
DFA Insurance Company Case Study

2001 Casualty Actuarial Society Special Interest Seminar on Dynamic Financial Analysis

Boston, Massachusetts
June 7-8, 2001

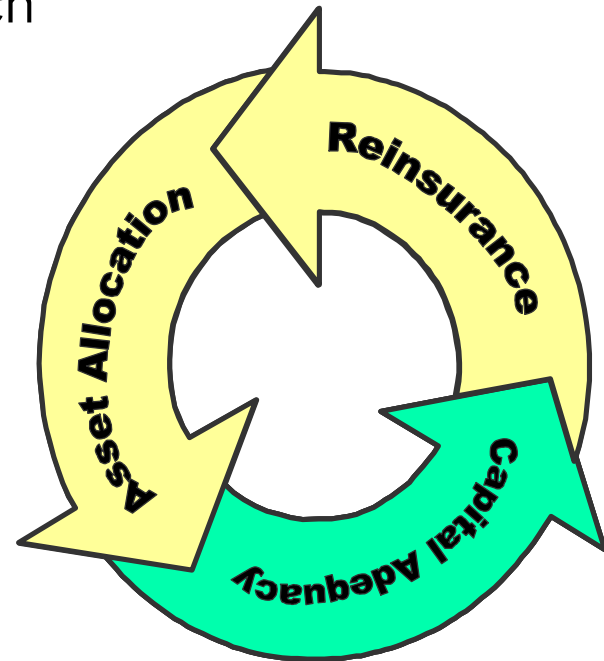
Stephen Philbrick, Robert Painter, John Burkett

Call Paper Questions

- **Is the Company adequately capitalized? Is there excess capital? How much capital should the Company hold as a stand-alone insurer?**
- **Should the Company buy more or less reinsurance? What type? How efficient is its current reinsurance program?**
- **How efficient is the asset allocation?**
- **How should the capital be allocated to line of business?**

Agenda

- Introduction
 - Recap of DFAIC
 - 7 Step General DFA Analysis Approach
 - Capital Adequacy
 - Reinsurance
 - Strategic Asset Allocation
 - Capital Adequacy Revisited
 - Capital Allocation
 - Conclusions & Comparisons
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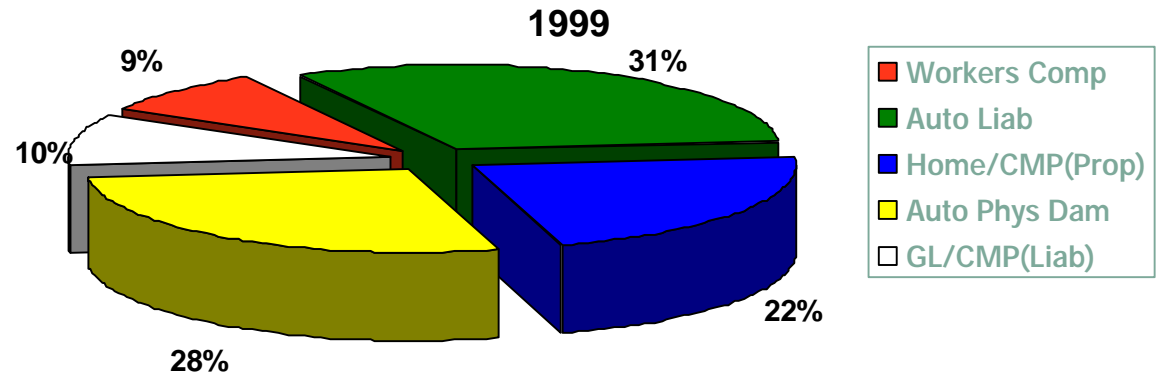
Introduction - Recap of DFAIC

1999 Underwriting Summary

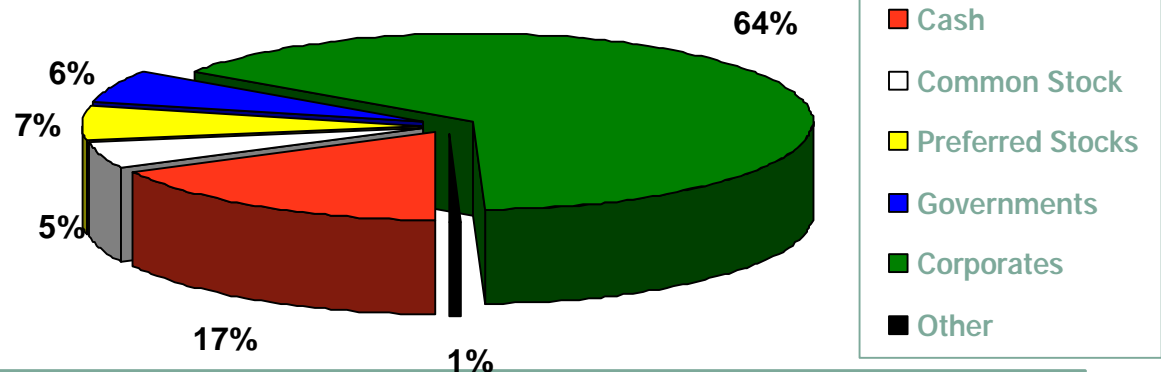
- Loss & LAE Reserves \$ 2,330 million
- Direct Written Premium \$ 2,565 million
- Net Written Premium \$ 2,350 million
- Booked Accident Year Loss&LAE Ratio

Gross	86.3%
Net	82.0%
- Expense Ratio (including policyholder dividends) 29.5%

Distribution of Net Earned Premium



Asset Mix



Asset Summary

Invested Assets

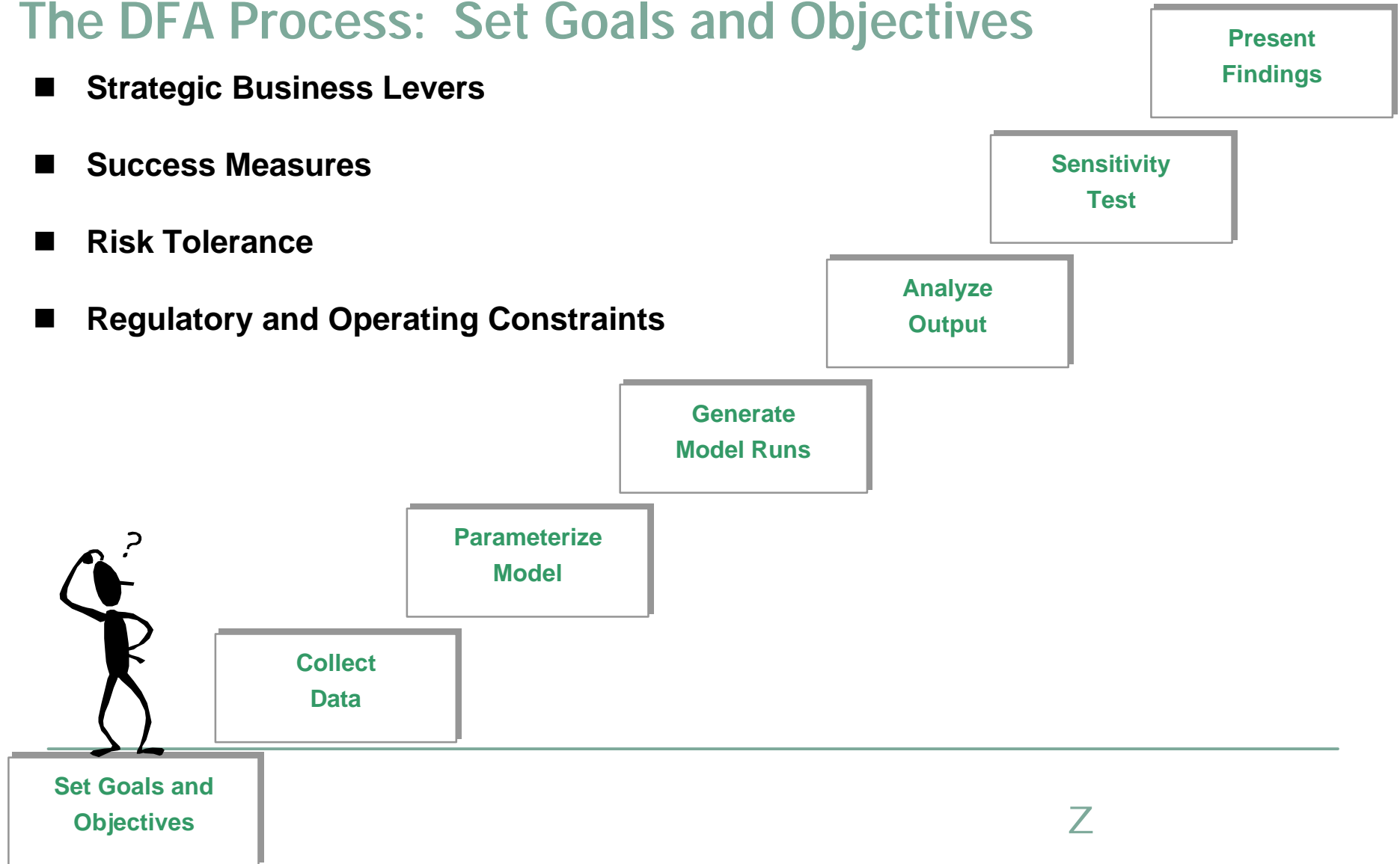
Book Value: \$4,702 million
 Market Value: \$4,746 million

Fixed Income Analysis

Average Maturity: 9.2 years
 Duration: 5.3 years

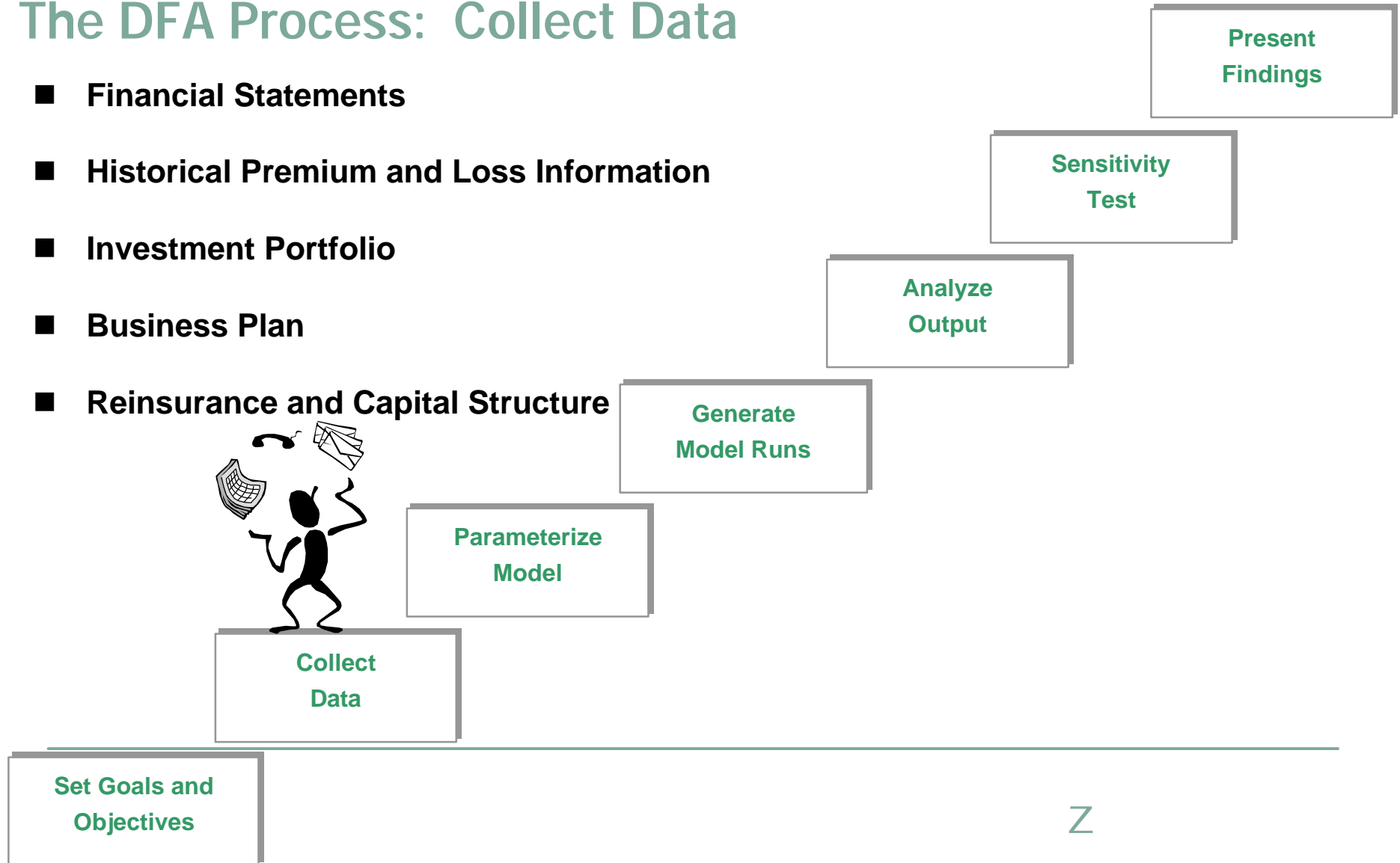
The DFA Process: Set Goals and Objectives

- Strategic Business Levers
- Success Measures
- Risk Tolerance
- Regulatory and Operating Constraints



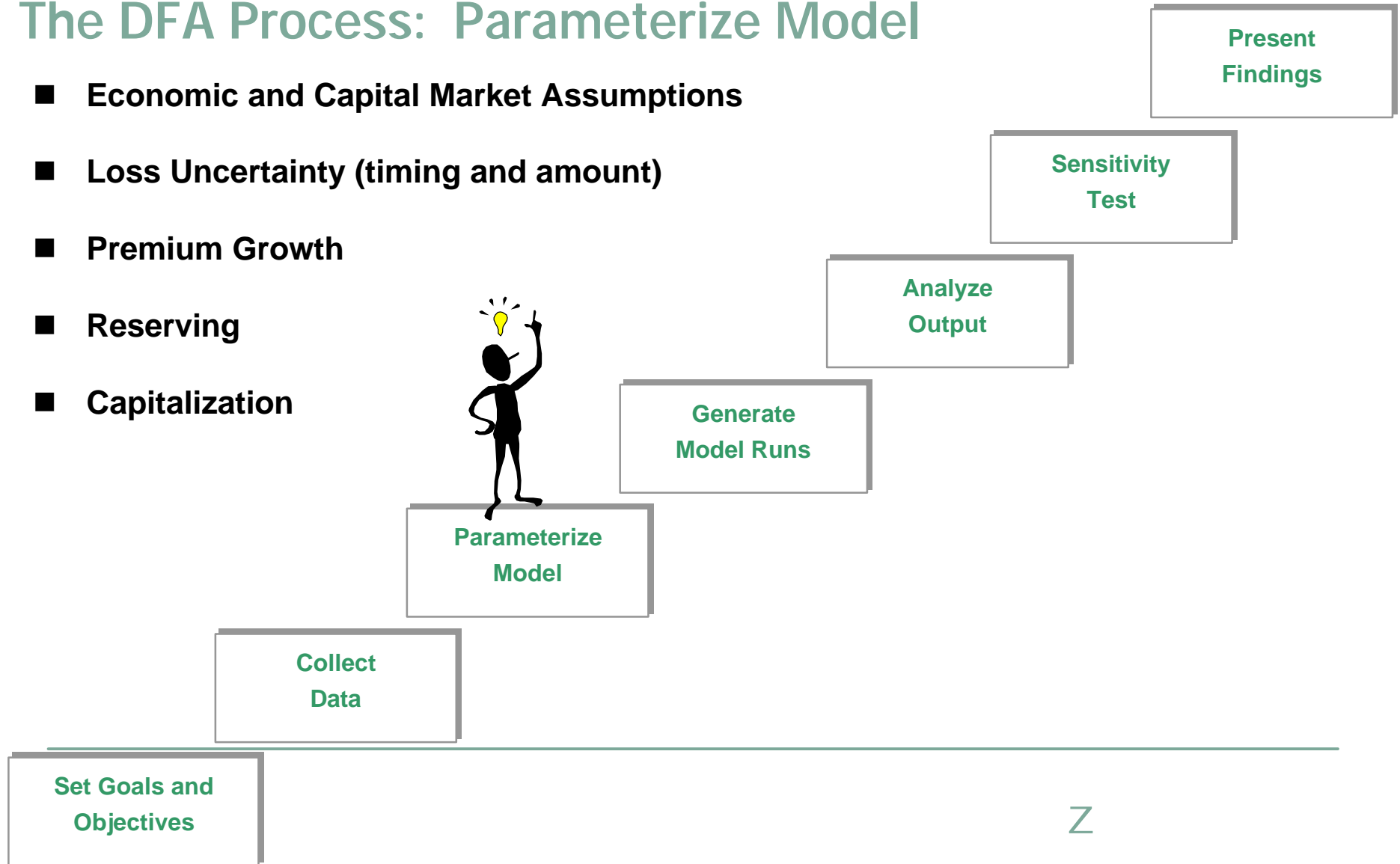
The DFA Process: Collect Data

- Financial Statements
- Historical Premium and Loss Information
- Investment Portfolio
- Business Plan
- Reinsurance and Capital Structure



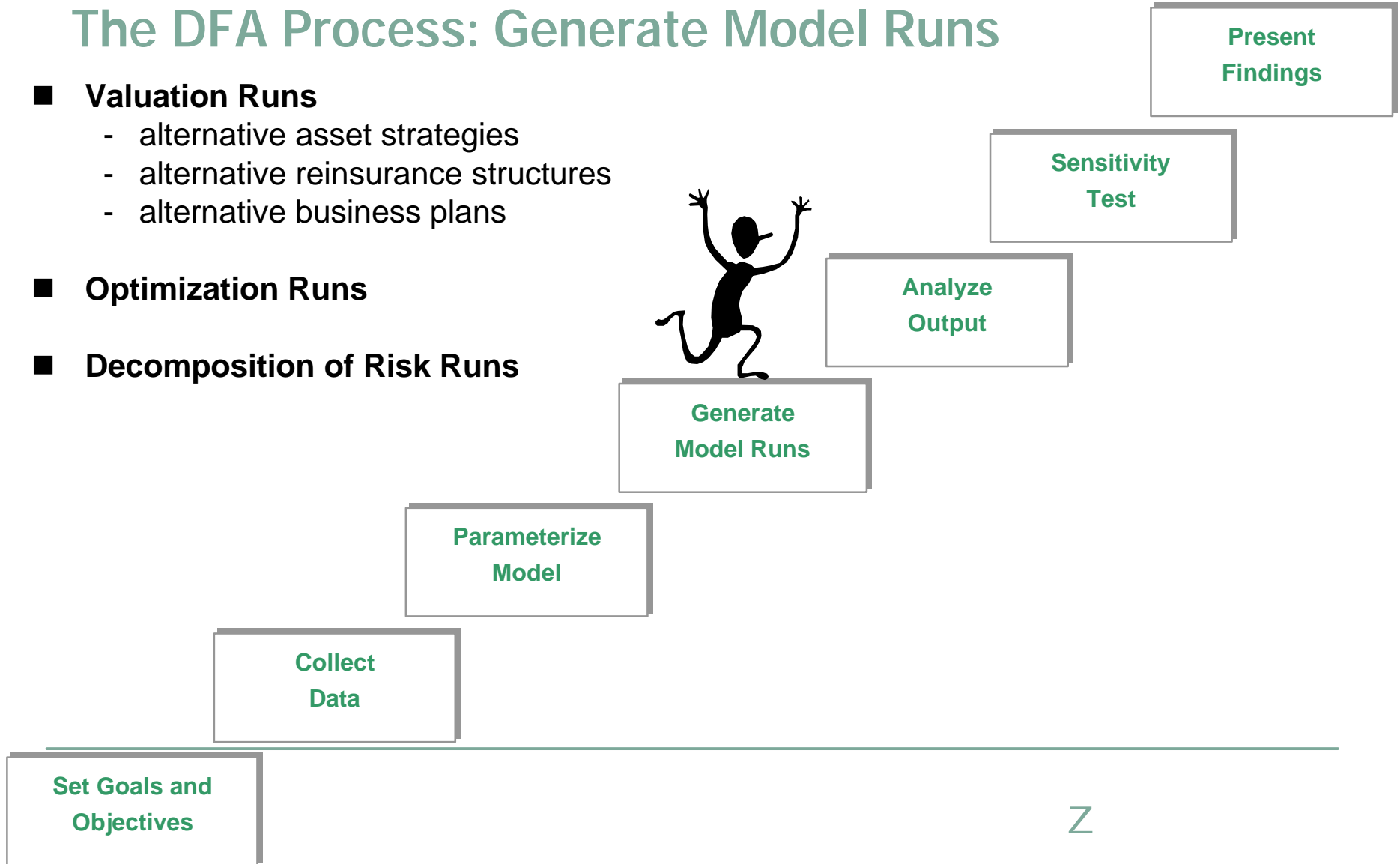
The DFA Process: Parameterize Model

- Economic and Capital Market Assumptions
- Loss Uncertainty (timing and amount)
- Premium Growth
- Reserving
- Capitalization



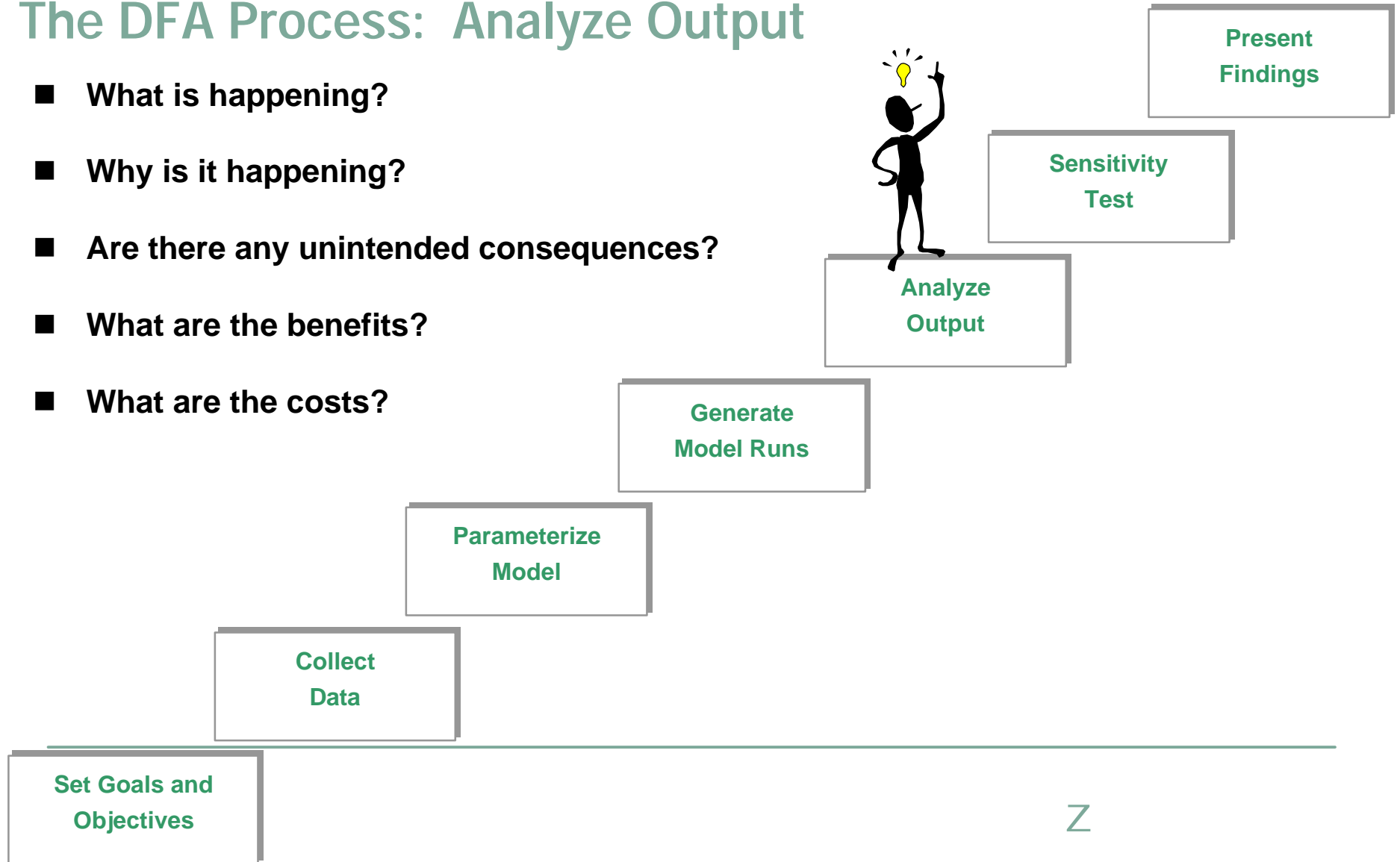
The DFA Process: Generate Model Runs

- **Valuation Runs**
 - alternative asset strategies
 - alternative reinsurance structures
 - alternative business plans
- **Optimization Runs**
- **Decomposition of Risk Runs**



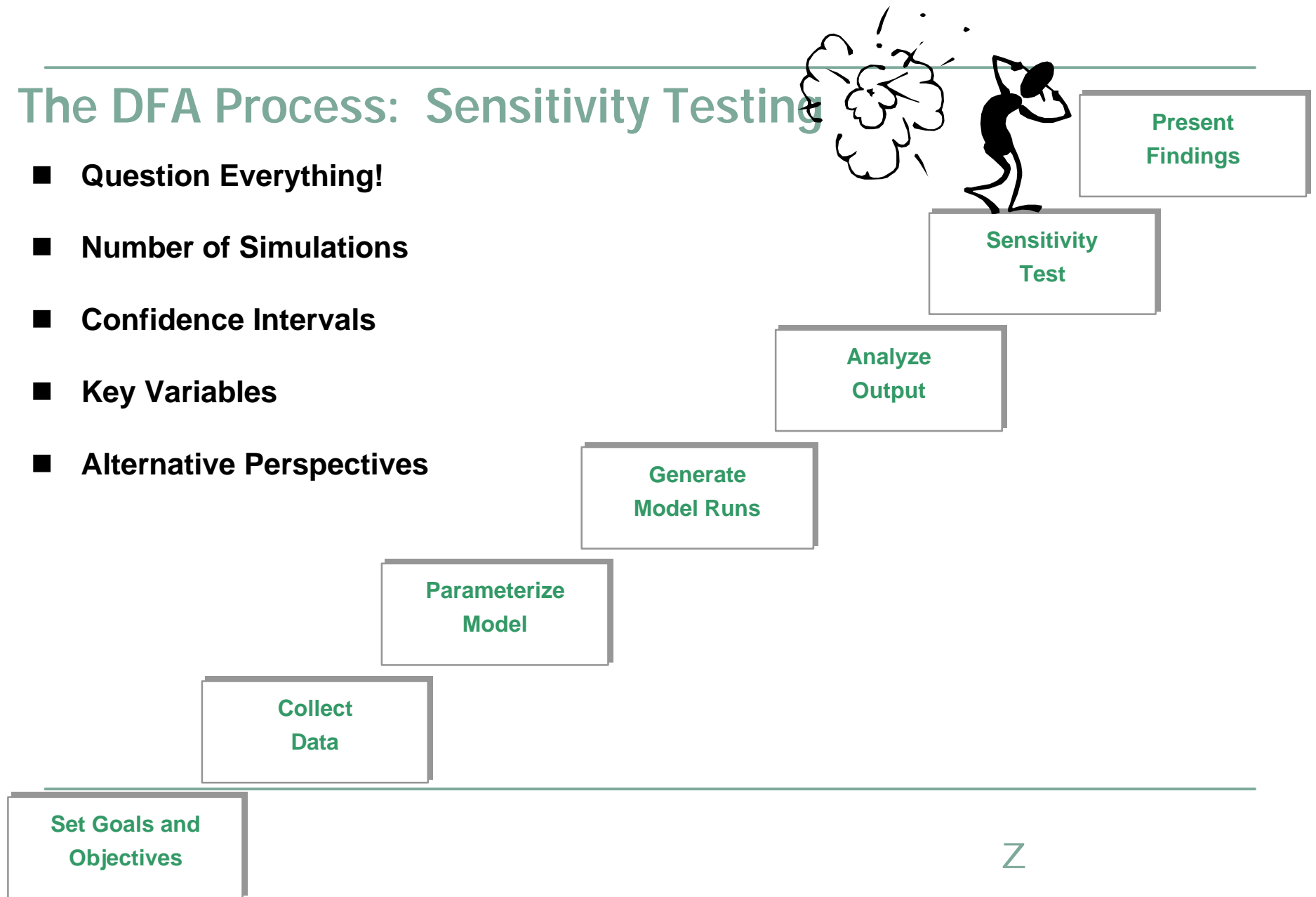
The DFA Process: Analyze Output

- What is happening?
- Why is it happening?
- Are there any unintended consequences?
- What are the benefits?
- What are the costs?



The DFA Process: Sensitivity Testing

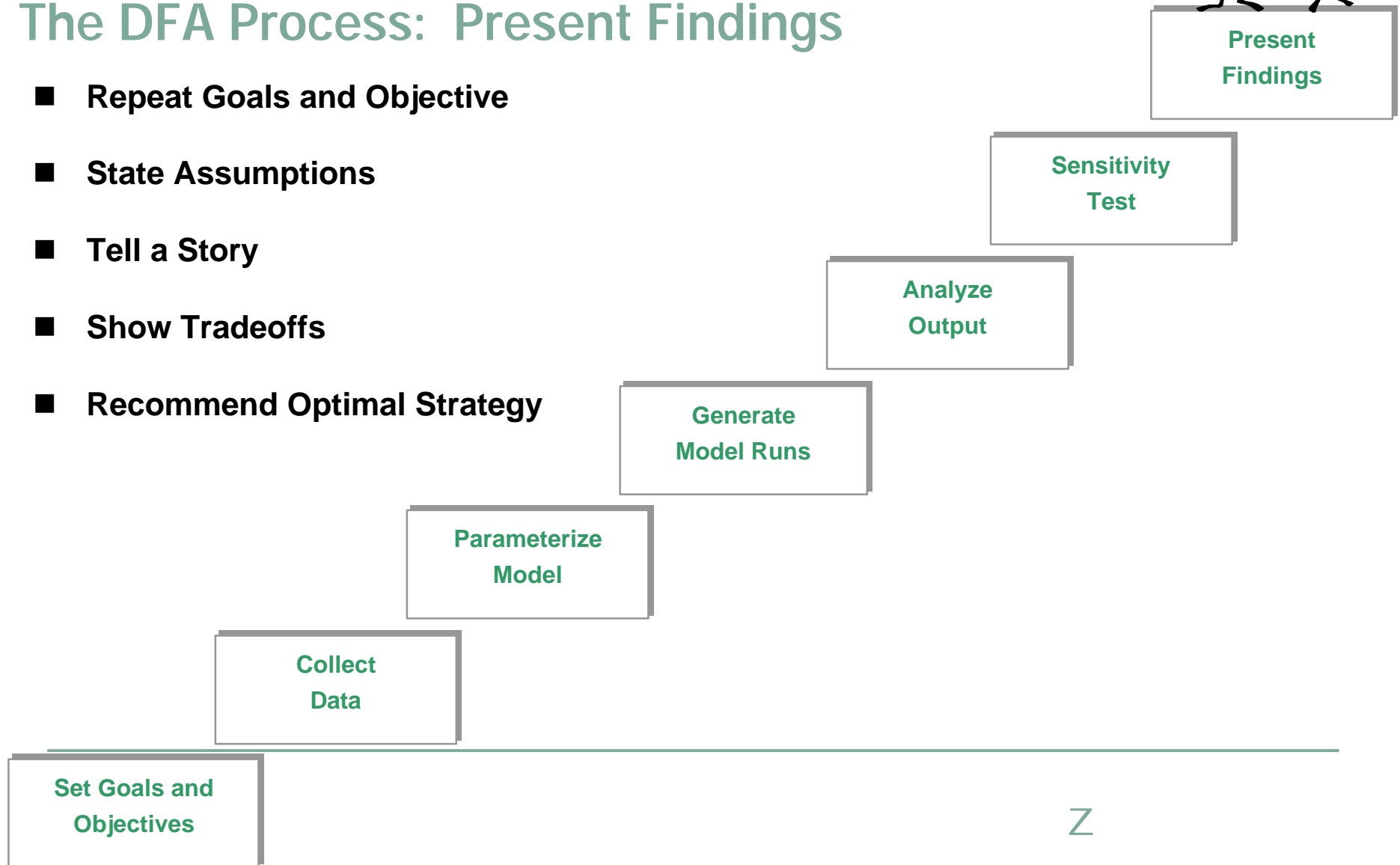
- Question Everything!
- Number of Simulations
- Confidence Intervals
- Key Variables
- Alternative Perspectives





The DFA Process: Present Findings

- Repeat Goals and Objective
- State Assumptions
- Tell a Story
- Show Tradeoffs
- Recommend Optimal Strategy



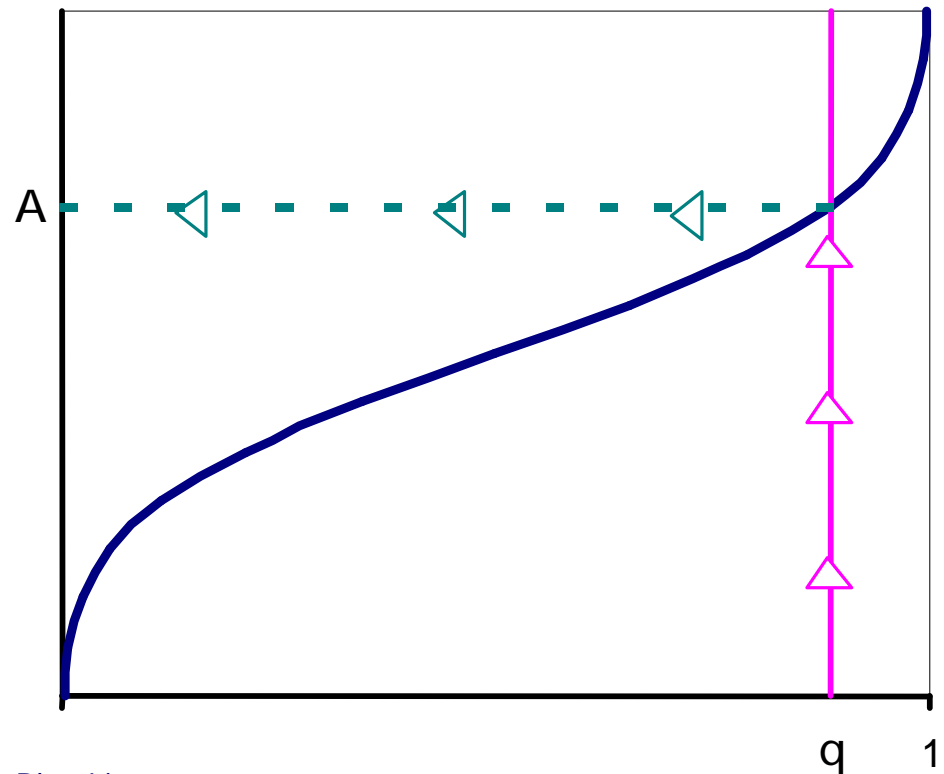
Capital Adequacy - Introduction

- Discuss Different Risk Measures
- Coherent Measures of Risk
- Applied to a Risk Variable that takes into account both assets and liabilities
- Compare TCE of Required Capital to other recognized Capital Adequacy Measures
- Later on the Second Iteration of the DFA Spiral: Compare estimates of Required Capital for an alternative Reinsurance/Asset Allocation structure

Capital Adequacy - Risk Measures

Probability of Ruin:

- In the banking industry also known as Value at Risk (VaR)
- Specific Sense: Probability capital falls below zero.
- General Sense: The corresponding value, for a selected q th percentile tolerance, for a given financial variable.

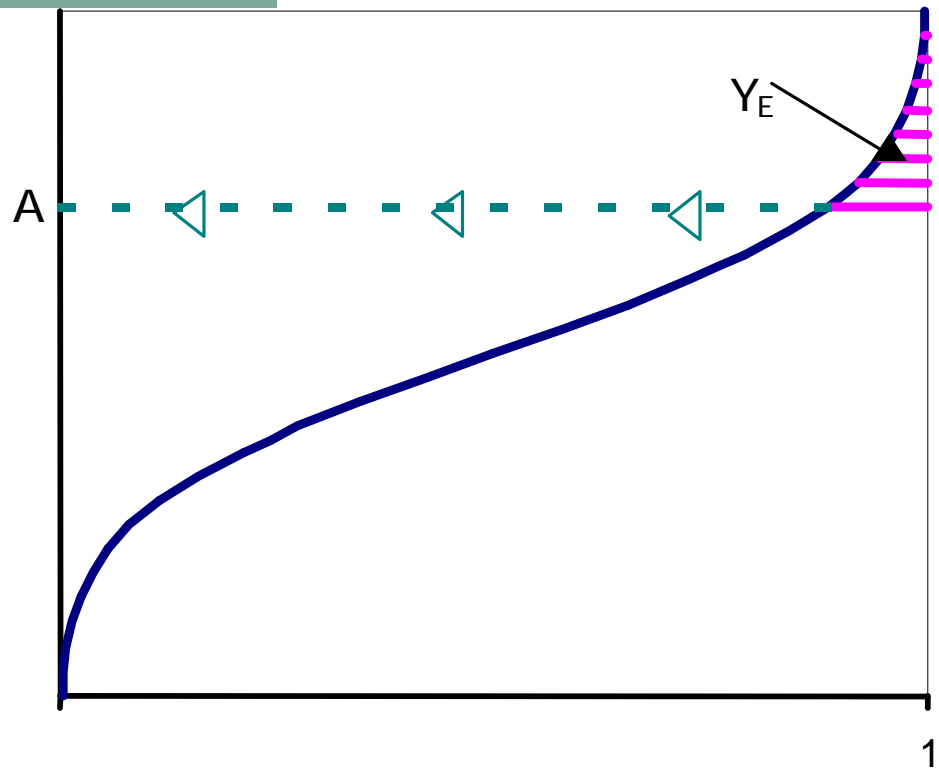


Blue Line =
Inverse Cumulative Distribution Function for a given Risk Variable

Capital Adequacy - Risk Measures

Expected Policyholder Deficit (EPD):

- Unlike VaR, EPD takes into account the magnitude of insolvency.
- Specific Sense: The amount or percentage of total obligations that will not be met.
- General Sense: The corresponding value, for a selected tolerance percentage Y_E of all summed potential outcomes, for a given financial variable.



Capital Adequacy - Coherent Risk Measures

Definition of Terms:

- X_i represent portfolios of risks. (Think of it as the liabilities of a particular insurance company).
- α be some constant
- $\rho(\cdot)$ be a function that assigns a value of risk to a portfolio

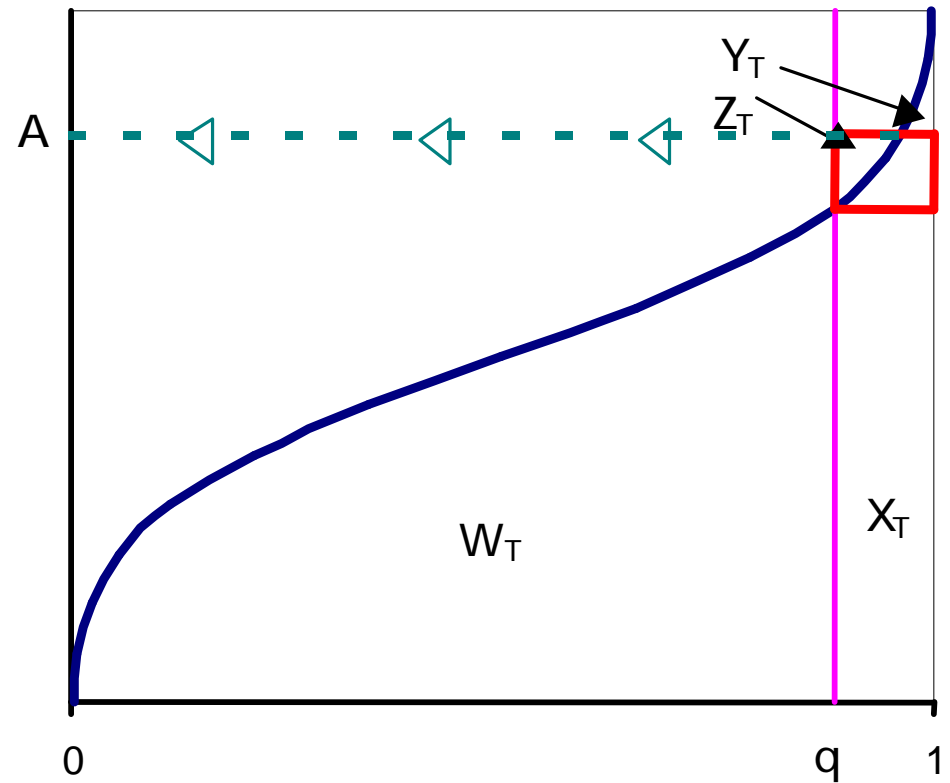
Four Axioms of a Coherent Risk Measure:

- $r(\mathbf{X} + a) = r(\mathbf{X}) + a$ **Translation Invariance**
- $r(\mathbf{X}_1 + \mathbf{X}_2) \leq r(\mathbf{X}_1) + r(\mathbf{X}_2)$ **Subadditivity**
- $r(a\mathbf{X}) = a r(\mathbf{X})$ **Positive Homogeneity**
- **For $\mathbf{X}_1 < \mathbf{X}_2$, $r(\mathbf{X}_1) < r(\mathbf{X}_2)$** **Monotonicity**

Capital Adequacy - Risk Measures

Tail Conditional Expectation (TCE):

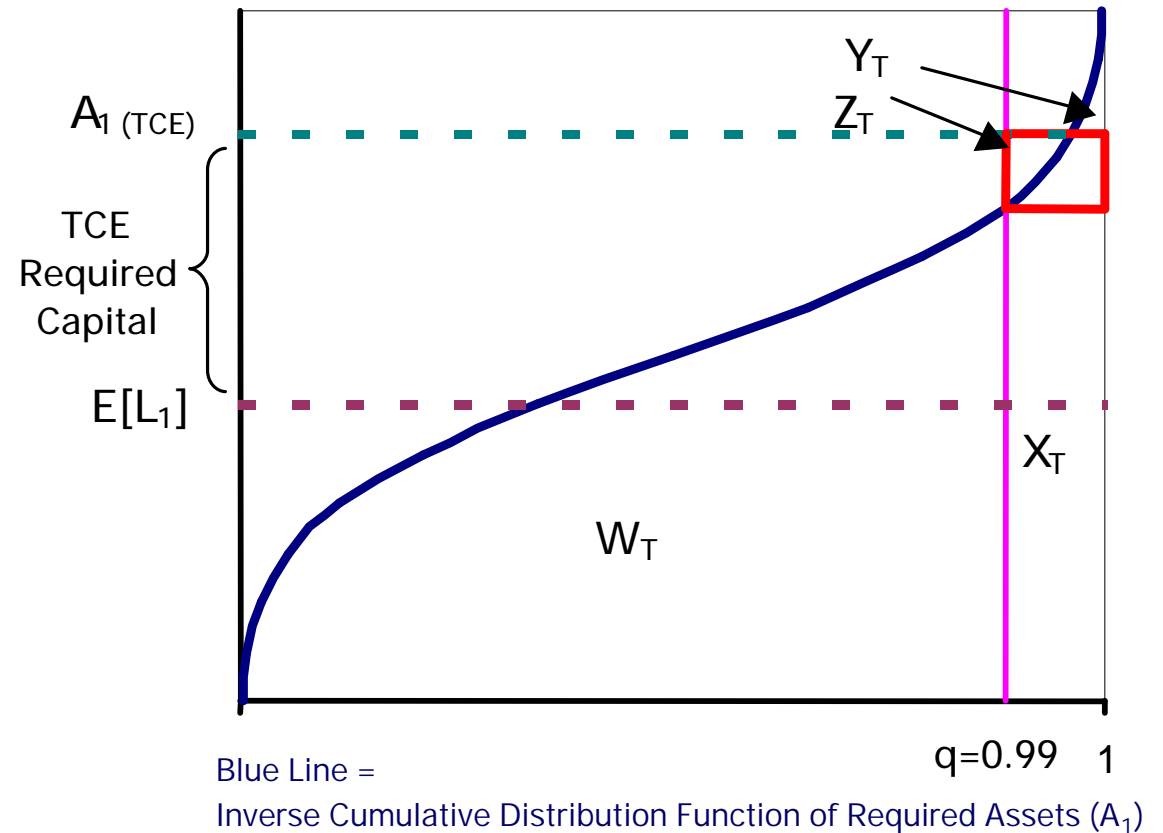
- Also known as Tail Value at Risk
- Unlike the standard deviation risk measure, TCE concentrates on the tail of the distribution.
- Combination of VaR and EPD
- Unlike VaR and EPD it is a Coherent Risk Measure
- Expected Value of the Largest $(1-q)$ of all possible outcomes



Capital Adequacy - Risk Variables

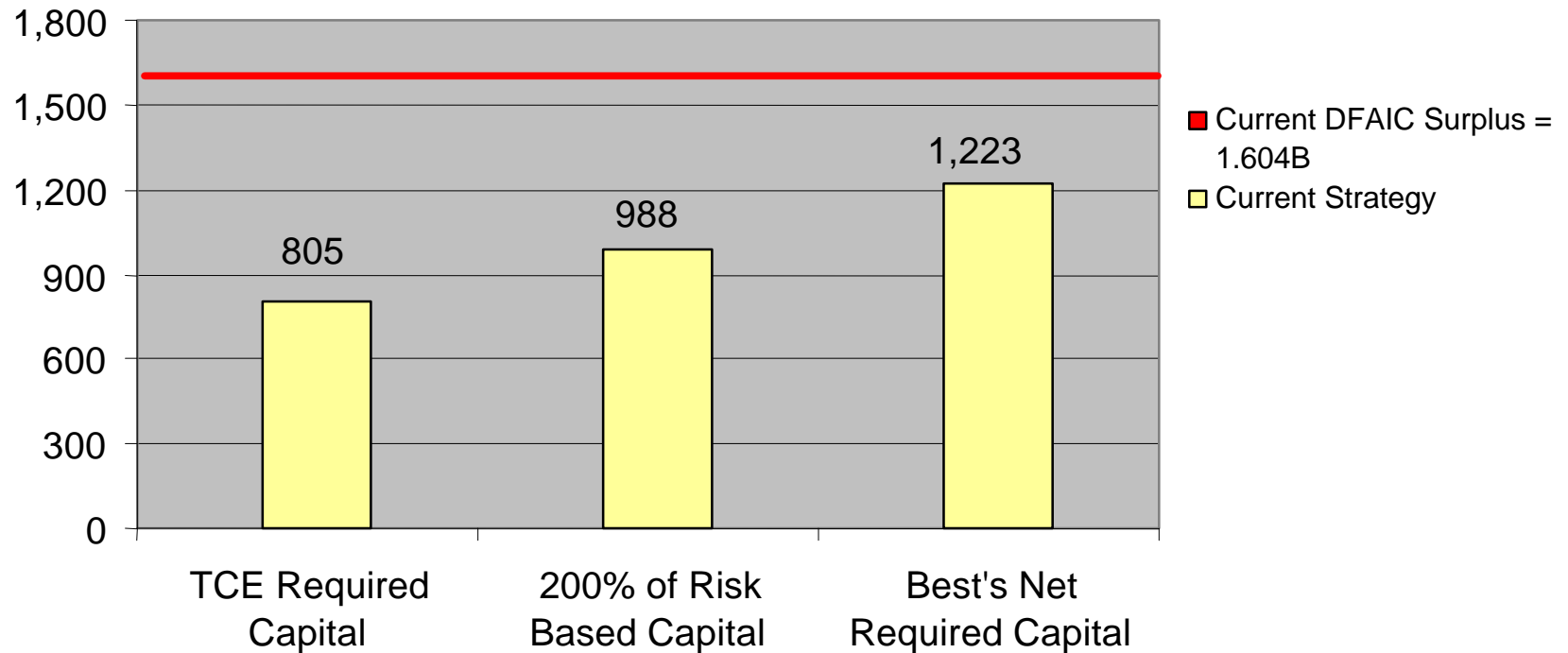
TCE Required Capital:

- Apply TCE(.99) to the distribution of "required assets" (\tilde{A}_1).
- Takes into account the volatility of entire balance sheet.
- $\tilde{A}_1 = E[A_1] - \tilde{S}_1$
- \tilde{S}_1 is 1) stochastic and 2) recognizes undiscounted ultimate loss immediately.
- TCE Required Capital = TCE Required Assets - $E[L_1]$



Capital Adequacy - Results

Estimates of Required Capital for DFAIC TCE Required Capital versus Other Common Measures



Current Strategy = Current Reinsurance Program, Equity Allocation = 11%, Fixed Income Duration = 5

Capital Adequacy - Conclusion

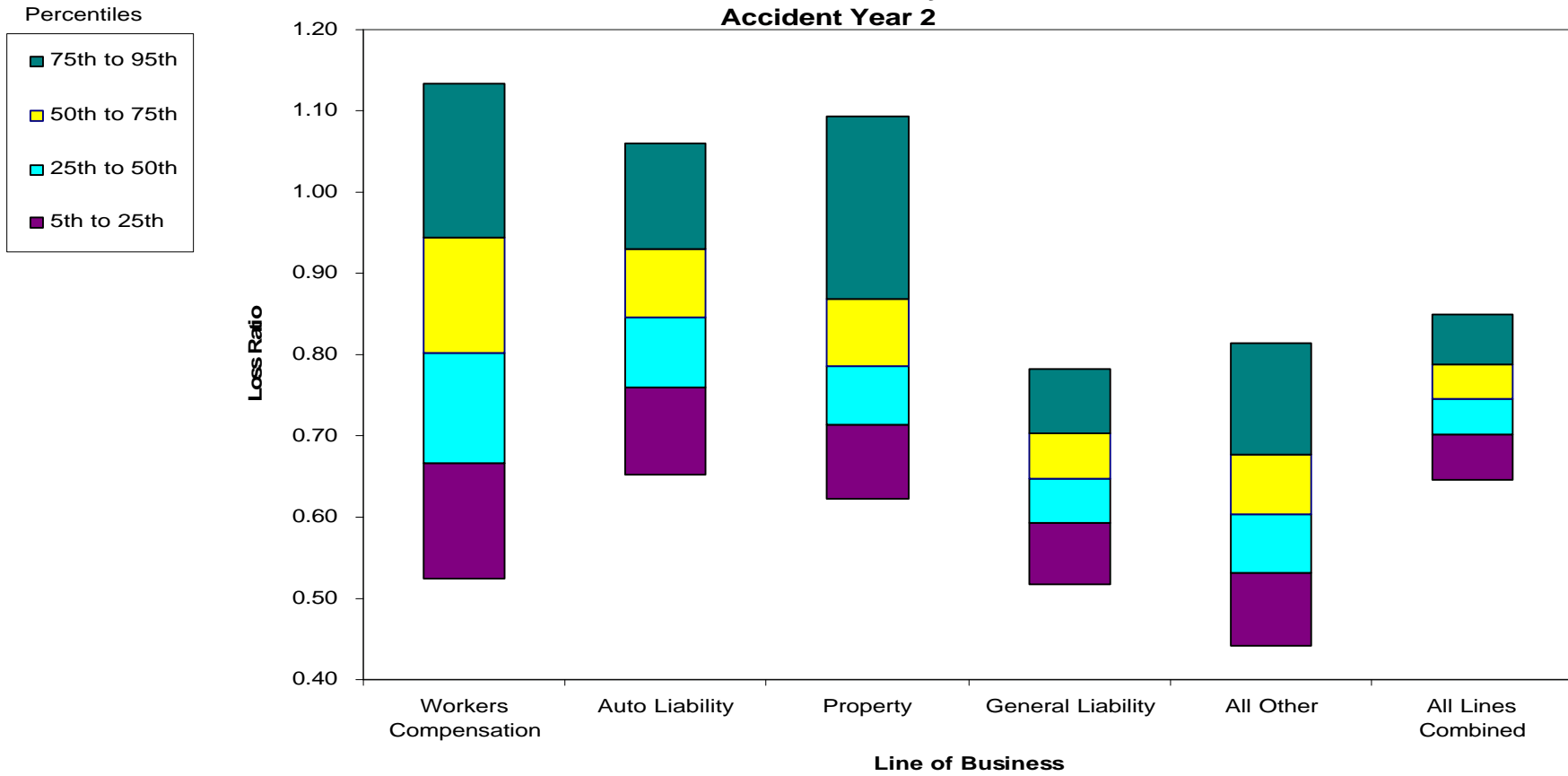
- DFAIC is Over-Capitalized
- Select a risk measure, i.e. TCE, that satisfies a set of reasonable axioms.
- Select a risk variable that takes into account all financial risks to solvency, including asset risk.
- Analysis accounts only for financial risk, and not operational contingencies.

Reinsurance

- Current Program
 - Per occurrence excess of loss coverage attaching at \$500K.
 - Per risk excess cover on commercial property.
 - Property catastrophe cover attaching at \$50 million.
- Proposed Program
 - Accident Year aggregate stop loss covering 75% of 20 loss ratio points excess of 80.
 - Property catastrophe cover attaching at \$50 million.

Reinsurance

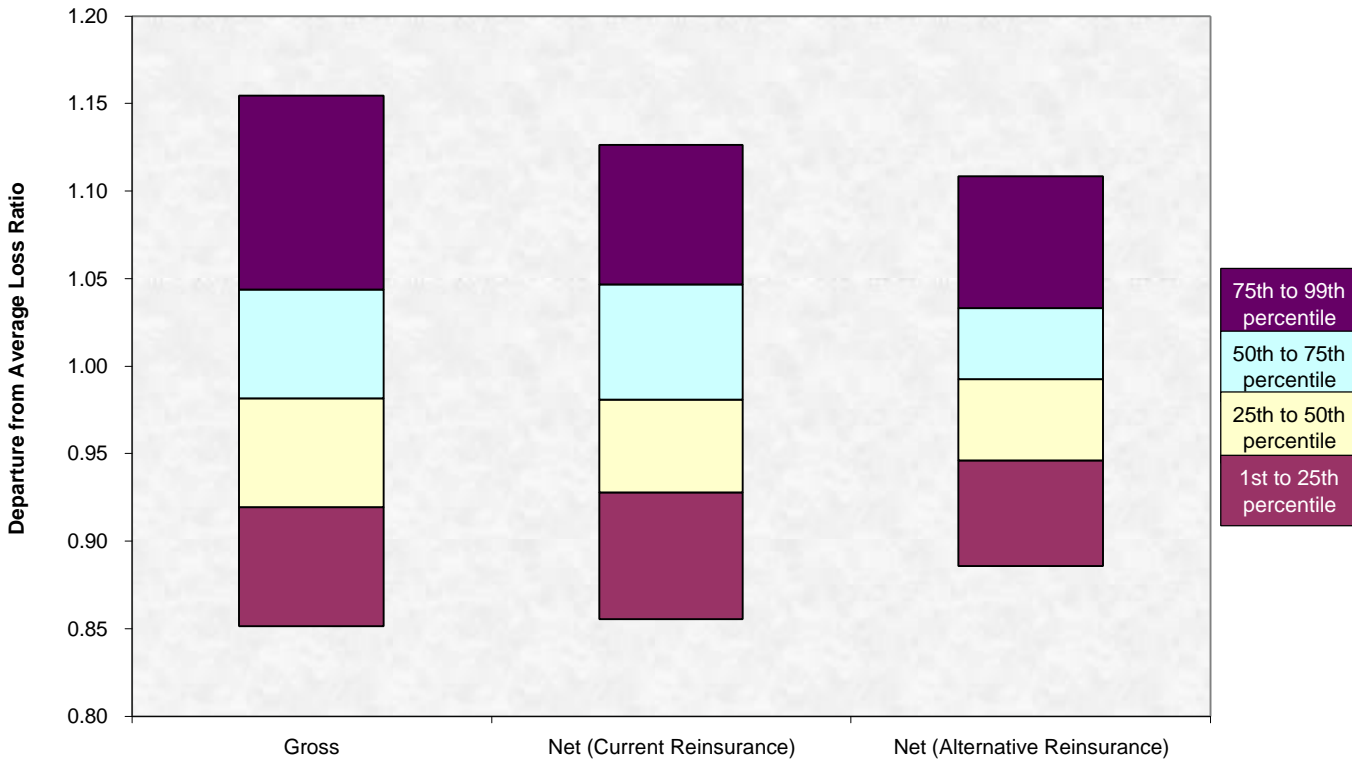
**Gross Loss Ratios by Line
Accident Year 2**



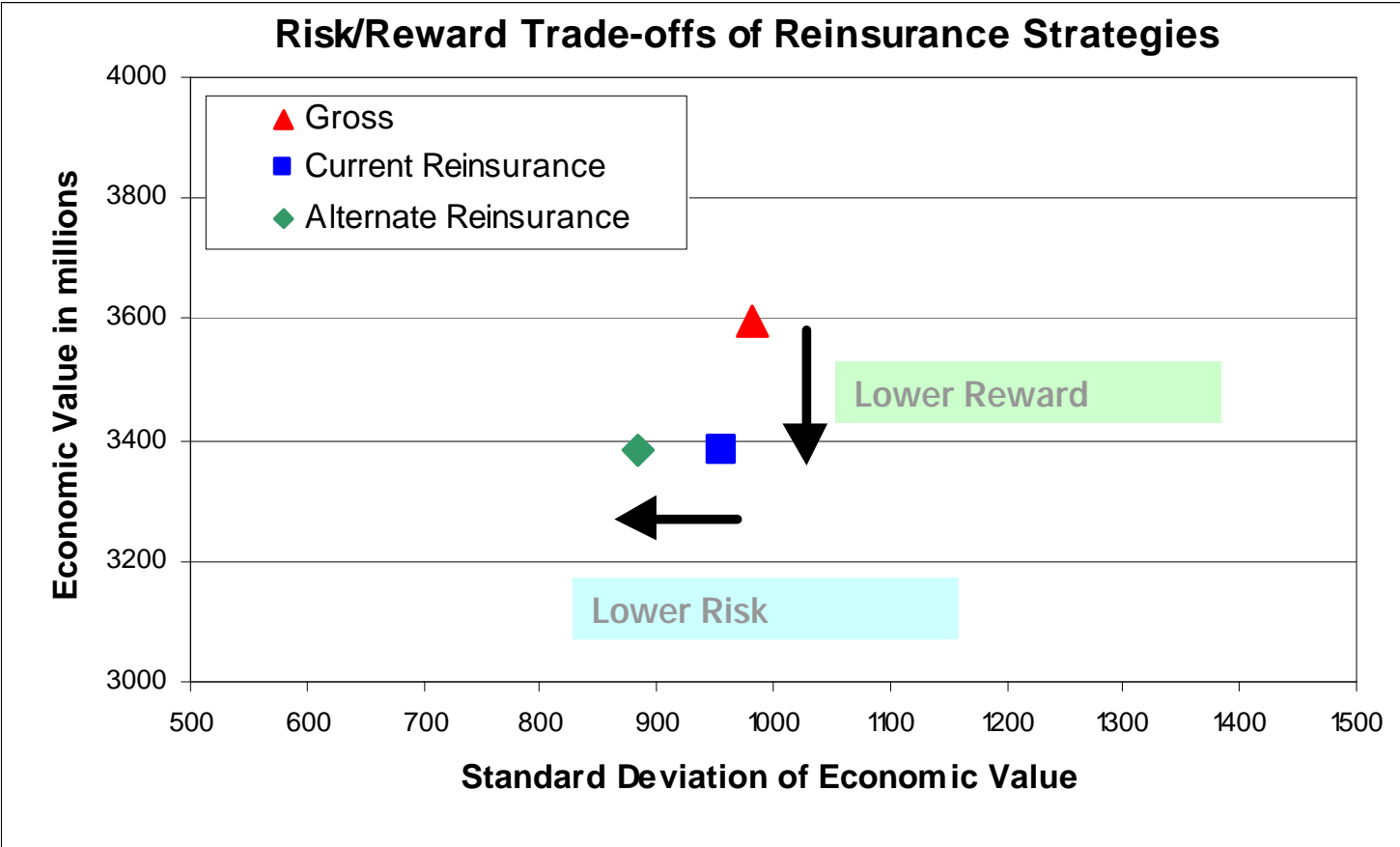
Reinsurance

DFA Insurance Company

Gross versus Net Loss Ratios



Reinsurance



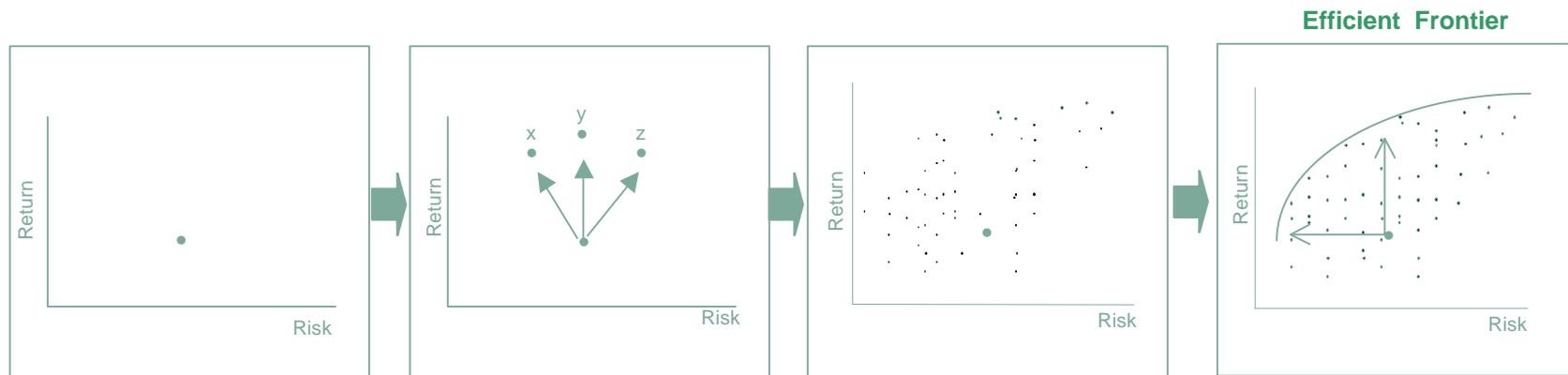
Strategic Asset Allocation

- Efficient Frontier - Optimal trade off between risk and reward.
 - Economic value vs. standard deviation of economic value.
- Efficient asset allocation.
 - The target fixed-income duration.
 - The target allocation to equities.
 - The target split between taxable and tax-exempt bonds.

Efficient Frontier Analysis

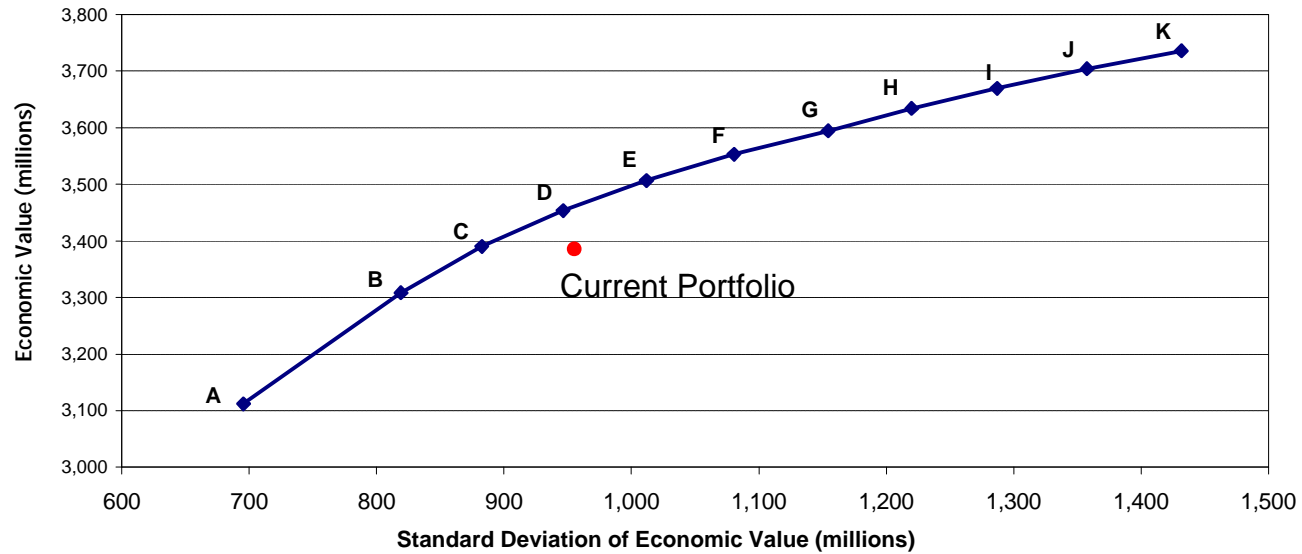
Given a large number of potential asset strategies, how can you determine which are best for your business plan?

- Evaluate current strategy
- Assess some variations (what if we did x or y or z?)
- Try all combinations (usually not possible due to large number)
- Employ computer algorithms to search for best strategies for each level of risk (non-linear optimization) -- The Efficient Frontier



Strategic Asset Allocation

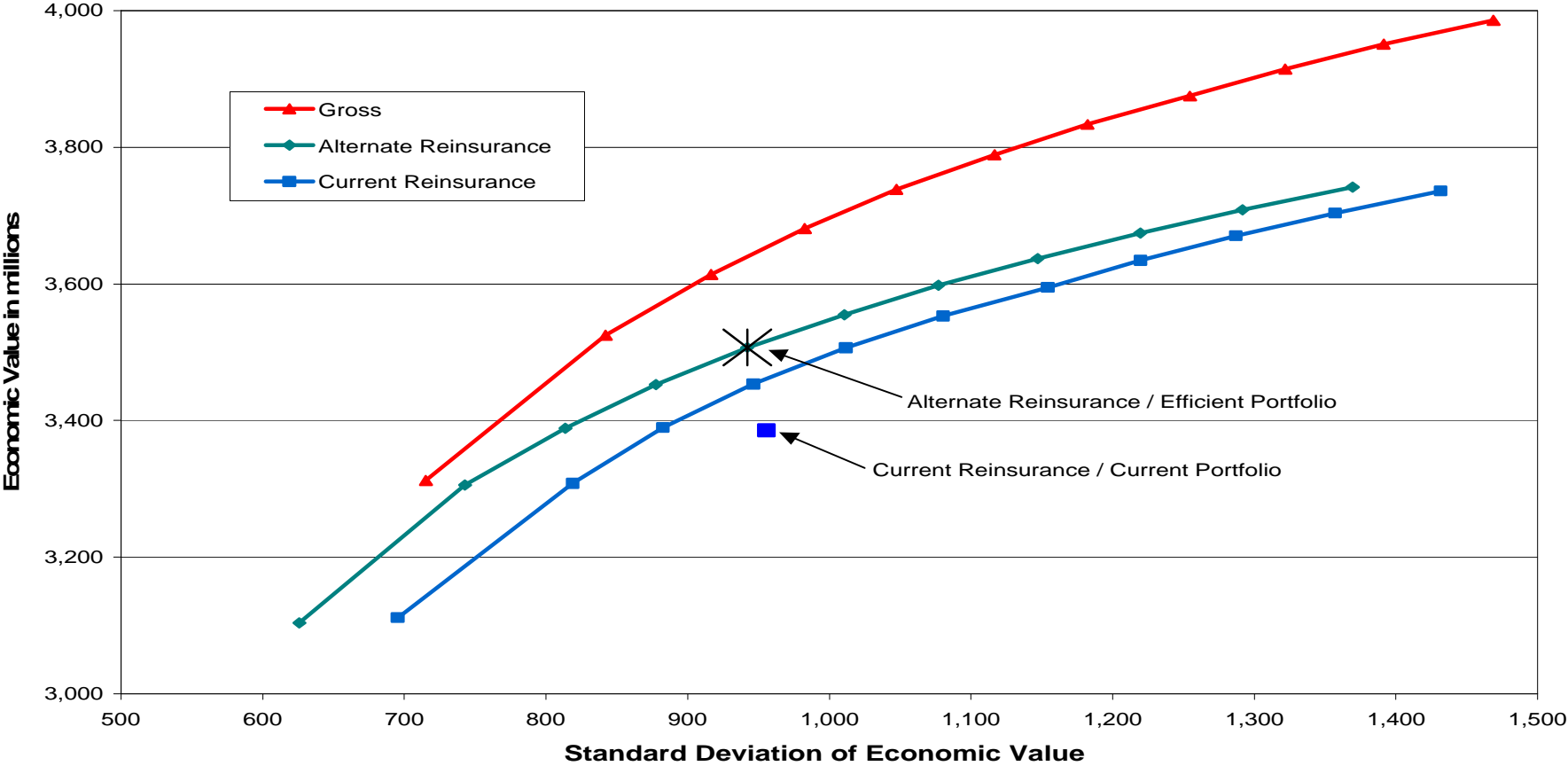
**DFAIC Economic Efficient Frontier
5-Year Horizon**



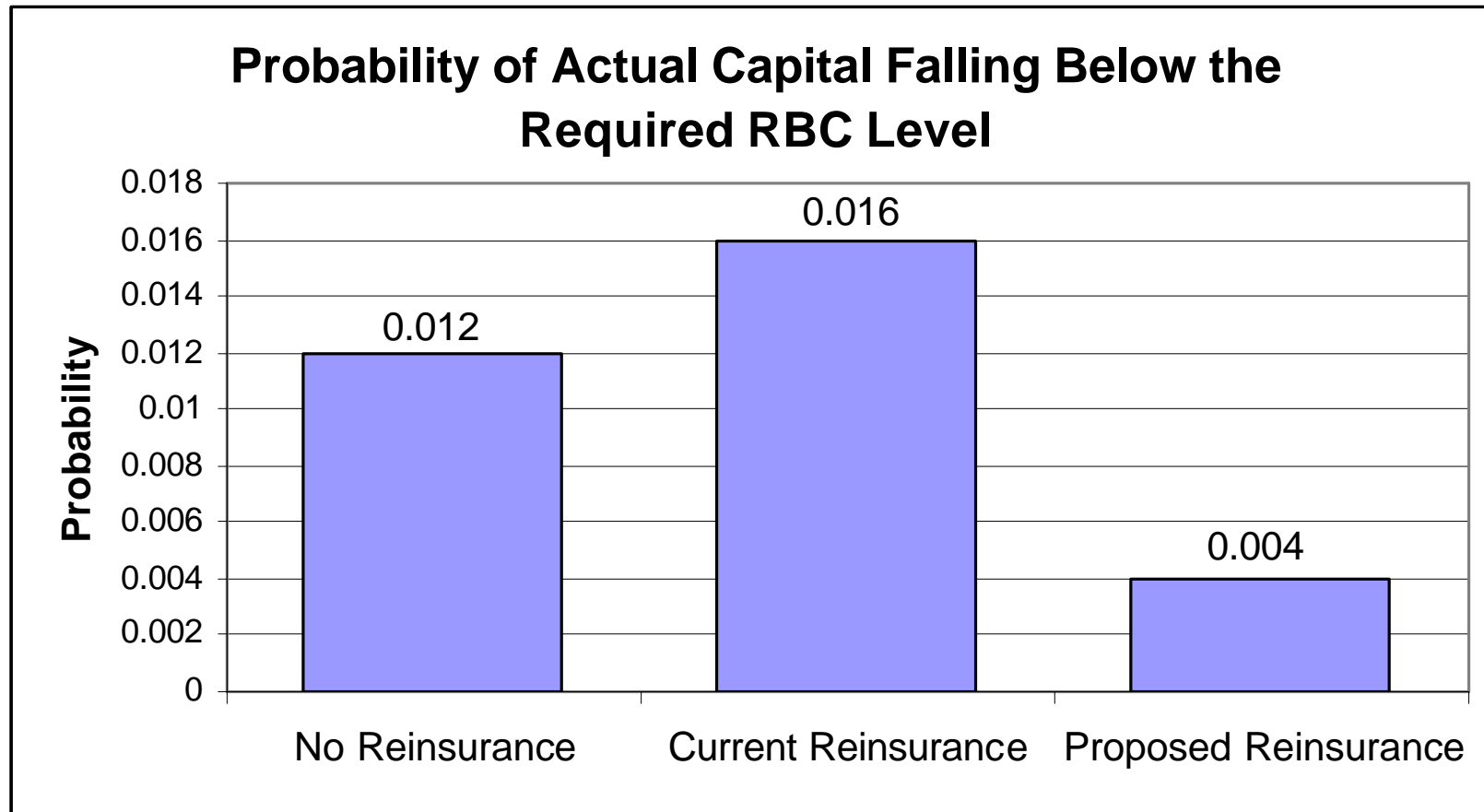
	Current	A	B	C	D	E	F	G	H	I	J	K
Fixed Income:												
Taxable	88.0	100.0	95.4	84.6	72.7	60.3	51.7	38.0	29.3	20.3	7.7	2.0
Tax-Exempt	-	-	-	4.0	10.0	18.9	20.0	35.1	37.1	39.5	47.3	48.0
Duration	5.0	0.3	2.1	2.6	3.2	4.1	4.0	6.1	6.0	6.0	6.6	6.4
Equity:	11.2	-	4.5	11.4	17.3	20.8	28.3	26.9	33.6	40.2	45.0	50.0

Reinsurance and Strategic Asset Allocation

Efficient Frontiers Under Varied Reinsurance Strategies



Reinsurance

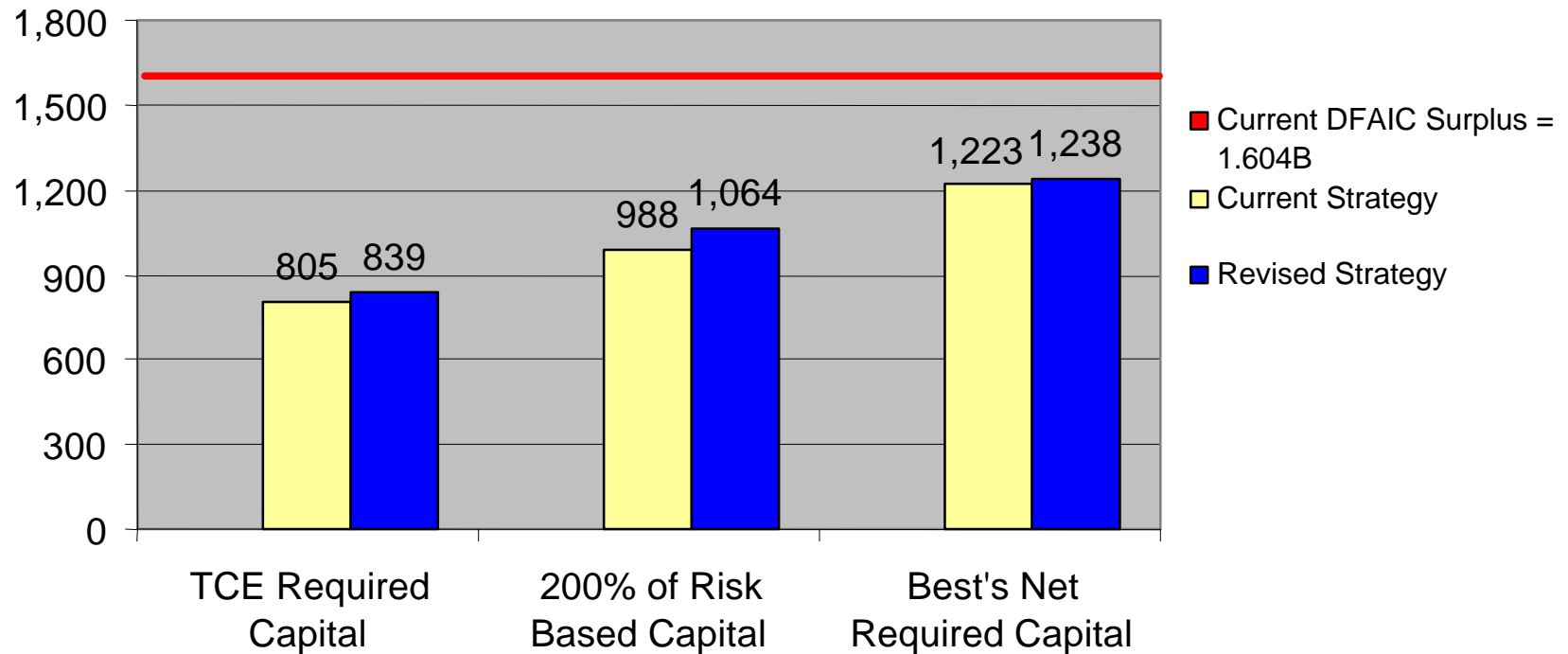


Reinsurance and Strategic Asset Allocation

- Focus on enterprise-wide risk.
 - Assets
 - Liabilities
- Risk and reward trade-off.
 - Appropriate risk measures.
 - Appropriate reward measures.

Capital Adequacy - Further Results

Estimates of Required Capital for DFAIC TCE Required Capital versus Other Common Measures



Current Strategy = Current Reinsurance Program, Equity Allocation = 11%, Fixed Income Duration = 5

Revised Strategy = Aggregate Accident Year Stop Cover, Equity Allocation = 20%, Fixed Income Duration = 4.5

Capital Adequacy - Conclusion

- DFAIC is still Over-Capitalized after revised reinsurance and asset structures implemented.
- DFA generated capital adequacy measures (such as TCE Required Capital) explicitly and consistently account for the interaction and diversification effects of all modeled variables.
- Standard capital adequacy measures (RBC, Best's Net Required Capital) offer a generic approximation of these effects.

Capital Allocation - Introduction

- Identify different Allocation Methods
- Discuss the Methodology we selected to allocate DFAIC's capital:
 - Risk Metric: TCE Required Capital
 - Allocation Method: Shapley Value
 - Explicit allocation to both assets and liabilities
- Compare and contrast 3 different Allocation Methods:
 - Shapley: an axiomatic approach
 - Simple comparative example
- View DFAIC results

Shapley Value Introduction

- The Marginal “First-In” allocation method allocates based on the stand-alone risk of each business segment.
 - The Marginal “Last-In” allocation method evaluates the marginal risk addition to the business as a whole.
 - The Shapley Value allocation method expands on the Marginal “Last-In” concept by considering all possible permutations of entry.
 - Shapley Value evenly splits the mutual covariance between the “With” and “Without” marginal scenarios.
-

Shapley Value Axioms

- Collective Rationality - It does not allow one line of business to subsidize another. Removes incentive for groups of lines of business to act independently of the company as a whole.
- Monotonicity in Costs - Given an increase in the overall cost of the company, each line must participate in the rise of the total cost.
- Additivity - The subdivision of a line of business into two lines should not affect the total allocation to the combined line.

Shapley Value Illustration

Line of Business	Standalone Capital	Allocated Capital
A	1,000	548
B	2,000	1,095
C	3,000	1,643
D	4,000	2,191
Sum	10,000	5,477
Total Company	5,477	
Ratio	54.8%	

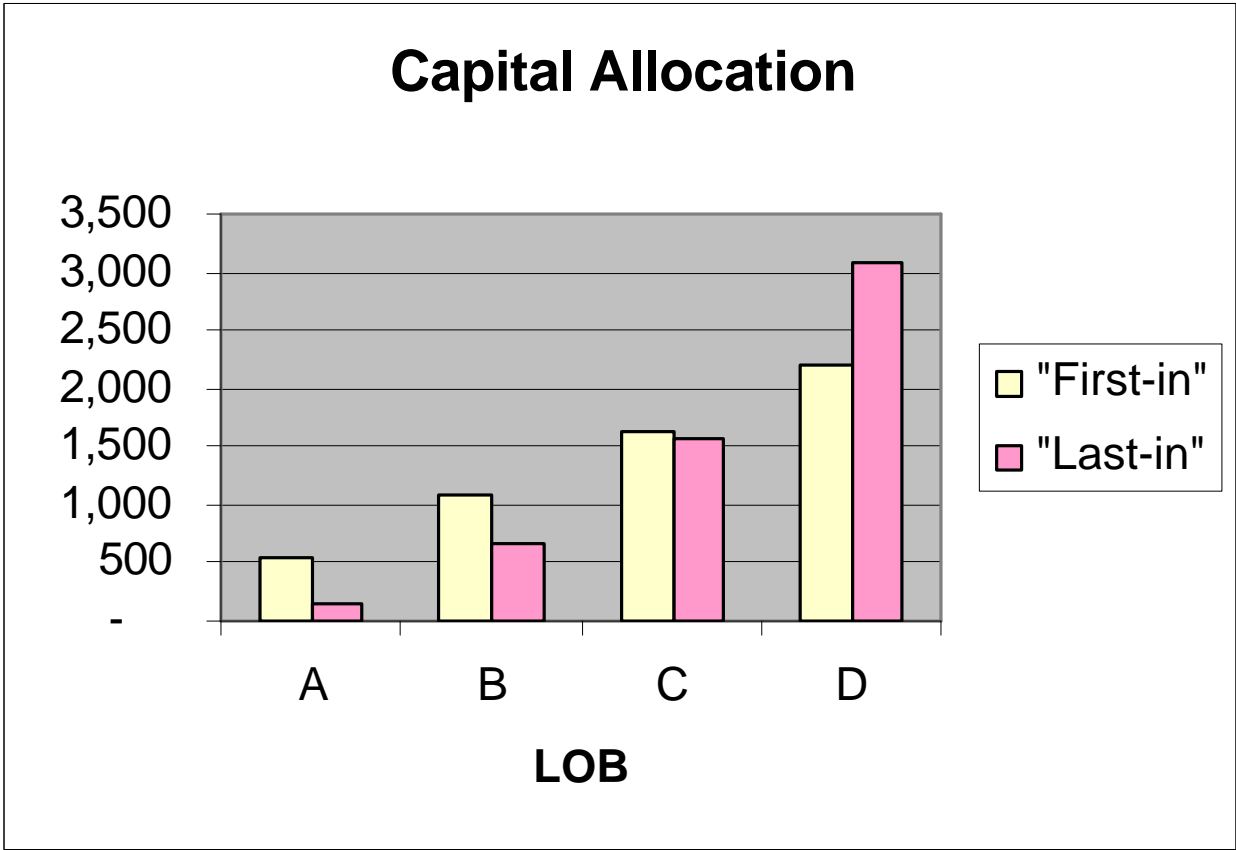
Shapley Value Illustration

Line of Business	Marginal Capital	Allocated Capital
A	92	163
B	378	668
C	895	1,580
D	1,736	3,066
Sum	3,100	5,477
Total Company	5,477	
Ratio	176.7%	

Shapley Value Illustration

Line of Business LOB	Standalone Capital	Allocated Capital "First-in"	Allocated Capital "Last-in"
A	1,000	548	163
B	2,000	1,095	668
C	3,000	1,643	1,580
D	4,000	2,191	3,066
Sum	10,000	5,477	5,477

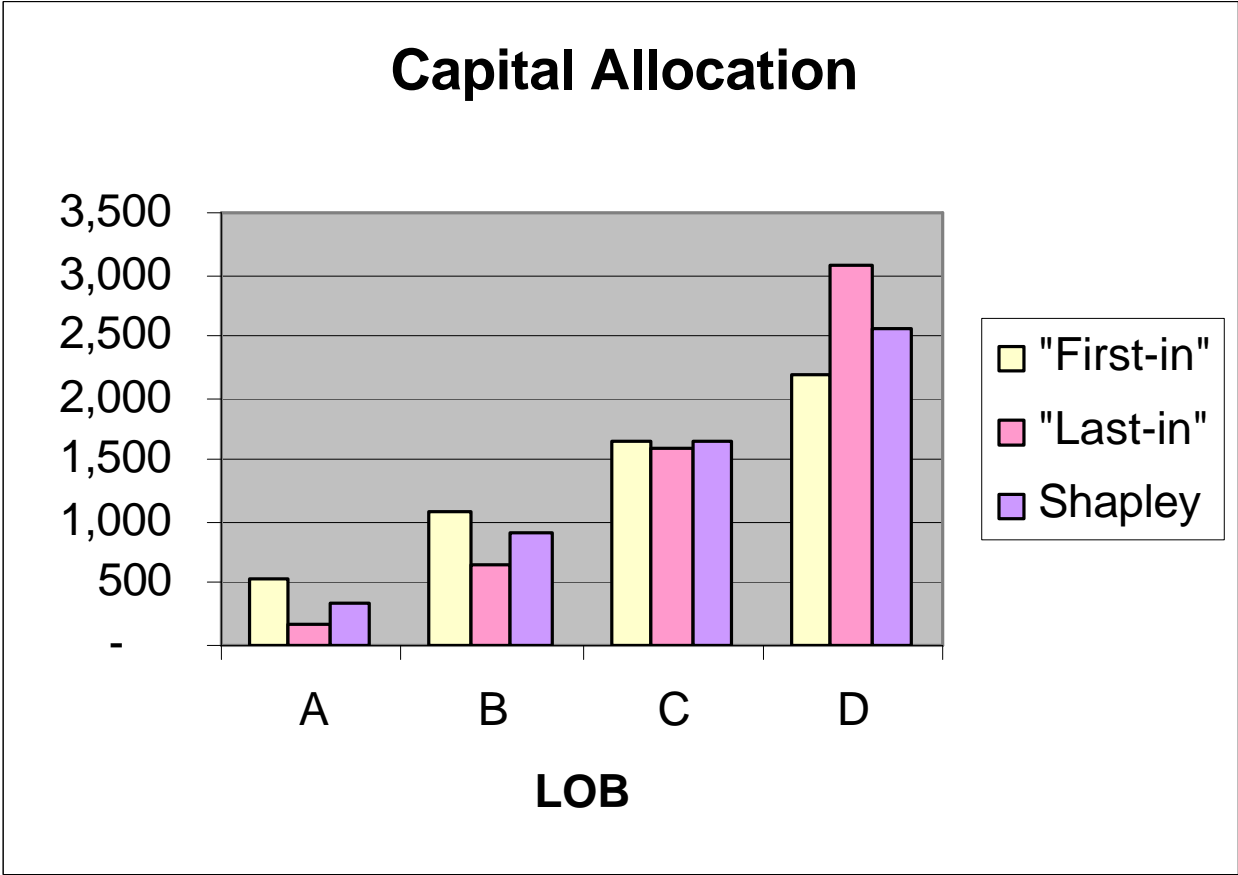
Shapley Value Illustration



Shapley Value Illustration

Line of Business LOB	Standalone Capital	Allocated Capital "First-in"	Allocated Capital "Last-in"	Allocated Capital Shapley
A	1,000	548	163	345
B	2,000	1,095	668	906
C	3,000	1,643	1,580	1,654
D	4,000	2,191	3,066	2,572
Sum	10,000	5,477	5,477	5,477

Shapley Value Illustration



Capital Allocation Methodology

- We selected TCE Required Capital as the Risk Metric
- All 3 identified Allocation Methods allocate capital based on the Marginal Impact of a particular variable (e.g. Difference between With and Without Workers Comp)
 - **First-In Marginal Contribution (Standalone)**
 - **Last-In Marginal Contribution (Marginal)**
 - **Shapley Value**
- We selected the Shapley Value Allocation Method

“Without” Line of Business Definition

On the liability side:

We selected to reinsure the new and existing business away.

BUT, what about assets?

“Without” Assets Definition

Determine asset allocation that minimizes risk measure. (ie minimum risk efficient frontier portfolio)

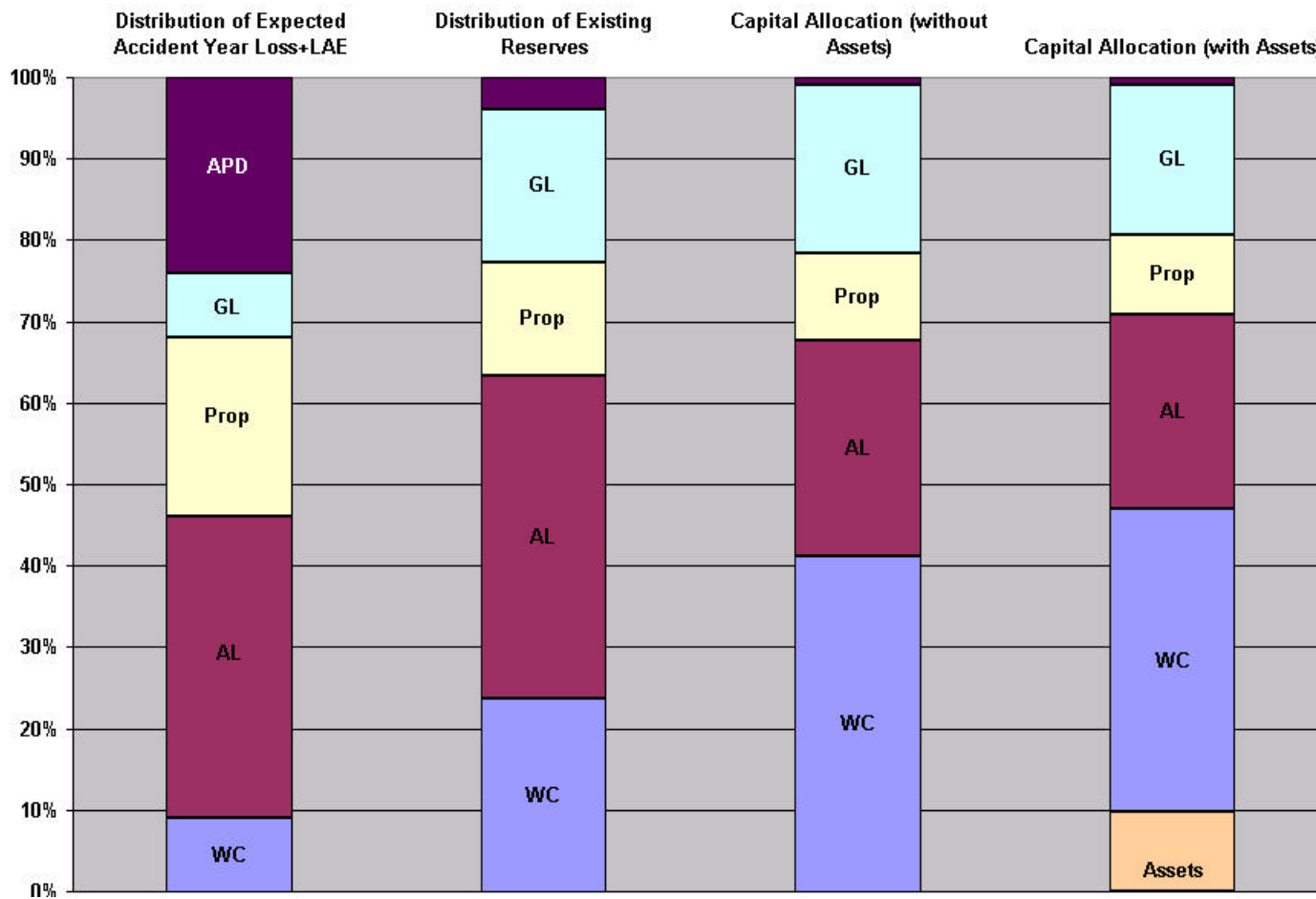
Advantages:

- Eliminates possibility of negative capital allocation

Disadvantages:

- Much more complex
- Need a solution for each marginal run
- Very time consuming, especially for Shapley values

Shapley Value Allocation Using TCE Required Capital



Capital Allocation - Conclusion

- Shapley is based on reasonable axioms.
- Shapley can be time consuming and difficult to calculate.
- Specific allocation of capital to assets (i.e. investment department) can be considered.
- Based on our selected tail sensitive risk measure (TCE Required Capital), DFAIC allocated a relatively greater portion of capital to its longer-tailed more inflation sensitive lines of business.

General Conclusions

- Strategic Issues

- **Capital** - Over-Capitalized.
- **Reinsurance** - Move to more efficient reinsurance structure designed to protect DFAIC at the company level.
- **Asset allocation** - Shorter Duration Fixed Income, Increase Equity Allocation, some investment in Tax-Exempts in Combination with Revised Reinsurance Strategy.

- Holistic Approach

- Consistent modeling of variable interactions
- Allows common evaluation of different strategic decisions.

Comparison of Results - Capital Adequacy

Author	Conclusion	Methodology
Bohra&Weist	Over Capitalized	Probability of Ruin, EPD
Meyers	Over Capitalized	TCE(.99) applied to End of Year Aggregate Loss
Smith&Christofides	Over Capitalized	Probability Distribution of the Minimum Premium to Surplus Ratio
Swiss Re Investors	Over Capitalized	TCE(.99) applied to "Required Capital", Comparison to other Standard Measures

Comparison of Results - Reinsurance Efficiency

Author	Conclusion	Methodology
Bohra&Weist	Current Program Inefficient, Replace with Aggregate Stop	Std Dev EOY Surplus, P[Surplus Decline] > 0%, 10%, 25%
Meyers	Stop Buying Reinsurance (if no regulatory/rating impacts), Should not buy reinsurance that removes diversifiable risk	Comparison of Cost of Reinsurance to Change in Cost of Capital
Smith&Christofides	Reduce Current Reinsurance Purchasing Levels	Probability Distribution of the Minimum Premium to Surplus Ratio
Swiss Re Investors	Current Program Inefficient, Replace with Aggregate Stop	P[Surplus]<Required RBC, Mean&StdDev EOY 5 Economic Value

Comparison of Results - Asset Strategy

Author	Conclusion	Methodology
Bohra&Weist	22% Allocation to Stock	Mean&Std Dev EOY Surplus Comparison for 6 runs with different Allocations to Stock
Smith&Christofides	Reduce Stock Exposure it is destroying value	Cost of Capital Evaluation
Swiss Re Investors	20% Allocation to Stock, Portfolio Duration = 4.5, Tax-Exempt Allocation = 22%	Economic Value ALM Efficient Frontier Optimization, Comparison of Surplus Distributions

Comparison of Results - Capital Allocation

Author	Methodology
Bohra&Weist	Shapley Value Allocation Methodology using Return on Surplus as the Risk Variable
Meyers	Marginal Allocation Methodology using Tail Value at Risk @ 99%ile as Risk Variable
Smith&Christofides	Apportionment of Systematic, Non-Systematic, and Frictional Costs
Swiss Re Investors	Shapley Value Allocation Methodology using Tail Conditional Expectation@99%ile

DFA Insurance Company Case Study

2001 Casualty Actuarial Society Special Interest Seminar on Dynamic Financial Analysis

Boston, Massachusetts
June 7-8, 2001

Stephen Philbrick, Robert Painter, John Burkett