Preliminary Due Diligence of DFA Insurance Company

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Abstract

This paper is a DFA case study of a hypothetical insurance company, DFAIC The study was completed using American Re-Insurance's proprietary DFA model The company data used was provided in the Call Paper request The study evaluated capital adequacy, capital allocation, and underwriting performance issues Also, strategies regarding asset allocation and reinsurance structures were tested

In keeping with the case study format of the call request, the paper was written as a presentation to management with a cover letter and a technical appendix This format illustrates how recommendations from a DFA analysis can be effectively presented The presentation highlights the importance of understanding management's success criteria and quantifying management's measure and tolerance of risk

The technical document discusses how limited data can be used to parameterize a DFA model and what additional data would be needed to expand the analysis

Acknowledgements

This study and paper could not have been completed without the guidance of Donald Mango, the assistance of Timothy Lu, and the support of American Re-Insurance's DFA model development team

MEGAGroup Insurance *Memorandum*

To: Mr. Joseph Merger, CEO
From: Raju Bohra, Thomas Weist
Re: Analysis of DFAIC Acquisition

We have completed our preliminary due diligence of MEGAGroup's potential acquisition of DFA Insurance Company (DFAIC) Attached please find a presentation of the results along with a technical document detailing our methodology

This study was performed using the Dynamic Financial Analysis (DFA) model licensed by MEGAGroup from American Re-Insurance The model comprehensively reflects variability in both capital market conditions and liability results This study represents the type of dividends our company can expect from its investment in DFA modeling

KEY RESULTS

- DFAIC's capitalization exceeds levels generally required for solvency However, solvency analysis only reflects extreme ruin probabilities From an investor's perspective, the company has a material level of potential capital loss
- The reinsurance structure should include an accident-year stop loss (AYSL) cover with limits of 10% excess of a 70% LALAE ratio This would provide valuable protection to the company's net results
- The asset allocation should be changed to increase the company's level of equity holdings to 22% It is currently 12% on a market basis. An increase in equity exposure would provide a favorable risk/reward tradeoff
- Return distributions for each of DFAIC's lines of business have been calculated based on our allocation of capital. On a risk adjusted return basis, both the PPA and CA liability lines are performing worse than the company average.

The purpose of this study is to provide quantitative support to management The study was completed given the data provided When additional information is available a more comprehensive study can be performed The types of additional data that would be useful are listed in the technical document More importantly, however, a greater understanding of management's objectives and risk tolerances would greatly facilitate future modeling and result analysis This issue is illustrated in the presentation

We feel this study provides a good starting point for discussion A basic sense of how the answers vary in response to changing assumptions and risk tolerances can be seen from the various risk return charts included in this study

Analysis of DFA Insurance Company (DFAIC)

Using Dynamic Financial Analysis

Introduction

- MEGAGroup's Strategic Analysis Department evaluated the potential acquisition of DFA Insurance Company
- The analysis was performed using Dynamic Financial Modeling techniques.
- Data for the study was basically limited to publicly available information
- The study can be refined with additional data
- A technical document detailing the methodology used for the study is attached

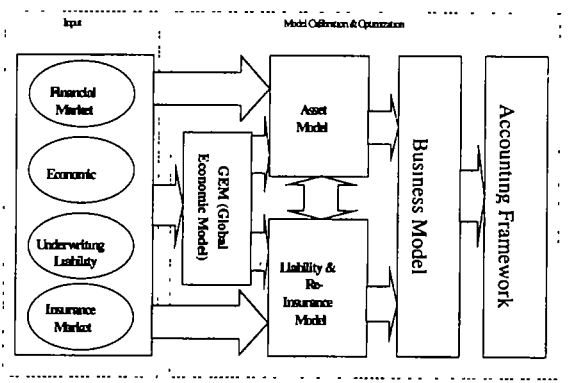
Scope of Study

- Questions:
  - Is the company adequately capitalized?
  - How efficient is the reinsurance structure?
  - How efficient is the asset allocation?
  - How should capital be allocated to lines?
  - What is the return distribution for each line?

DFA Model Used

- A simulation model, licensed from American Re-Insurance Company, reflecting variability in economic, capital market, and liability conditions
- The model includes the following modules
  - Economic module to generate future states of economic variables and capital market conditions
  - Asset module to price current asset portfolio and implement target investment strategy
  - Liability module to project loss, expense and premium results
  - Reinsurance module to model the impact of all reinsurance terms
  - Accounting module to bring together all balances, cash flows and accruals into an accounting framework and reflect taxes

DFA Model Structure



Assumptions

- Due to limited data, certain assumptions were made
  - Projected loss ratios were based on historical averages
  - Stated reserves were used, assuming no deficiency or redundancy However, variability was introduced
  - Premium growth and loss trends were modeled to be flat
  - Base target asset allocation was set to the current allocation
- Other assumptions regarding parameterization of the model are discussed in the technical document
- These assumptions do not materially impact the study conclusions However, additional data would allow expansion of the scope and detail of the study

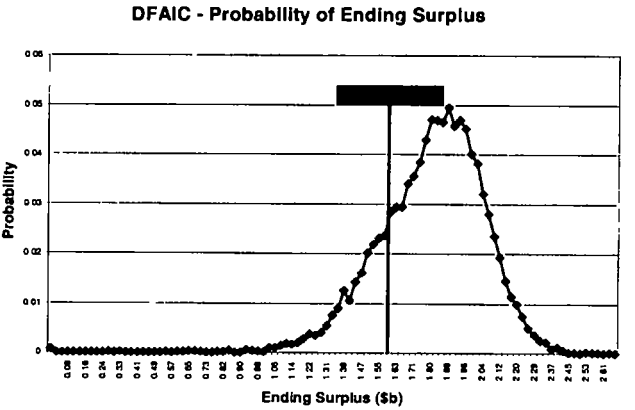
Capital Adequacy

Capital Adequacy

- Capital adequacy is a measure of a company's ability to pay all potential obligations.
- Surplus is exposed to the following risks.
  - Asset risk - default or drop in the value of assets
  - Interest rate risk - drop in asset values due to interest rate change
  - Credit risk - default on recoverable from agents and reinsurers
  - Reserve risk - reserves develop adversely
  - Premium risk - current business losses worse than plan

Capital Adequacy

- Rating agencies use a schedule of risk charges to compute capital requirements, then rank companies based on relative capital strength
- Using DFA, a complete probability graph of a company's ending surplus can be calculated Using this graph, more detailed capital adequacy measures can be developed
- A probability graph of DFAIC one-year ending surplus is displayed on the following slide



Capital Adequacy

- As the graph shows, there is a very small probability DFAIC's surplus will be insufficient. However, the probability of surplus decline is significant
- Measures used to quantify probability of insolvency are
  - Probability of Ruin probability that surplus will be exhausted
  - Expected Policyholder Deficit quantifies degree to which surplus may be exhausted relative to expected loss
    Above measures are analogous to rating agency calculations
- Measure used to quantify probability of surplus decline:
  - Expected Default Loss Rate quantifies degree to which surplus may be reduced relative to initial capital
    Analogous to bond default rates in the capital markets

Capital Adequacy

DFAIC Capital Safety Levels

Risk Measure	**Level Implied by Current Capital**
Probability of Ruin	1 in 10,000 years or 0.01%
Expected Policyholder Deficit	0.5% EPD
Expected Default Loss Rate	2.66% EDLR

Capital Adequacy

- This study indicates that the company is very well capitalized. However, further data concerning extreme loss events are needed before the results of this study can be considered definitive
- The Probability of Ruin and EPD measures calculated are well within the thresholds rating agencies generally associate with highly capitalized insurers
- The results of this study would provide statistical support for raising the company's rating or allowing a release of capital during rating agency discussions

Capital Adequacy

- From an investor viewpoint, probability of surplus decline is as important as insolvency risk
- The Expected Default Loss Rate (EDLR) calculated for the company is 2.66%
- *Moody's Investor Service* categorizes bonds with a one-year default rate of 2.66% as speculative ("junk") grade.
- To reduce the company's EDLR to 1% ("investment") an additional $200mil of capital would be needed
- Alternatively, additional reinsurance, particularly a stop-loss cover, would reduce the EDLR to 1% This strategy is discussed in the following section

Reinsurance Structure

Reinsurance Structure

- Reinsurance analysis is based on examining the risk return trade-off of various alternative structures.
- Rationally priced reinsurance provides a reduction of risk at the cost of expected return (margin). The alternatives in this study were priced using internal pricing models.
- The key issue is the risk tolerance of the buyer:
  - Less reinsurance generally increases expected return.
  - More reinsurance will reduce risk for risk-averse buyers.
  - Need to determine the point where the trade-off is favorable.
- It is important to define a risk measure in alignment with the buyer's risk tolerance.

Reinsurance Structures

- For this study, four risk measures were analyzed for the current structure and the alternative structures:
  - *Standard deviation of ending surplus*: (Analytical) This measure is used in classical investment portfolio analysis. However, it is not a good measure of downside risk which is the focus of reinsurance.
  - *Probability of surplus decline > 25%*: (Regulatory) Such a decline would probably trigger regulatory action.
  - *Probability of surplus decline > 10%*: (Rating agency) Such a decline would probably trigger a rating downgrade.
  - *Probability of surplus decline > 0%*: (Investor) Such a decline would be analogous to a loss of principal on an investment.

Reinsurance Structure

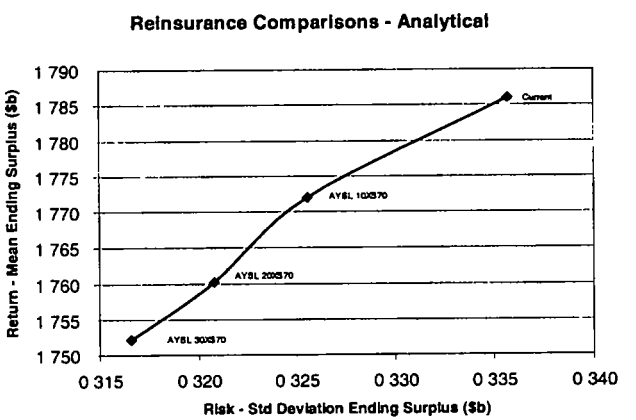
- Accident year stop loss (AYSL) covers were tested since they address the following issues facing DFAIC:
  - Volatility in net results
  - Sizeable catastrophe net PML after current reinsurance
  - Frequency of small retained weather losses
  - Significant probability of surplus decline
- Four reinsurance structures were tested:
  - Current program
  - Three AYSL: 10%x70%, 20%x70%, 30%x70% (Loss and ALAE)
- Insufficient data was available to test alternatives to the company's excess of loss and catastrophe covers.

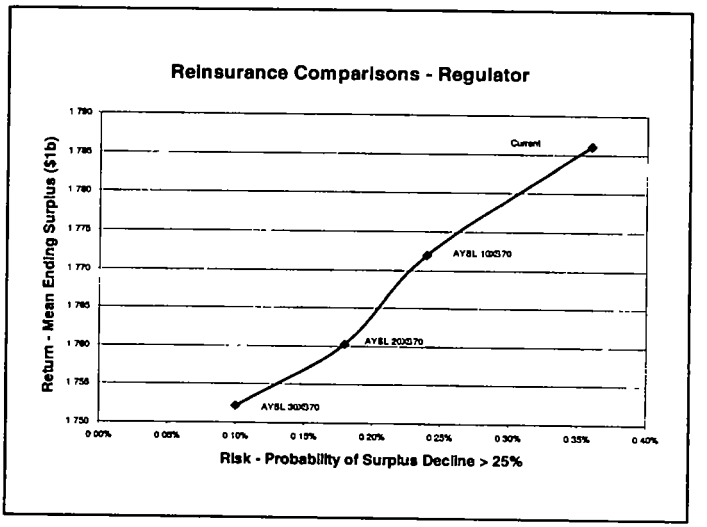
Reinsurance Structure

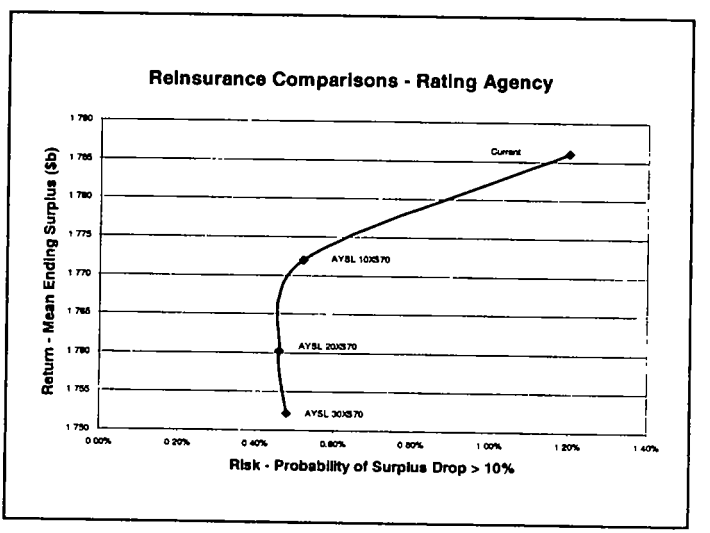
- The following charts show the risk return trade-off for the four structures under the various risk tolerance levels
- Also following is a table of ratios that quantify the risk return trade-off. The ratio is defined as:

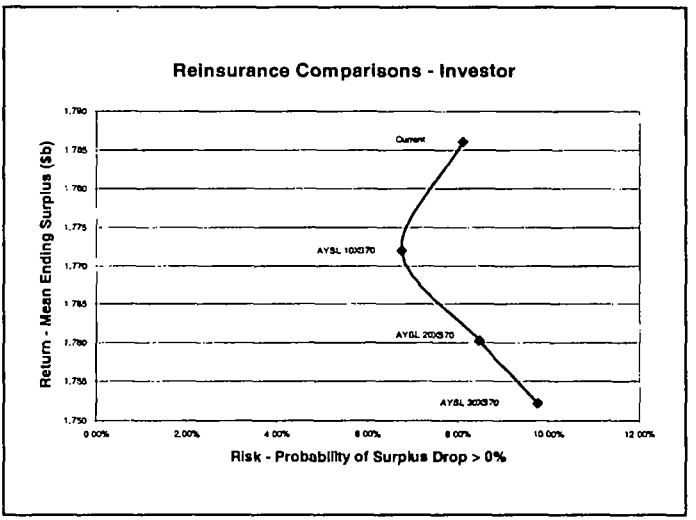
$$\frac{\text{(Pct change in return measure)}}{\text{(Pct change in risk measure)}}$$

- A ratio below 100% is favorable as relatively more risk protection is being afforded than expected margin charged. Negative ratios are unfavorable as risk is increasing.




Reinsurance Comparisons - Regulator
Return - Mean Ending Surplus ($1b)
1 790
1 785
1 780
1 775
1 770
1 765
1 760
1 755
1 750
Current
AYSL 10X370
AYSL 20X370
AYSL 30X370
0 00%
0 05%
0 10%
0 15%
0 20%
0 25%
0 30%
0 35%
0 40%
Risk - Probability of Surplus Decline > 25%


Reinsurance Comparisons - Rating Agency
Return - Mean Ending Surplus ($b)
1 790
1 785
1 780
1 775
1 770
1 765
1 760
1 755
1 750
Current
AYSL 10X370
AYSL 20X370
AYSL 30X370
0 00%
0 20%
0 40%
0 60%
0 80%
1 00%
1 20%
1 40%
Risk - Probability of Surplus Drop > 10%



Reinsurance Structure

	Model Results					Trade-off Ratios			
Reinsurance Alternatives	Avg. Surplus	St.Dev. Surplus	Drop >25%	Drop >10%	Drop >0%	Analytic Level	Regulator Level	Rating Level	Invest Level
Current Structure	$1.786b	$0.336b	0.36%	1.20%	8.12%	Base	Base	Base	Base
AYSL 10x70	$1.772b	$0.326b	0.24%	0.52%	6.76%	26.1%	2.4%	1.4%	4.7%
AYSL 20x70	$1.760b	$0.321b	0.18%	0.46%	8.48%	45.6%	2.6%	5.7%	(2.6)
AYSL 30x70	$1.752b	$0.317	0.10%	0.48%	9.76%	34.8%	1.0%	(10.5)	(3.0)

Reinsurance Structures

- As the exhibits show, the "best" reinsurance structure depends on the selected risk tolerance.
- At lower risk tolerances (e.g. Analytical, Regulatory, and Rating) buying additional reinsurance is almost always favorable since the focus is on extreme events.
- At an Investor level, the focus is on protecting against surplus decline. Here the high costs of excessive reinsurance will be evident.
- The study indicates that purchasing AYSL coverage up to 10% would make sense, but greater coverage is too costly except for a very low risk tolerance level.

Asset Allocation

Asset Allocation

- The DFA model was used to evaluate varying the asset allocation using a risk return framework.
- For insurers, diversification possibilities exist if movements in capital market prices are assumed uncorrelated with changes in liability results.
- Six strategies were evaluated:
  - Current asset allocation, stock holding equal 12%
  - Stock holdings of 17%, 22%, 27%, 32%, and 37%.

Asset Allocation

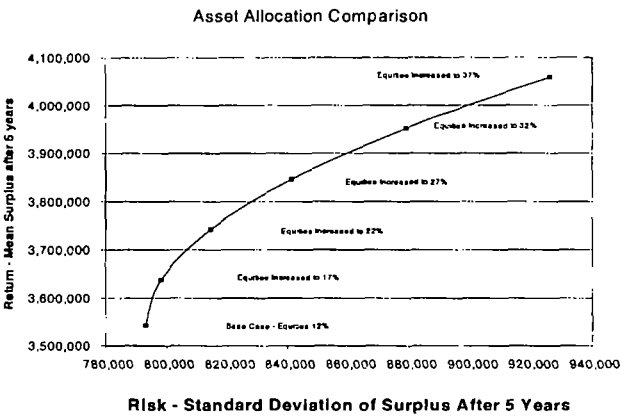
- Each strategy was run through the model over five years.
- The return measure used was five year ending surplus.
- The risk measure used was standard deviation of surplus in keeping with classical investment portfolio analysis.
- An allocation is efficient if its return cannot be increased without increasing risk.

Asset Allocation

- The following chart shows the risk-return trade off for the six asset allocations.
- Like the reinsurance analysis, trade-off ratios were calculated . The ratio is defined as:

  (Pct change in return measure)
  (Pct change in risk measure)

- For this comparison, ratios *above* 100% are favorable as relatively more expected return is being afforded than risk . Negative ratios reflect inefficient portfolios.



Asset Allocation

Allocation Strategy	Model Results Average Surplus	Std Dev Surplus	Trade-off Ratio
Current 12%	$3.542b	$0.793b	Base
Equities 17%	$3.638b	$0.798b	403%
Equities 22%	$3.741b	$0.814b	140%
Equities 27%	$3.846b	$0.841b	85%
Equities 32%	$3.952b	$0 879b	61%
Equities 37%	$4.059b	$0.926b	50%

Asset Allocation

- As the exhibits show, the current allocation is efficient. However, increasing the allocation of equities to 22% provides a favorable risk return trade-off.
- Other aspects of investment strategy that can be evaluated in this manner include:
  - Duration of the fixed income portfolio
  - Average credit risk of asset portfolio
  - Mix of taxable and non-taxable holdings
  - Impact introducing securities with callability risks

Capital Allocation & LOB Return Distributions

Capital Allocation

- Profitability across line of business can be measured by risk adjusted ROE.
- The capital allocation to lines is based on the relative contribution of each line to the company's overall risk.
- ROE by line is then calculated using the formula:

$$\left(\text{Net Income} \Big/ \text{Allocated Capital} \right)$$

- Each line can now be evaluated on a common basis.

Capital Allocation

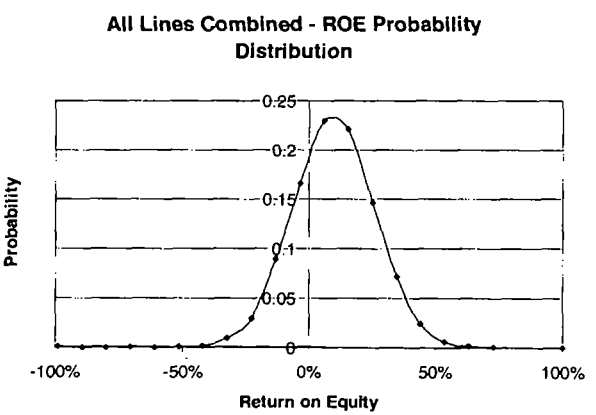
- However, the variability of a line depends on the order in which lines are analyzed. Often the diversification benefit of new business is not distributed to existing business.
- Also, most by-line risk measures usually do not add up to the total company risk measure.
- This often leads to an allocation of surplus which is not conducive to the stability of the group.
- In this study, Game Theory techniques were used to alleviate these problems, yielding an allocation that is order-independent, additive, and stable.

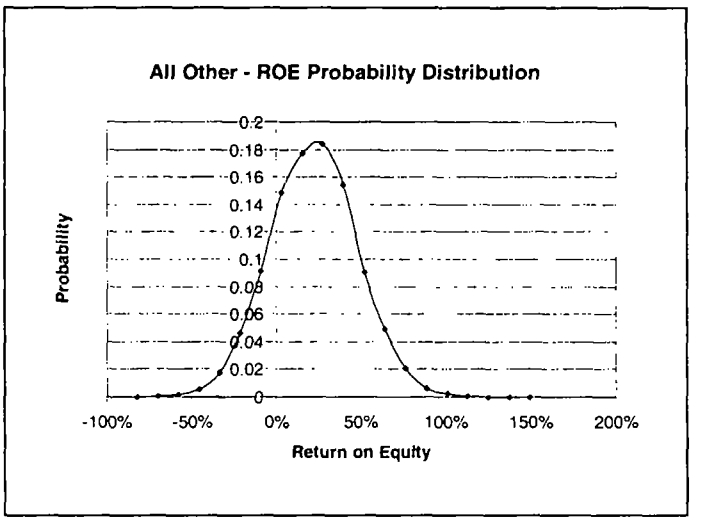
Capital Allocation

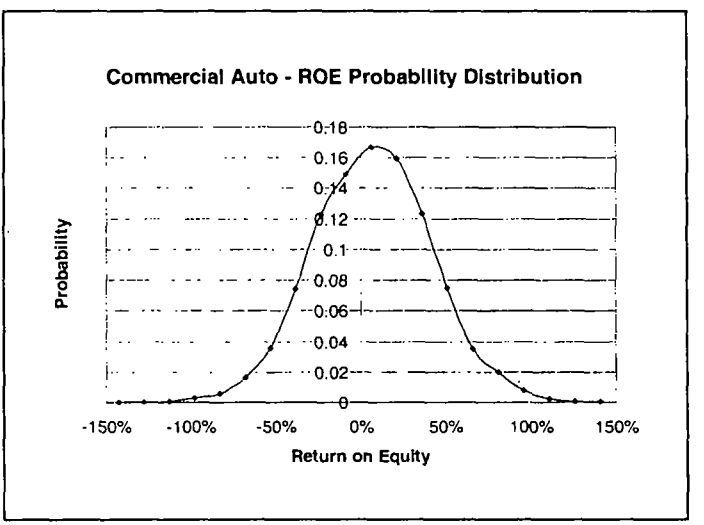
- The next exhibit displays the ROE results for each line.
- Following the chart are graphs displaying the distribution of ROE for each line.
- Based on the model results, both PPA and CA Liability are performing worse than the company average.
- Homeowners has the greatest variability of results due to catastrophe exposure.

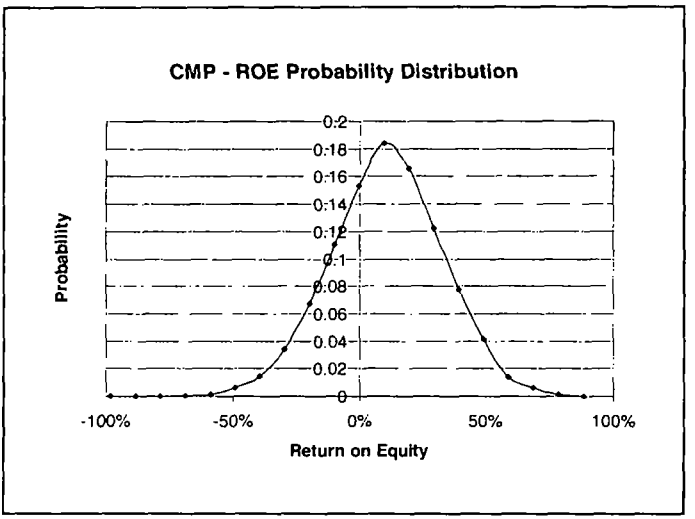
Capital Allocation and ROE

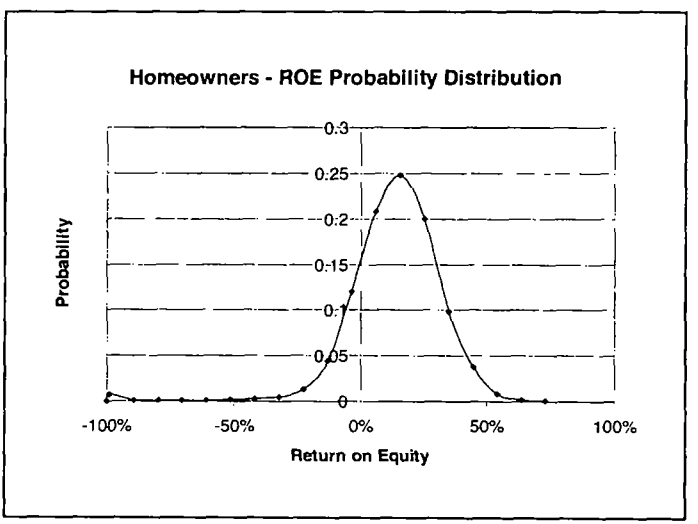
Line of Business	Net Earned Premium	Average Net Income	Allocated Capital	Average ROE	Std Dev. ROE
All Other	$60.9m	$6.0m	$38.2m	15.7%	25.8%
CA Liab	$162.5m	($0.3m)	$71.3m	(0.5%)	34.9%
CMP	$335.0m	$12.8m	$223.4m	5.7%	22.0%
Home	$344.0m	$9.1m	$216.5m	4.2%	163.6%
PPA Liab	$602.1m	($23.2m)	$386.7m	(6.0%)	20.5%
Short Property	$659.0m	$56.9m	$485.1m	11.7%	13.2%
Workers Comp.	$208.7	$8.2m	$182.9m	4.5%	19.8%
ALL LINES	$2,372.1m	$69.5m	$1,604.1m	4.3%	27.2%

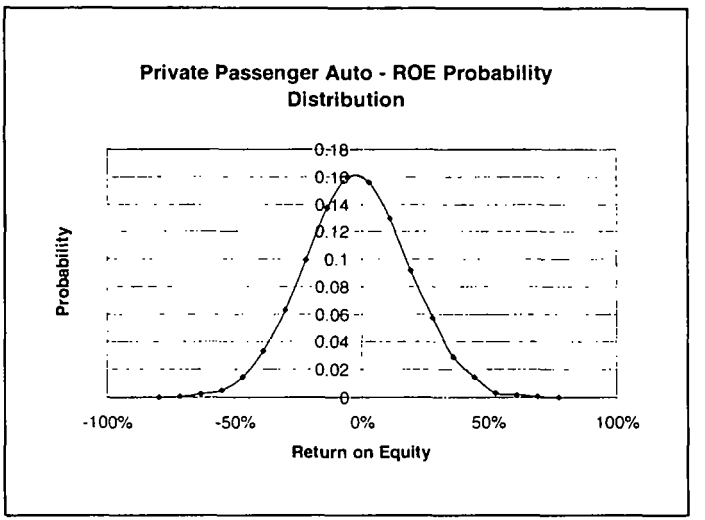


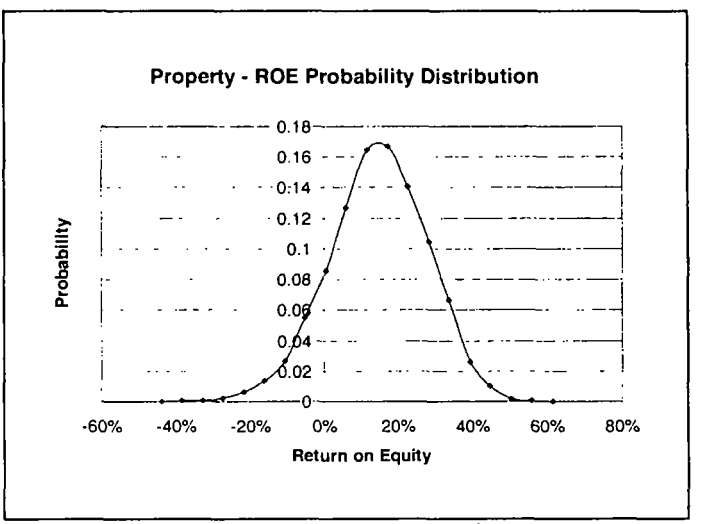

All Other - ROE Probability Distribution
Probability
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-100%
-50%
0%
50%
100%
150%
200%
Return on Equity

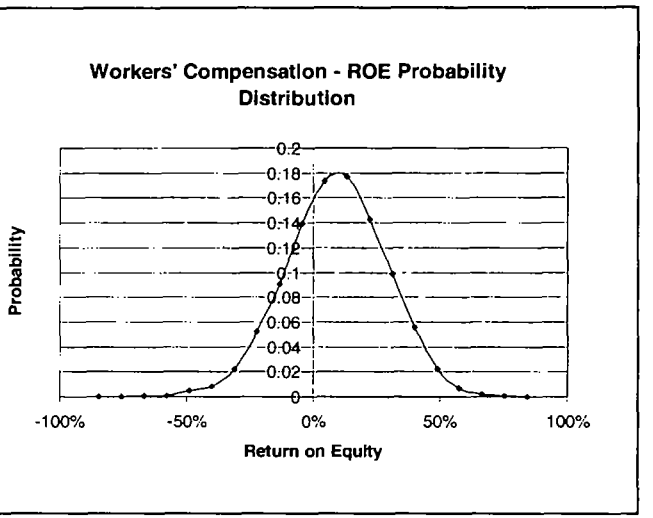

Commercial Auto - ROE Probability Distribution
Probability
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-150%
-100%
-50%
0%
50%
100%
150%
Return on Equity


CMP - ROE Probability Distribution
Probability
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-100%
-50%
0%
50%
100%
Return on Equity


Homeowners - ROE Probability Distribution
Probability
0.3
0.25
0.2
0.15
0.1
0.05
0
-100%
-50%
0%
50%
100%
Return on Equity


Private Passenger Auto - ROE Probability Distribution
Probability
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-100%
-50%
0%
50%
100%
Return on Equity


Property - ROE Probability Distribution
Probability
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-60%
-40%
-20%
0%
20%
40%
60%
80%
Return on Equity



Next Steps

- Gain better understanding of management's return criteria and risk tolerance.
- Gather additional data to expand scope and detail of study.
- Calculate a probability distribution of the economic value of DFAIC to evaluate the proposed purchase price.

ANALYSIS OF DFA Insurance Company
Technical Document

SCOPE

We dynamically modeled the entire asset and liability structure of the company. Asset/Liability integration occurs through the use of links to a common economic model.

The starting point for the analysis was the year-end balance sheet, and other financial statements including Schedule D and P.

ECONOMIC MODELING

The economic scenario generator models relationships among economic variables with stochastic difference equations. The equations were calibrated using historical data. The economic model is multi-period and captures risks both within and across time[1].

User inputs specify the current economic environment and expectations for long-term median trends, i.e. mean reversion parameters. The model then generates plausible time series outcomes for each variable for future economies using simulation.

The following are the environmental variables of the economic model. We have also noted the data sources used to parameterize the initial state of the model.

1. Money Supply Growth

The M2 Growth statistic is taken from the Ibbotson database as of 10/1999. The data in the database is collected monthly. Instead of annualizing the 10/1999 value, we calculated the annual M2 growth over the latest 12 months.

2. Monetary Velocity Growth

V2 growth is calculated from M2 Growth and GDP Growth. The formula is

$$V2\_Growth = (1 + M2\_Growth) \cdot (1 + GDP\_Growth) - 1$$

[1] Berger, A., and Madsen, C., "A Comprehensive System for Selecting and Evaluating DFA Model Parameters," *CAS Forum*, Summer 1999, Dynamic Financial Analysis Call Paper Program, p. 51.

3. GDP Growth (Real)

GDP growth is modeled as real GDP Growth. This is the number customarily quoted in the financial press. Usually GDP is indexed to a base year to adjust for inflation.

For our model we used the GDP growth statistic released by the Commerce Department as of the 1st quarter, 2000. We used the trailing 4 quarters of GDP growth rather than the latest annualized growth figure.

4. Inflation

The Consumer Prince Index was selected as a measure of inflation in the economy. We used the figures available is as of May 2000. We calculated the inflation rate over the previous 12-months rather than annualizing the latest monthly data.

5. S&P 500 Earnings Growth

The *S&P 500* web site posts several statistics and estimates for the S&P 500 companies. The projected growth rate for the group is 19% next year.

6. S&P 500 Earnings Yield

Earnings Yield is calculated as 1 / Price-to-Earnings Ratio, which is a statistic readily available on the S&P web site. Price over the trailing 12-month earnings is the customary way of calculating the P/E ratio. Per S&P, this P/E ratio is 27.87.

7. S&P 500 Dividends Yield

This statistics also came from the S&P web site.

8. Interest Rate and Yield Curve

The interest rate and yield curve was based on the on the US Treasury Yield Curve.

Initial Economic Parameters:

Economic Variable	Current	Mean Reversion		Interest Rates	Current	Mean Reversion
				3 months	0.0582	0.0488
M2 Growth	0.060	0.060		6 months	0.0621	
V2 Growth	-0.015	-0.015		1 year	0.0610	
GDP Growth	0.045			2 years	0.0629	
Inflation	0.035	0.035		3 years	0.0634	
Equity Earn Growth	0.100	0.100		5 years	0.0616	0.0548
Equity Earn Yield	0.040	0.040		7 years	0.0607	
Equity Div Yield	0.015	0.015		10 years	0.0597	
				20 years	0.0598	
				30 years	0.0598	0.0598

ASSET MODELING

In setting up the company's asset portfolio, limited data from Schedule D was available. Ideally, for analyses where investment strategy is relevant, more detailed asset information by specific holding would be provided.

Based on the data given, an asset portfolio was constructed by creating broad asset classes. The modeled portfolio was set to match the company portfolio with respect to:

1) Asset allocation (cash, bonds, equities, and other)
2) Taxable and tax-exempt holdings
3) Average duration of bonds (years to maturity set to term)
4) Average credit quality
5) Coupon rates that result in expected bond income

Fixed income valuation is performed using market yields based on the projected yield curve adjusted for a credit spread. Equities were modeled as the S&P 500 index in the economic model.

Initial Invested Asset Portfolio

Asset Class	Market Value	Term (=YTM)	Coupon Rate	Yield Spread*
Cash	$869,870			
Common Stock	$236,120			
Preferred Stock	$327,085			
UST 1YR	$10,173	1	8.00%	
UST 3 YR	$262,238	3	8.00%	
UST 12YR	$14,199	12	8.00%	
MUNI 1YR	$94,154	1	6.00%	-0.11%
MUNI AA 5YR	$698,317	5	6.00%	-1.64%
MUNI AA 12YR	$1,641,392	12	6.00%	-1.40%
MUNI AAA 20YR	$212,602	20	6.00%	-1.28%
CORP 1YR	$13,653	1	8.00%	0.20%
CORP AA 2YR	$122,455	2	8.00%	0.30%
CORP AA 5YR	$197,255	5	8.00%	0.37%
CORP AA 10YR	$51,314	10	8.00%	0.52%
JUNK MUNI 5YR	$6,255	5	6.00%	6.25%

**Yield spreads were based on market rates. For municipal bonds the yield spread was set below zero to reflect tax-exempt status.*

LIABILITY MODELING

The objective of liability modeling is to reflect the impact of the company's liabilities on capital and profitability evaluation, asset/liability management, and reinsurance structure analysis.

The model captures the following basic aspect of the liabilities:

1) Expected values of losses and reserves and variability
2) Correlation between liability groups
3) Payment patterns for liabilities with variability
4) Premiums and expenses reflecting collection, earning, and payment patterns
5) Trends for losses, premiums, and expenses

Methodology is described below for both prospective business and existing reserves.

Prospective Business

The company was modeled assuming level premium writings and losses based on historical averages. If a business plan is available, prospective modeling should reflect the company's projections to some degree. The company's business was grouped according to Schedule P lines. Ideally, the model should group business on a basis that reflects how the company manages its operations.

Generally, business should first be modeled on a direct or gross basis. The impact of the current reinsurance structure on direct results would then be modeled to arrive at net results. In this case, all business was modeled on a net-of-reinsurance basis. This was done due to a lack of detailed information about the current reinsurance structure. In using historical net data, an implicit assumption was made that the reinsurance structure has not changed over time.

Premiums and Expenses

For this study, premium and expenses were modeled as non-stochastic variables. Premiums were set flat and expenses were set uniformly across all lines. Since projected premiums and expenses were not adjusted for changes in exposure or inflation, no loss trend was applied to projected losses. Also, in this analysis, losses include ALAE.

Losses (including ALAE)

Losses for each line can be modeled either in aggregate or by separate frequency and severity components. Data concerning large losses would be needed to perform separate frequency and severity modeling.

In this case, losses were modeled in aggregate using Schedule P loss ratios. Historical rate change, exposure, and trend information would be needed to bring the information to current levels.

Losses for each line of business were fit to a lognormal distribution. For this study, the homeowners line was split into catastrophe and non-catastrophe groups. The catastrophe bracket was parameterized using the fact that the company's net PML for a 1-in-100 year catastrophe event is $160mil. This provided the 99^{th} percentile of the net catastrophe distribution. A rough estimate of the average retained catastrophe loss was made using net and direct Schedule P losses for homeowners. Based on these two points a lognormal distribution was fit. The non-catastrophe homeowners line was parameterized net of the modeled catastrophe losses.

Prospective Business Parameters

	Historical Data Parameters			Lognormal Fitted Params.	
LINE	Mean	Std. Dev.	C.V.	Mu	Sigma
HO – xCAT	212,326	9,000	0.042	12.265	0.043
HO – CAT	25,000	18,866,213	754.649	3.501	3.640
PPA – Liab	439,214	42,993	0.098	12.989	0.096
CAT – Liab	115,850	11,514	0.099	11.655	0.102
WorkComp	145,123	24,806	0.171	11.872	0.171
Comml MP	221,173	28,879	0.131	12.299	0.132
Short Prop	387,456	50,295	0.130	12.860	0.130
All Other	37,140	6,639	0.179	Use Normal Distribution	

Correlation

Next correlation of losses between lines of business was estimated based on historical loss ratios. The empirical results were highly volatile as would be expected using limited data. The average correlation across all lines was slightly under 25%. This was selected as the correlation parameter between all lines of business. The catastrophe group was assumed to be uncorrelated with the other lines.

No correlation was assumed between prospective lines of business and run-off of existing reserves. If the setting of reserves depends in large part on expected or historical planned loss ratios, then reserve development may co-vary with movements in the prospective losses. This can be particularly evident in long tail lines and reinsurance. Sufficient information was not available to model this effect.

Payment Patterns

Payment patterns for each line of business were based on the historical loss development shown in Schedule P. Payment pattern variability was introduced using a method that applies variability to the reserve disposal rates using a symmetrical beta distribution. The

variability used in the beta distribution was based on the variability in the historical development patterns.

Existing Reserves

The stated reserves for each line were assumed to be accurate. No attempt was made to test the reserves for adequacy. A recent reserve study would have been useful in this regard.

Payout patterns for the reserves were calculated using the accident year payment patterns in Schedule P data and converting to a stream of future calendar year payments.

Although the expected value of the reserve liability was set to the carried amount, the possibility of adverse or favorable reserve development was introduced. In other words, the ultimate reserve amount was modeled as random variable with an expected value set to the held reserve.

Reserve variability by line was modeled using a method analogous to the payment pattern variability method described above. For this purpose, the modeled variability in each age-to-ultimate development factor was used to get a distribution of ultimate losses for each accident year. Paid losses to date were subtracted from the modeled accident year ultimate losses to arrive at a distribution of reserves. This methodology has the desirable quality of decreasing reserve variability as accident year maturity increases.

REINSURANCE MODEL

The purpose of reinsurance modeling is to reflect the impact of the current and proposed reinsurance structures on the results of the company.

To parameterize the module, detailed information about a reinsurance structure is required, including:

1) Coverage terms for each cover, e.g. retentions, limits, etc.
2) Rates, commissions, and profit-sharing terms
3) Subject business definitions
4) Inuring relationships
5) Cash flow impacts, e.g. collection and payment schedules

The model is capable of handling losses in aggregate or on a claim level depending on the detail of liability modeling. Claim level losses and reinsurance terms can be specified on a per-claim or occurrence basis.

For DFAIC, the reinsurance structure was not described in detail. However, as the liability modeling was on a net basis, the base case results of the model can be said to model the current structure implicitly.

Alternative Structures

The study was not able to consider changes to the company's excess of loss retention or catastrophe program retention. This would have required additional data such as a large loss listing or output distributions from a catastrophe model such as RMS.

Alternative reinsurance structures on top of the current structure were modeled, however. This was done in the form of accident year stop loss (AYSL) covers. The model was used to evaluate the ability of these covers to reduce the volatility of the company's net results at an acceptable price.

Three levels of AYSL coverage were considered: 10%, 20% and 30% coverage in excess of a 70% loss and ALAE ratio. Prices for these treaties were estimated using a pricing model for AYSL reinsurance. The pricing reflected not only expected losses and expenses, but also a risk load based on the variability of ceded losses. The DFA model will have to be updated to the extent actual market prices are different.

Reinsurance Alternatives ($000)

	Alternative #1	Alternative #2	Alternative #3
Attachment	70.0%	70.0%	70.0%
Limit	10.0%	20.0%	30.0%
Ceded Premium	$35,000	$50,000	$60,000
Expected Loss	$16,088	$17,248	$17,867
Std. Dev. Loss	$42,196	$50,147	$56,684

CAPITAL ADEQUACY

Capital adequacy is a prospective measure of the expected value and volatility of a company's surplus. Regulatory and Rating agencies are concerned with the probability of insolvency of a company. This can be evaluated by analyzing the outcome probability distribution of surplus. For regulatory agencies, this is usually done on a statutory basis. Rating agencies often make some economic adjustments to surplus.

Two measures were used to calculate capital adequacy from an insolvency perspective:

Probability of Ruin - This measure reflects the probability that the company will have negative surplus under simulated conditions. Often a "safety level" is selected. This represents the percentile of ruin. Then a required surplus number is calculated that results in probability of insolvency below the safety level. The required surplus is compared against the actual surplus to measure capital adequacy.

Expected Policyholder Deficit (EPD) - This measure reflects not only the probability of insolvency but also the severity of insolvency under simulated conditions. EPD is often stated as a percentage of expected loss.

$$\text{EPD Ratio} = \frac{\text{Expected [min(0,simulated ending surplus)]}}{\text{Expected [Losses]}}$$

The distribution of surplus can also be used to determine the probability of surplus decline. A measurement of this type would be of interest to an investor concerned with the preservation of investment principal. A measure of this type is Expect Default Loss Rate on Surplus[2] (EDLR). EDLR can be used to evaluate adequacy of capital in a manner analogous to how bonds are evaluated by rating agencies based on their default rates.

Expected Default Loss Rate – This measure reflects of the probability of any surplus decline. This is stated relative to current surplus.

$$\text{EDLR Ratio} = \frac{\text{Expected [min(0,current surplus - simulated ending surplus)]}}{\text{Current Surplus}}$$

CAPITAL ALLOCATION

Capital allocation to lines of business should be based on the relative contribution of each line's risk to the company's total risk. In this study, capital allocation was performed using the relative variability of net income by line of business.

A method based on Game Theory[3] techniques was employed to fairly allocate capital. This ensured the surplus requirements by line added to the company total. Also, it resulted in diversification benefits being equitably shared among all lines.

The allocation scheme was based on Shapley value calculations. Since the risk measure used was variance of results, the Shapley value is represented by:

$$\text{Shapley Value} = \text{Var[division]} + \text{Cov[Rest of company, division]}$$

When the Shapely value is compared to the formula for marginal variance,

$$\text{Marginal variance} = \text{Var[division]} + 2 \times \text{Cov[Rest of company, division]}$$

the Shapley value splits the covariance evenly among divisions.

[2] Mango, D., "Capital Allocation and Adequacy Using Dynamic Financial Analysis," *CAS Forum*, Summer 2000, Dynamic Financial Analysis Call Paper Program, p. 55.
[3] See Mango [2].