



# **Casualty Actuary Society**

## **Risk – Methodological Approaches to RAROC in the Insurance Industry**

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July 2002

Toronto

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# INTRODUCTION

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- The insurance industry is seeing a number of new approaches for assessing risk over the last few years. The most popular of these is Value-at-Risk (VaR) and Dynamic Financial Analysis (DFA).
- I will attempt to compare and contrast these methods at a high level and focus on the strong and weak points of both as would be argued by their respective supporters.
- Finally, I will comment on what I believe should be the capabilities of any risk model without regard to the approach.

## DYNAMIC FINANCIAL ANALYSIS - DFA

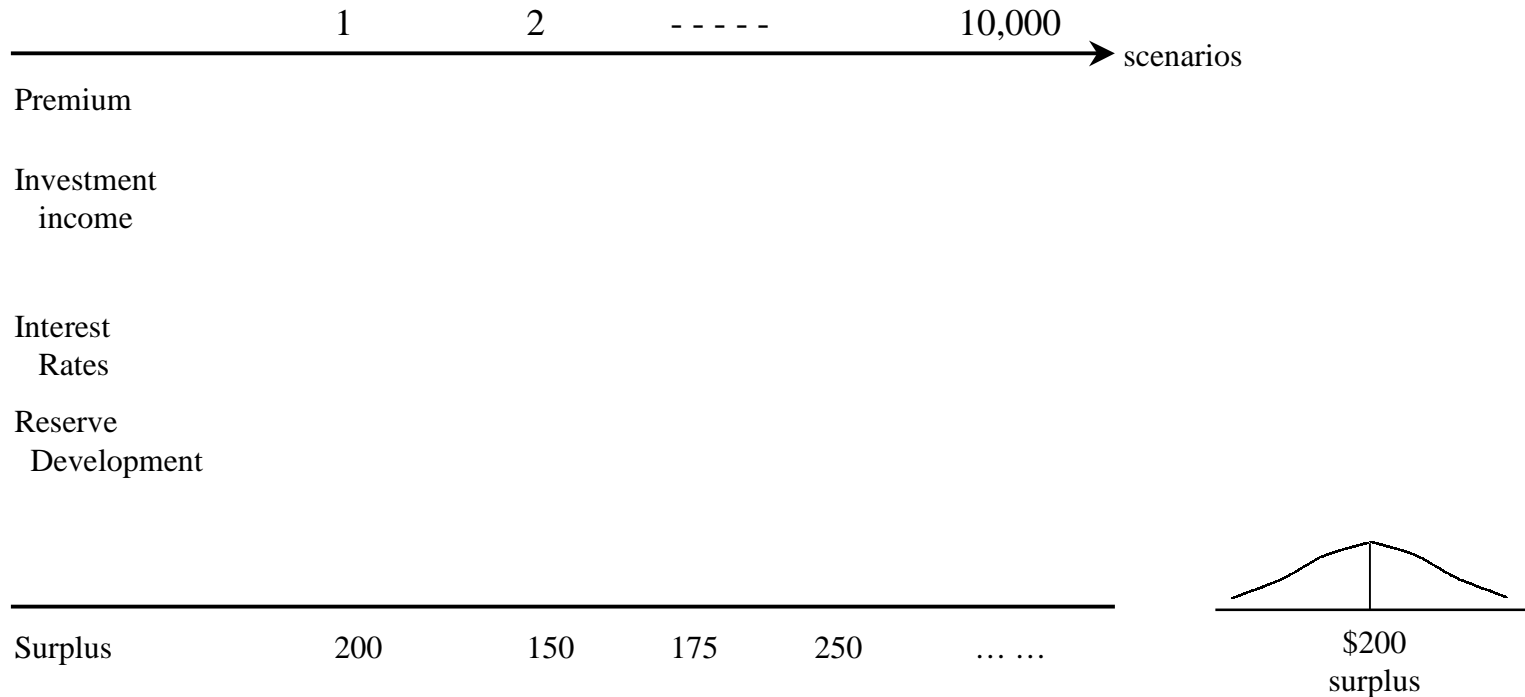
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- DFA is designed to be a projection tool.
- DFA is designed to project several years of the future income statements and balance sheets given a set of highly specific assumptions including:
  - Premium growth,
  - Earnings growth,
  - Investment returns,
  - Investment strategies,
  - Management decisions,
  - Decision rules, etc.

# DYNAMIC FINANCIAL ANALYSIS - DFA

## *Basic process*

A simulation based multi period model that attempts to link macroeconomic variables to the economic drivers of risk and return in insurance companies



## ASSUMPTIONS - DFA

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- **Multi-Period Model:** Requires that assumptions be made about the company's future premium, loss ratios and expenses
- **Decision Rules:** Must be programmed into DFA to instruct the program how to handle future events
  - How to invest realized capital gains if taken
  - How to raise cash if required etc.
- **Interest Rates:** Normally governed by some type of mean-reverting process. May use various interest rate models, HJM.

## **DFA CRITICISMS/RESPONSES**

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### **Subjectivity:**

- Much of the company's risk results from projected input values such as future premiums, expenses and loss ratios. This detracts from DFA's objectivity.

### **Response:**

- It is unrealistic to assess insurance companies' risk in one time period. There are too many factors that influence the health of insurance companies to restrict the model to one time period.

# DFA CRITICISMS/RESPONSES

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## **Model Runtime**

- The significant time it takes to run DFA tends to reduce its value as a strategic decision tool. Very few companies use DFA as a strategic decision tool.

## **Response:**

- Very few companies use VaR as a strategic decision tool; although, VaR has not been available very long.

# DFA CRITICISMS/RESPONSES

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## Capital Allocation

- DFA typically attempts to allocate capital using the “shapley” method, which requires the model to identify  $2^n - 1$  combinations of business activities. This nearly makes impossible allocating capital to more than six lines of business due to the time required (see appendix).

## Response:

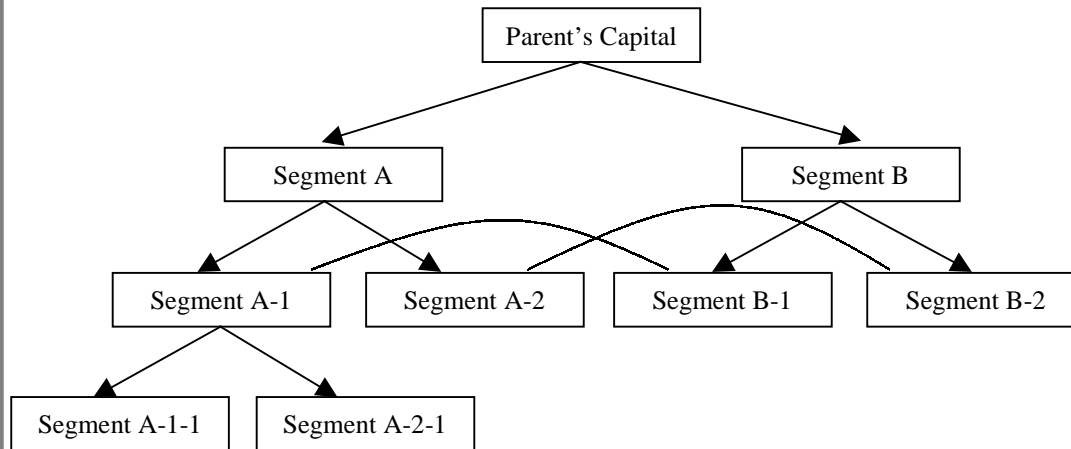
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# DFA CRITICISMS/RESPONSES

To circumvent the Shapley procedure, many DFA practitioners will make assumptions about a company's correlation structure.

Numerous iterations are required to calculate an "order-independent" risk contribution by segment. The number of iterations required increases exponentially as the number of segments increases. Normal risk models cannot correctly allocate capital in a reasonable time, some take a disastrous short cut – they allocate capital in many levels.



- This method may be incorrect because it assumes certain correlation structure among segments.
- It assumes that the correlation between the sub-segments within the same segment is a lot higher than the correlation between segments.
- For example, correlation between segments A-1 and A-2 are much higher than the correlation between segment A and segment B..

## **DFA CRITICISMS/RESPONSES**

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### **Risk Analysis for single line of business**

- As a result of its significant long runtime, DFA can only analyze a limited number of risks without scarifying accuracy.

### **Response:**

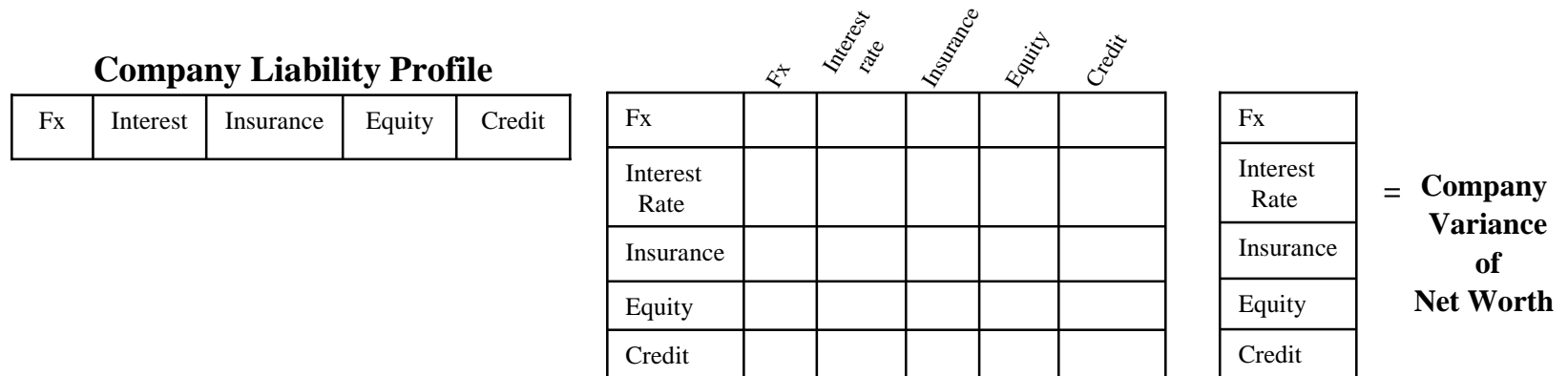
- For a single line of business, DFA can do a very good job in analyzing its risk. It can produce numerous important reports that are especially useful for reinsurance analysis.

# VALUE-AT-RISK (VaR)

VaR is a one period model that uses a variance-covariance matrix for assessing risk rather than measuring the relationship between macro-economic variables and the drivers of risk in insurance companies. VaR is not a revenue or projection model. VaR measures the variability in net worth of an insurance company over a defined period of time—usually not more than one year. VaR can be specified as a simulation process.

There are two types of VaR models, 1) delta approximation that uses matrix multiplication to approximate the variance of the portfolio, and 2) multivariate simulation which functions like a one period DFA model with a very robust correlation matrix.

The below figure is of the delta approximation method.



## **KEY ASSUMPTIONS -VaR**

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### **Risk Distribution**

- VaR assumes that asset prices are log normally distributed. The proponents of DFA assert that the distribution of asset prices are influenced by factors that can only be assessed using macroeconomic models.

### **Response:**

- VaR supporters assert that the log normal assumption is the most objective and that the use of macroeconomic models to improve these estimates have not been consistently demonstrated.

## KEY ASSUMPTIONS - VaR

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### **Response:** (continued)

- **Static Portfolio:** Since VaR does not project a portfolio's risk through time, the portfolio is held constant. The portfolio's composition may be changed as frequently as desired. VaR takes a snapshot of the company's risk for one year from the day of measurement.
- This assumption relieves the model from having to use decision rules about how to handle contingent events. This freedom permits a well designed VaR model to be very fast compared to DFA.

## VaR CRITICISMS/RESPONSES

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### **Correlation Structure**

- VaR attempts to assess risk by measuring many correlations. Correlations can be very unstable.

### **Response:**

- The instability of correlations is not a problem inherent to VaR, but rather to any form of risk management that attempts to measure the drivers of firm risk-correlation being one of the prime drivers. Because other forms of analysis may ignore correlations does not mean that this risk disappears.

# VaR CRITICISMS/RESPONSES

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## Financial Reporting

- VaR does not produce financial statements or projections

## Response:

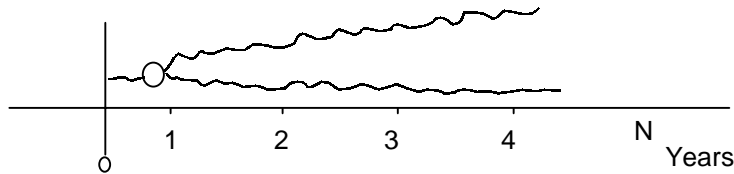
- True, VaR is not an accounting model. VaR is an economic and risk model that takes a picture of a firm's risk today and for a specified time interval, usually not more than one year.

# CRITICISMS/RESPONSES

- VaR is a one period model. How can it adequately measure the risk of long term insurance liabilities?

## Response:

- VaR measures the present value of long term risk



### Example:

Casualty Reserve Exposure 3 years from today:

$$\text{NPV: } \sum_{t=1}^3 \frac{\$1000}{(1+r)^t} = \$925.00$$

r = Interest rate volatility for 3 year zero Treasury

If interest rates change, so will the NPV of the casualty reserve, and the company's net worth will change.



# ENTERPRISE RISK MODEL

*Regardless of which approach your company pursues, here are the critical issues:*

<u>Model Capability</u>	<u>General Capability</u>	<u>High Recommended</u>
<ul style="list-style-type: none"><li>• How many asset groups are analyzed?</li></ul>	About 10 groups	CUSIP level
<ul style="list-style-type: none"><li>• How many business segments can be analyzed?</li></ul>	10-30	No limitation
<ul style="list-style-type: none"><li>• Does the model assume a static correlation matrix?</li></ul>	Yes	Correlation Matrix. Should be dynamic so that each time a change is made in the assets or liabilities, the correlation matrix will change to reflect its new composition.
<ul style="list-style-type: none"><li>• Does the model handle the individual risk characteristics of each MBS and ABS?</li></ul>	No	Yes

# ENTERPRISE RISK MODEL

*Regardless of which approach your company pursues, here are the critical issues:*

<u>Model Capability</u>	<u>General Capability</u>	<u>High Recommended</u>
<ul style="list-style-type: none"> <li>• How long does it take the model to calculate the enterprise risk of a company one time based on 10,000 scenarios?</li> </ul>	Between 15 minutes and two hours	seconds
<ul style="list-style-type: none"> <li>• How long does it take to allocate capital once in order to calculate segment RAROC?</li> </ul>	Days	seconds
<ul style="list-style-type: none"> <li>• How long does it take to rerun the model assuming a line of business is sold?</li> </ul>	Days	seconds
<ul style="list-style-type: none"> <li>• How long does it take to rerun the model assuming that interest rates increase by one percent?</li> </ul>	Days	seconds
<ul style="list-style-type: none"> <li>• How long does it take to rerun the model assuming a merger?</li> </ul>	Weeks	seconds

# ENTERPRISE RISK MODEL – FREQUENTLY ASKED QUESTIONS

- What is a dynamic correlation matrix?

**Answer:** Correlations are rigorously measured over a defined period of time. The model’s architecture is constructed so that each time the composition of assets and/or liabilities change, the correlation matrix will change to reflect the new composition.

- Why is it important to have a dynamic correlation matrix?

**Answer:** Nearly half of a firm’s capital is tied up in its diversification benefit. If our understanding of the firms’ correlation structures are not specified, or limited to just a few classes of assets, the model will not be an accurate representation of firms’ risks. Nor will it be possible to trace the sources of firms’ risks.

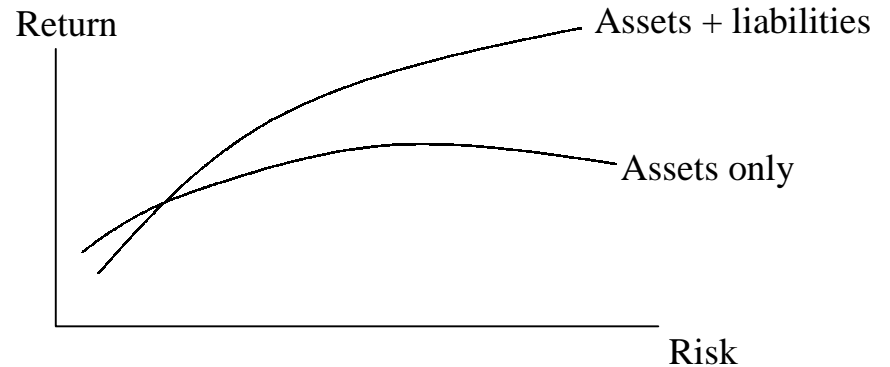
- Why is it necessary for the model to operate at the CUSIP level?

Each asset and liability has a unique relationship with every other asset and liability held by the firm. Reducing this granularity to a few large asset and liability grouping will not allow the firm to understand the risk contribution of the different risk factors.

# ENTERPRISE RISK MODEL – FREQUENTLY ASKED QUESTIONS

- Asset Allocation

The firm will want to select the most efficient investment portfolio given its liability configuration. If a firm has only managed to identify the correlation between 10 groupings of assets and between 7 and 15 lines of business, the Firm will have a very limiting notion of its efficient frontier.



## DFA Runtime to Allocate Capital

- The most important shortcoming of DFA as a risk management tool is its inability to allocate capital correctly. It is not feasible to use DFA to allocate capital to more than 7 divisions. VaR models can allocate capital to as many as 1,000 divisions.
  - The correct capital allocation method must have the characteristics of additivity, order independence and stability. These characteristics can all be found in an allocation scheme based on the Shapley value.
  - According to two well-respected DFA experts, Don Mango and John Mulvey\*, using the Shapley value to allocate capital to *“a small number of divisions, the calculation is not too burdensome. However, as the number of divisions increases, the number of permutations grows geometrically.”*
  - How bad does it get? According to Mango and Mulvey, allocating capital to 6 divisions requires 63 reruns of, say, a 5,000 scenario DFA, 10 divisions – 1,023 reruns, 15 divisions – 32,767 reruns, 20 divisions – 1 million reruns

\*Donald Mango and John Mulvey, “Capital Adequacy and Allocation Using Dynamic Financial Analysis” Summer 2000, Dynamic Financial Analysis Call Papers, CAS  
<http://www.casact.org/pubs/forum/00sforum/00sf055.pdf>

## DFA Runtime to Allocate Capital

• Assume we can run a 5,000 scenario DFA in as little as 5 minutes (if the DFA program is written in a high level computer language such as C++). Assume you use one computer to run DFA 24 hours a day, 7 days a week, these are the approximate run times to allocate capital once:

		5 minutes per 5,000 scenarios	
		1 Computer	
		<u>Run Time</u>	
# of Divisions	Required Reruns	Hours	Weeks at 24/7
6	63	5.3	0.0
7	127	10.6	0.1
10	1,023	85.3	0.5
13	8,191	682.6	4.1
15	32,767	2,730.6	16.3
20	1,048,575	87,381.3	520.1
25	33,554,431	2,796,202.6	16,644.1
30	1,073,741,823	89,478,485.3	532,610.0