodology is as follows:

1. Start with face values and coupon rates
2. Model coupon payments by multiplying the face value by the coupon rates
3. Determine end of year statutory book values using straight line amortization
4. Determine end of year market value according to the following formula:

   $MV = FV \times \Sigma\, CF_t \,/\, (1+i)^t$ where CF is the Cash flow ratioed to the face value

5. Mature bonds between maturity buckets assuming uniform distribution. Thus 20% of the market values in the maturity grouping "Over 5 years through 10 years" are assumed to migrate into maturity grouping "Over 1 Year through 5 Years"
6. Coupon rates are adjusted for each maturity group to reflect bonds maturing in and out and the purchase of new bonds

This model can be re-parameterized fairly easily to model collateralized mortgage obligations (CMO's) on a simplified basis. The inclusion of CMO's involves two additional steps. The first step is the modeling of the expected percentage of mortgage prepayments. The prepayment percentage is based upon the Public Securities Association (PSA) model, which assumes that the proportion of mortgages prepaid increases linearly by 0.2% annually for the first thirty months, then levels off at 6% per year thereafter. These assumptions are then indexed to represent greater or lesser prepayment activity due to change in interest rates. For example, if the interest rate were to increase by 100 basis points we would expect a decrease in the prepayment activity. Thus the PSA model would be adjusted down to reflect fewer mortgage prepayments and accordingly fewer prepayments of CMO's. The CMO model can be set up to handle a number of interest rate change ranges. Currently it is set up according to the following:

Interest Rate Change From Starting Point	% of PSA
+1.5%	50%
+1.5% to +0.5%	75%
+0.5% to −0.5%	100%
-0.5% to −1.5%	125%
-1.5%	150%

Once the percentages of prepayments are known, we assume the CMO's are prepaid in the same proportion according to the maturity of the bond. Using the same steps as outlined above we offer three additional steps to include in the process:

2a. Face value redemption would be calculated as the prepayment percentage times the face value. This will generate a cashflow available for claims or reinvestment.
3a. Book values are recalculated assuming a decrease according to the modeled percentages.
4a. Market values are also decreased in proportion to the modeled prepayment percentages.

Checks for reasonableness are best performed using historical result. Past prepayment levels can be compared to interest rate level changes in determining the factor adjustment to the PSA study.

Advantages and disadvantages of these methodologies are as follows:

Advantages

1. Simple to understand
2. Allows the user to test the impact of CMO's on the company's returns and cashflows
3. Models the correlation between change of interest rates and prepayment of CMO's in an understandable manner

Disadvantages

1. Does not take into consideration impacts on different traunch holdings
2. May be an over simplification of the real world

Underwriting Expense Modeling

In DFA and general actuarial literature, underwriting expenses have historically taken a back seat to research on losses (in terms of their impact on rates and reserves) and assets. The reason for this lower priority in the development of DFA research is that underwriting expenses have less variability and therefore have a smaller impact on the mean and variability of future company results. However, as more companies focus on operational efficiency, the need for more sophisticated expense modeling has grown. We will examine two added levels of complexity that some insurers may wish to consider adding to a general DFA model if their company's situation warrants a more detailed parameterization: fixed versus variable expenses and step-wise incremental fixed expenses.

For the purpose of this discussion we will define other underwriting expenses (OUE) as the sum of the other acquisition expense and general expense items. The easiest approach that can be taken for parameterizing and simulating other underwriting expense ratios is to assume a constant percentage of direct written premium will be used for underwriting expenses regardless of increases or decreases in premium level, rate adequacy, or any other operational change. This approach works exceptionally well for commissions and taxes that are almost completely variable with written premium. For companies with stable expense ratios, this fixed percentage approach also provides a reasonable approximation of reality for other underwriting expenses that can be programmed and modeled easily. In fact, the public access version of The model uses this approach for simplicity and the broadest possible applicability. However, companies can be faced with many situations where this approach is not reasonable. For example, a start-up organization whose premiums are growing rapidly may see substantial decreases in their expense ratios as fixed costs (office space, computer systems, etc.) are spread over a larger premium base. Companies going through premium reductions, down-sizings, changes in distribution channels, or acquisitions of other companies or additional blocks of business may also be in situations where the underwriting expense ratio is a moving target rather than a fixed one.

The first parameterization alternative is to recognize some other underwriting expenses as fixed. Any other underwriting expense that remains completely unchanged regardless of premium level can be viewed as fixed. Typical fixed expenses are such items as computers (especially large mainframe computers), rent and other overhead items. A common assumption about fixed expenses is that about half of all current OUE is fixed. This approach is intuitively appealing and is commonly used in the development of expense constants. For a company that feels that their expenses are materially different from this general assumption, an analysis of the "Acquisition, Field Supervision and Collection Expenses" column of Part I of the Insurance Expense Exhibit may be appropriate. We did such an analysis (see Exhibit 13) for a recent client and found the results not substantially different from the 50/50 split.

Another level of sophistication that can be added to projecting other underwriting expenses is the addition of incremental fixed expenses at specific levels of premium growth and needs a larger computer or more space. This modification reflects the realistic situation of additional fixed expenses being incurred as a company experiences significant growth. Situations that might give rise to this situation would include computer upgrades and renting additional office space. It should be noted that several of these items impact assets as well as liabilities and the DFA model needs to be customized on the asset side to reflect these additional non-invested assets. One simple approach to approximating this step-wise fixed expense behavior is to select a premium growth amount at which a fixed expense amount (either a dollar amount of incurred fixed expense or a percentage increase of the other underwriting expense ratio) is incurred. Note that when premium is declining this modeling approach has the effect of making the expense ratio increase until a fixed expense item can be eliminated. This parameterization causes the expense ratio to decrease less rapidly than a simple fixed expense approach and may create a more realistic projection of expense levels in models predicting substantial growth or decline.

Another expense modeling alternative is reflecting expenses that vary by unit cost. Items in this category would include loss control surveys, policy forms and jackets, identification card issuance and loss reporting kits. These items behave like variable expenses but are sensitive to rate adequacy per exposure and changes in average policy size.

A simple reasonableness check for the parameterization of the other underwriting expense generator is a graph comparing the other underwriting expense ratio (to direct written premium) to the change in direct written premium. As you can see in Exhibit 14, an all-variable expense model creates a horizontal line. A partially fixed expense model implies a line with some recognition of economies of scale. A partial fixed expense model with a recognition of additional fixed expenses after sufficient premium growth, decreases in a somewhat jagged fashion and at a slower rate than the partial fixed expense without the step-wise adjustment.

Advantages and disadvantages of these methodologies are as follows:

Advantages

1. Companies focused on operational efficiency as a style will want the split
2. Allows companies to incorporate staffing models into DFA analysis
3. Allows much better forecasts of U/W results under growth scenarios
4. Allows more accurate measurement of the expense component of the new business penalty[15]

Disadvantages

1. Future expense levels and management decisions difficult to parameterize
2. Could be an over-parameterization of the model for the subject company that could distract from more significant risks

Policyholder Dividends

Another expense related issue that may not be directly related to premiums is policyholder dividends. Many workers compensation writers, for example, have a wide variety of policyholder dividend plans that pay either a flat percent of premiums (flat dividend plans) or a percent of premium that varies depending on the insureds size and loss results (variable dividend plans). Neither the variable expense approach used for commissions, nor the fixed expense approach presented for other underwriting expenses works well for dividend plans. There are two reasons for this: 1) the market influences the type and number of dividend plans extended to a company's insureds, and 2) loss results, not premium, dictate how much of a dividend is paid out[16]. Furthermore, dividends are generally paid out six to nine months after policy expiration and so lag behind the earned premium and incurred losses with which they are associated.

The public access version of The model assumes policyholder dividends to be a minimal issue and is initially parameterized with a fixed percentage of premium approach. This accommodated our desire for the public access model to be as widely applicable and straightforward as possible. However, any company with a sufficient amount of written premium subject to dividend plans needs a more sophisticated approach. Two basic issues need to be parameterized in a more sophisticated dividend model: 1) the percentage of the

[15] Traditionally, the new business penalty has been thought of as a quantification of the inferior loss ratio results of new business. There is a similar penalty to the expense ratio for lines of business with substantial fixed costs associated with the first policy (e.g. MVRs, loss control surveys, policy file set up).

[16] It should be noted that the payout from flat dividend plans do not vary with loss results, except to the extent that by law, no dividend disbursement can be guaranteed so even a flat dividend could not be paid if loss results were poor enough. Flat dividend programs are currently used almost exclusively in states where the rate regulatory environment precludes deviation of rates from bureau levels (e.g. Wisconsin and New Jersey); therefore our discussion focuses on the more commonly used variable plans. If a company used predominately flat dividend plans a percentage of premium approach or an approach that varied the dividend according to market position might be more appropriate.

book of business that are offered each kind of dividend plan in a given phase of the market, and 2) the expected payout for each plan given a known loss result.

Exhibit 15 provides an example of how this model could be parameterized in the case of a company with 2 variable dividend plans. The modeler could develop an expected distribution of written premium in each dividend plan at each point in the cycle based on actual company experience and discussions with company personnel concerning their expected behavior. Information estimating dividend payouts at different loss ratios should be available for each plan or can be fairly easily approximated. Once this parameterization is accomplished, future dividend payouts are computed as the weighted average of the expected payouts for the two prior accident years as is shown in Exhibit 15. Net loss ratios can be used to approximate loss capping that occurs in some dividend plans, if retention levels are similar. A straightforward reasonableness check for this customization is a graph comparing loss ratios (net or direct as selected above) from a two year period versus the policyholder dividend ratio (to direct earned premium) paid in the first subsequent year.

This technique of modeling items as a percentage of premium based on loss results and market position has two other significant uses: 1) contingent commissions, and 2) residual market burdens. Contingent commissions are in many respects simply dividends paid to the agent instead of the policyholder. Multiple agency incentive plans with different payouts which can be extended to different numbers of agents depending on market conditions can be parameterized using an approach almost identical to the one shown in Exhibit 15. Residual market burdens can be viewed as a cost of doing business (literally a percentage of earned premium) in certain lines, most notably workers compensation, automobile and property lines in certain states. This cost of doing business varies by market position and jurisdiction. An approach that incorporates some elements of a jurisdictional risk assessment and is designed similarly to the dividend approach provides a reasonable approximation to future residual market loads. NCCI and AIPSO both provide data to member companies by line and state that assists greatly in parameterizing this customization. An example of a straightforward parameterization of residual market burdens is shown as Exhibit 16.

Advantages and disadvantages of these methodologies are as follows:

Advantages

1. Intuitively more reasonable
2. Easy to program
3. Recognizes the impact dividends, contingent commissions, and residual market burdens can have on operating results
4. Recognizes the loss and/or market sensitivity of these items

Disadvantages

1. Difficult to validate some parameters
2. May overcompensate
3. Increases impact underwriting cycle position has on underwriting results

AREAS OF CONTINUED RESEARCH

There are a number of areas of research in the area of model parameterization that the DynaMo research team is continuing to develop. Some of these include the following:

Enterprise-Wide Modeling – How are foundational risk factors that are common to many industries but with sometimes different impacts, like catastrophes, inflation, and interest rates, used to build an enterprise-wide DFA model for an organization that includes property/casualty insurance companies and other entities like banks and life insurance companies? What kinds of metrics are needed? How are the unique risk factors for these other industries parameterized and modeled?

Managed Care Impacts – How are the impacts of managed care penetration and network strength incorporated into estimated frequency and severity for a workers compensation writer? How will managed care impact loss payment patterns? How should network access and network management fees, especially contingent fee structures, be parameterized and modeled?

Securitization – How are the bond modeling and catastrophe modeling capabilities of a DFA model best blended to estimate the price of catastrophe bonds? How can a DFA model be used to test the loss payout risk in an apparent financial reinsurance agreement?

Ratemaking – What is the best approach to using a DFA model to simulate a range of possible indicated rate needs? Can this approach bring something akin to risk margins into ratemaking as an alternative method for computing a profit provision?

Demutualization, Mergers, and Acquisitions – How can a DFA model be customized to assist an insurance company deciding whether to demutualize? How can a company combine their own data with one or more merger or acquisition candidates in a DFA model to assess and potentially rank possible candidates? How can this information be used to estimate dilution value?

ACKNOWLEDGEMENTS

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Exhibit 1 – Operational Schematic

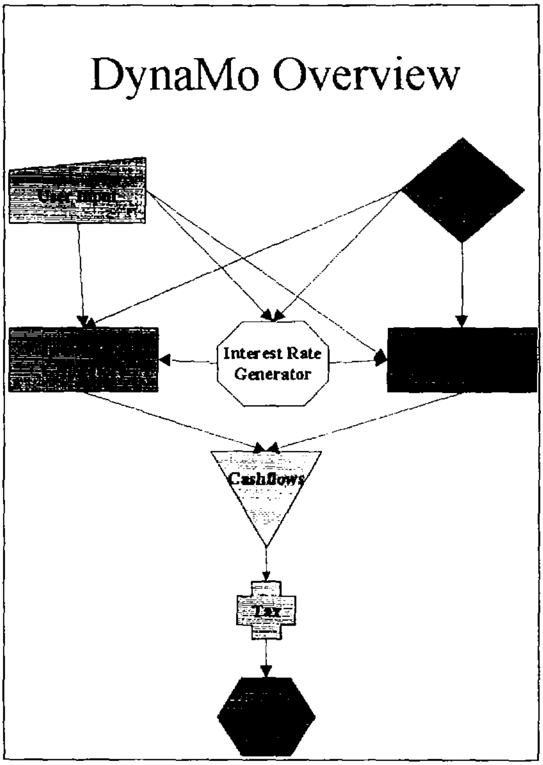

Exhibit 2

Cox Ingersoll Ross

Interest Rate Generator Formula

General Formula: $r_i = a \times (b - r_{i-1}) + s_i \times z_i$

Selected Formula: $r_i = 0.25 \times (0.06 - r_{i-1}) + 1.40 \times z_i$

where	r_i	=	90 day rate for year i
	a	=	reversion frequency parameter
	b	=	long-term mean for 90 day rates
	s_i	=	volatility parameter
	z_i	=	standard normal variate

Exhibit 3

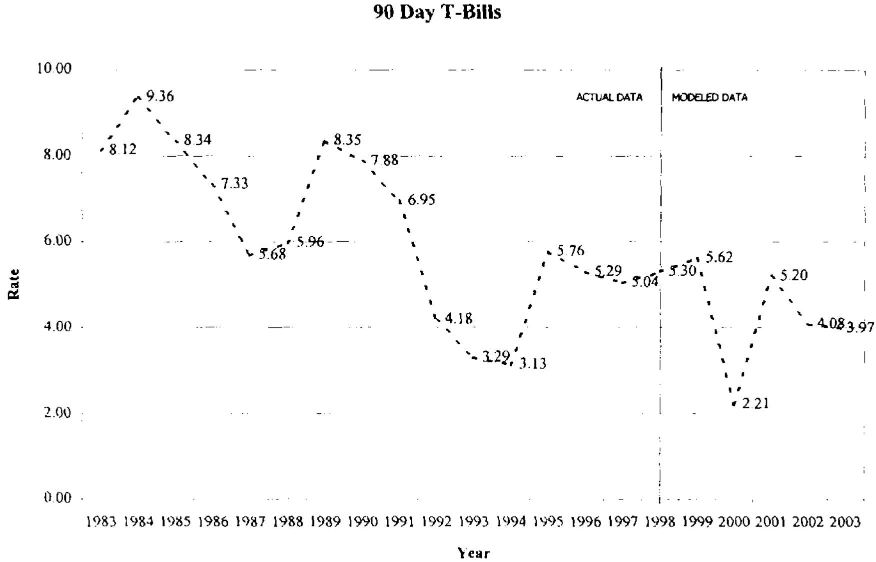

Exhibit 4

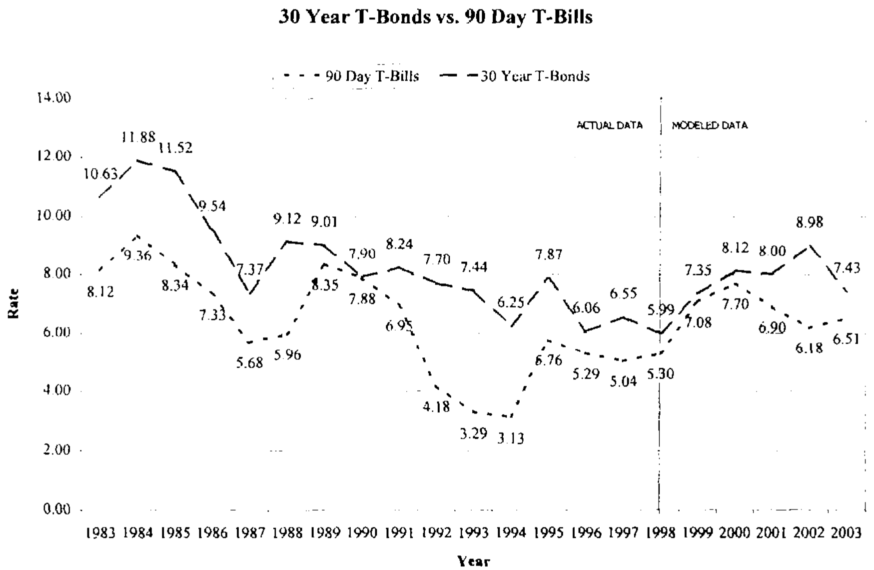

Exhibit 5

CPI = m (interest) + b + s2 x z2

Date	Interest	CPI
1984	9.36	3.58
1985	8.34	4.04
1986	7.33	3.79
1987	5.68	1.19
1988	5.96	4.42
1989	8.35	4.41
1990	7.88	4.64
1991	6.95	6.25
1992	4.18	2.98
1993	3.29	2.96
1994	3.13	2.81
1995	5.76	2.60
1996	5.29	2.60
1997	5.04	3.31
1998	5.30	1.70
1999	*6.66*	*3.56*
2000	*4.50*	*2.88*
2001	*4.85*	*3.48*
2002	*7.40*	*3.87*
2003	*7.15*	*3.33*

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.494962134
R Square	0.244987514
Adjusted R Square	0.186909631
Standard Error	1.133478755
Observations	15

	Coefficients	*Standard Error*
Intercept	1.386254038	1.031405168
X Variable 1	0.331762727	0.161532906

Exhibit 6

Inflation vs. 90 Day T-Bills

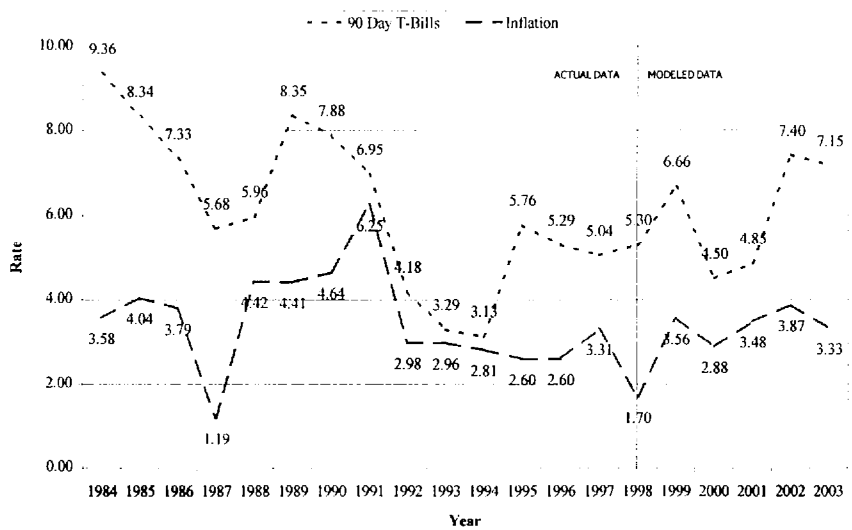

Exhibit 7

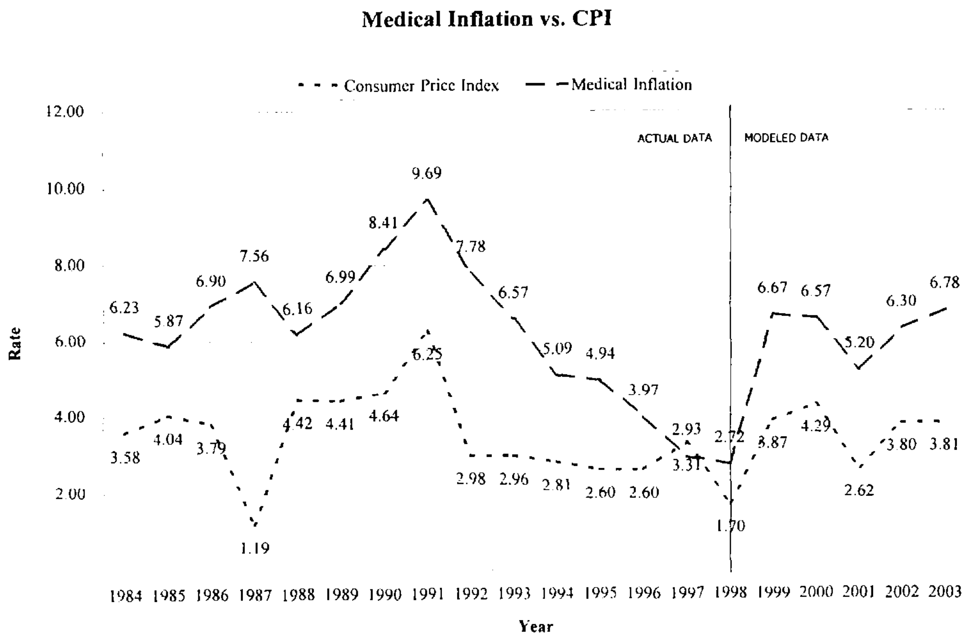
Medical Inflation vs. CPI
Consumer Price Index
Medical Inflation
ACTUAL DATA
MODELED DATA
Rate
Year
12.00
10.00
8.00
6.00
4.00
2.00
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
6.23 5.87 6.90 7.56 6.16 6.99 8.41 9.69 7.78 6.57 5.09 4.94 3.97 2.93 2.72 6.67 6.57 5.20 6.30 6.78
3.58 4.04 3.79 1.19 4.42 4.41 4.64 6.25 2.98 2.96 2.81 2.60 2.60 3.31 1.70 3.87 4.29 2.62 3.80 3.81

Exhibit 8

CPI = m (interest) + b + s2 x z2

Date	TB 3M	UE+2.5
1983	8.12	
1984	9.36	
1985	8.34	14.00
1986	7.33	11.10
1987	5.68	9.70
1988	5.96	8.65
1989	8.35	8.20
1990	7.88	7.50
1991	6.95	7.50
1992	4.18	8.05
1993	3.29	8.70
1994	3.13	8.45
1995	5.76	7.00
1996	5.29	6.00
1997	5.04	5.20
1998	5.30	4.80
1999	*2.63*	*6.08*
2000	*3.31*	*5.99*
2001	*4.34*	*5.92*
2002	*3.01*	*5.18*
2003	*2.75*	*5.91*

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.385638451
R Square	0.148717015
Adjusted R Square	0.077776766
Standard Error	2.270314616
Observations	14

	Coefficients	*Standard Error*
Intercept	5.062381825	2.252755614
X Variable 1	0.533179613	0.368247289

Exhibit 9

Unemployment vs. 90 Day T-Bills

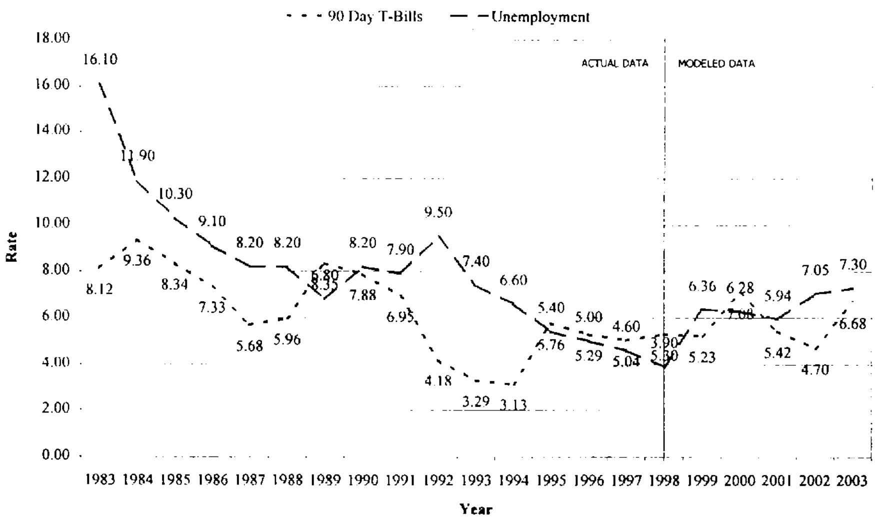

Exhibit 10 – Impact of Jurisdictional Risk on Selected Rate Level

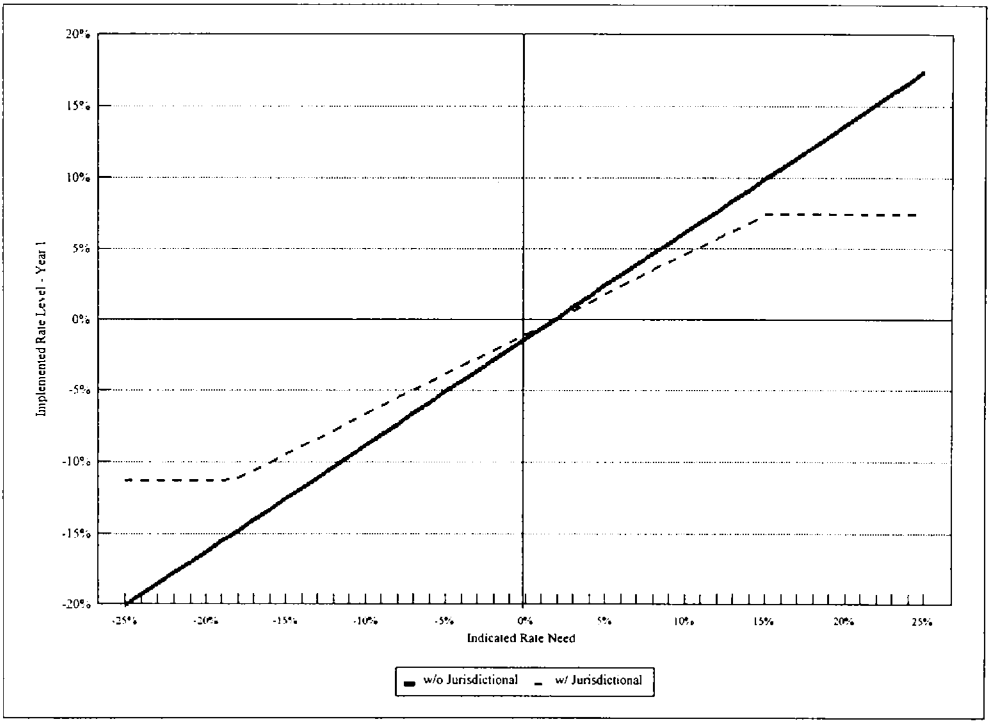

Exhibit 11 – Impact of Jurisdictional Risk on Direct Loss Results

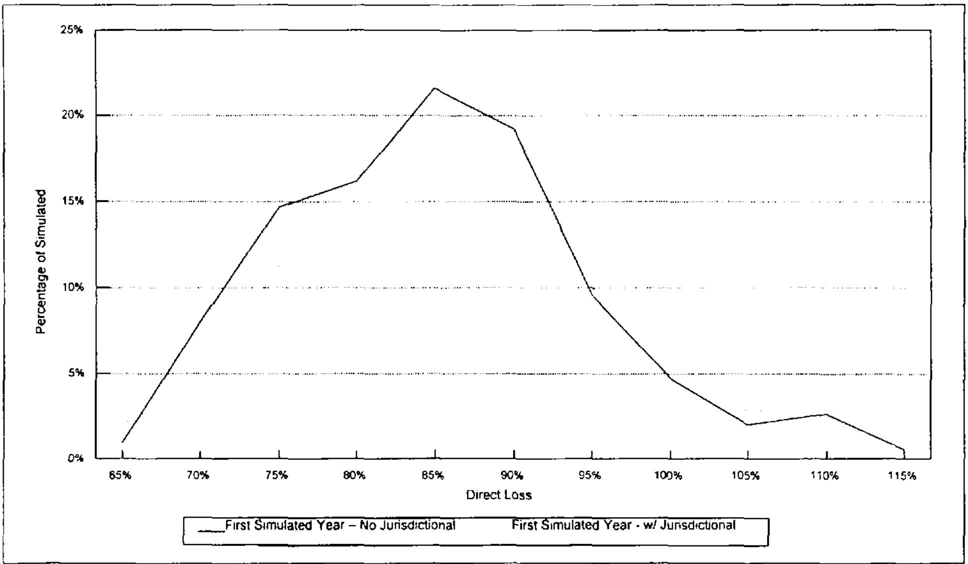

Exhibit 12 – Selected Rate Level Alternatives

Assumptions:
Loss Inflation – 4.0%
Change required for desired premium growth at existing point in cycle. – 5.0%
Method 4 weight assigned to inflation – 50%
Method 4 weight assigned to indicated rate level – 75%
No jurisdictional effects

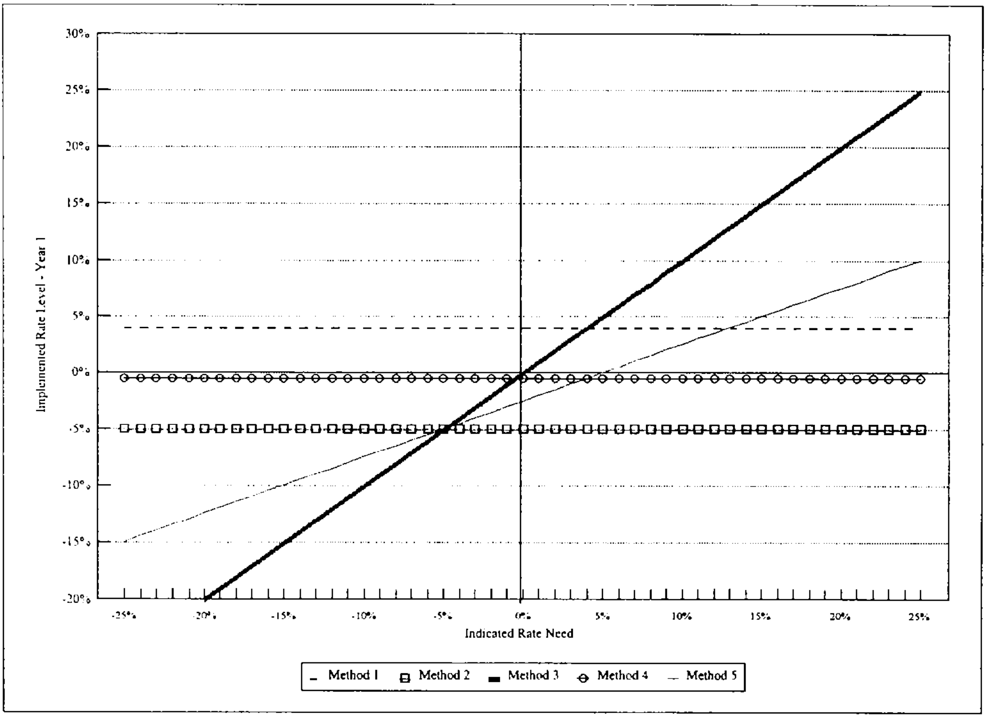

Exhibit 13 – Insurance Expense Exhibit Analysis of Fixed versus Variable Expenses

Category	Expense Dollars	Percent Fixed
Allowances to Managers	350	50%
Advertising	750	80%
Boards & Bureaus	-	0%
Surveys	-	0%
Audits	-	0%
Salaries	2,675	40%
Payroll Taxes	200	40%
Employee Relations	500	50%
Insurance	-	0%
Directors' Fees	-	100%
Travel	125	75%
Rent	175	100%
Equipment	425	100%
Printing	125	0%
Postage & Telephone	200	0%
Legal & Auditing	700	100%
TOTAL	6,225	57%

Exhibit 14 – Graphical Representation of Various Other Underwriting Expense Models

Assumes a current other underwriting expense ratio (to Direct Written Premium) of 18% and the ability/need to incrementally reduce/increase fixed expenses by 2% of DWP for every 15% decrease/increase in DWP.

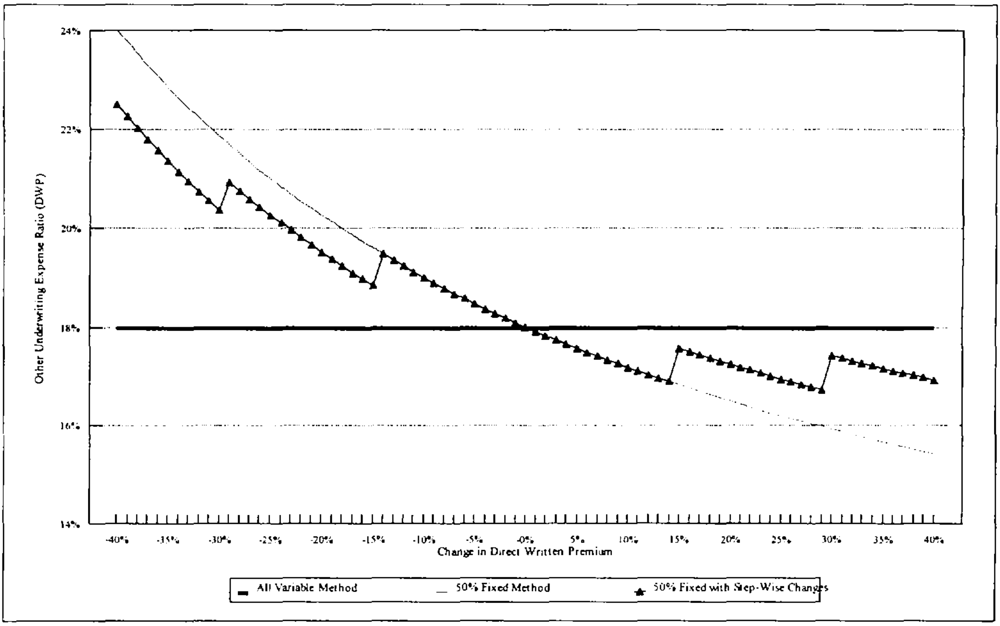

Exhibit 15 – Policyholders Dividend Ratio Parameterization

Expected Dividend Distribution

	% of DWP by Dividend Plan		
Phase	No Plan	Plan 1	Plan 2
Mature Hard	40%	50%	10%
Immature Soft	25%	40%	35%
Mature Soft	10%	35%	55%
Immature Hard	25%	40%	35%

Dividend Payout Estimate

Loss Ratio	Plan 1	Plan 2
20%	24%	37%
22%	23%	35%
24%	22%	34%
26%	20%	32%
28%	19%	30%
30%	18%	29%
32%	17%	27%
34%	16%	26%
36%	14%	24%
38%	13%	22%
40%	12%	21%
42%	11%	19%
44%	10%	18%
46%	8%	16%
48%	7%	14%
50%	6%	13%
52%	5%	11%
54%	4%	10%
56%	2%	8%
58%	1%	6%
60%	0%	5%
62%	0%	3%
64%	0%	2%
66%	0%	0%
68%	0%	0%
70%	0%	0%

Dividend Computation

Assume:
Mature Soft 2 years ago, with 56% loss ratio, $24 M DWP
Immature Hard last year, with 54% loss ratio, $30 M DWP

Expected Dividend = [Year 1 DWP * (% DWP in each plan * payout) +
Year 2 DWP * (% DWP in each plan * payout)] / (Total DWP)

Expected Dividend = [24* (0.35*0.02 + 0.55*0.08) + 30 * (0.40*0.04 + 0.35*0.10)] / (24 + 30)
= 5.1%

Exhibit 16 - Sample Residual Market Burden Parameterization

Residual Market Burdens as a Percentage of Direct Earned Premium

	Year in Market Condition			
Market Condition	1	2	3	4th and subsequent
Mature Hard	5.0%	6.5%	7.0%	Increase 0.3 points per year (no maximum)
Immature Soft	1/3 of gap to mature soft*			1.0%
Mature Soft	1.0%	0.8%	0.6%	Decrease 0.2 points per year (minimum 0)
Immature Hard	1/3 of gap to mature hard*			5.0%

* Module is programmed to calculate the difference between the last observed mature market burden and the next logical mature market burden and . For example, assume a 3rd year mature hard market was simulated to change to immature soft. The difference between the 3rd year mature hard residual market burden (7.0%) and the first year mature soft burden (1.0%) which equals 6.0% (7.0% - 1.0%) would be divided by 3 to reflect a selection that generally it takes 3 years for a residual market burden to change from mature hard to mature soft. This 2.0 point reduction (0.06/3) would be subtracted from the prior year burden of 7.0% to compute a burden of 5.0%. If the market stayed in the immature soft state for a second year, the burden would be 3.0% (5.0% - 2.0%). The immature burdens are capped at the appropriate first year mature market burdens.