ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Enterprise Risk-Reward Optimization: Two Critical Approaches

Damon Levine, CFA

April 8, 2016

Legal Disclaimer

Disclaimer: The views expressed in this paper are my own and not necessarily those of my employer, Assurant Inc.

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Goals for Today's Overview

- Risk modeling considerations
- Maximizing return on economic capital
- The mean-semivariance efficient frontier
- A mostly satisfied audience* (and a couple of confused looks)

**no guarantees of audience satisfaction are stated or implied*

ERM
ENTERPRISE RISK
MANAGEMENT SYMPOSIUM

Modeling Prerequisites

- Assume line of business (LOB) *distributions* of earnings have been modeled and vetted; include P&L and balance sheet modeling

- Each LOB distribution is a cumulative density function (CDF) for earnings over the upcoming year (Plan horizon)

- Models include financial statement details such as reserves, invested assets, GAAP/STAT earnings, capital, and distributable earnings

ERM
ENTERPRISE RISK
MANAGEMENT SYMPOSIUM

The Enterprise Risk-Reward Model

- Can use Excel: the model contains a sheet (tab) for each LOB
- Model contains financial statements in each LOB sheet: beginning of year balance sheet and stochastically simulated income statement and end of year balance sheet line items
- Rank correlations of earnings are reflected across LOBs through a non-parametric approach; we may randomly simulate each LOB’s financial results and properly aggregate to the enterprise level

ERM
ENTERPRISE RISK
MANAGEMENT SYMPOSIUM

Model Output

- LOB level Plan year detail: simulated average assets, earnings, infusion (shortfall vs. targeted capital), etc.

- Enterprise detail: simulated company average assets, earnings, and *net* capital infusion need from LOBs

- distributable earnings (DE)
  - DE = statutory earnings – Δ targeted capital
  - Reflects capital needs; good proxy for “free cash flows”
  - <u>*Negative DE is interpreted as a need for a capital infusion*</u> from the holding company/parent or “Corporate”
  - DE distributions are developed at both the LOB level and enterprise level, reflecting cross-LOB correlations

ERM
ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Definitions

- Assume each LOB has *negative* DE at the1st percentile level of its respective distribution for DE
- For a particular LOB "x" we have:
  - A_x = average asset level during forecast plan (includes planned surplus & any trapped capital)
  - I_x = | 1st percentile of DE |
- So A_x captures expected asset usage and I_x measures risk in terms of 1st %ile infusion

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Sample DE and Infusion Results: 3 LOB Example

	Simulated Annual Distributable Earnings				*Scenario Infusions at:*			
Simulation #	**LOB1**	**LOB2**	**LOB3**	**Enterprise**	**LOB1**	**LOB2**	**LOB3**	**Enterprise**
1	75	119	59	253	0	0	0	0
2	2	15	61	78	0	0	0	0
3	3	119	225	347	0	0	0	0
4	68	114	225	407	0	0	0	0
5	26	-27	-26	-27	0	27	26	27
6	70	-7	-34	29	0	7	34	0
7	46	118	115	279	0	0	0	0
8	7	-9	40	38	0	9	0	0
9	41	115	209	365	0	0	0	0
10	40	112	148	300	0	0	0	0

***Correlation reflected across LOBs; enterprise DE is sum of LOB DE values in a given simulation**

**** Important: Enterprise infusion need exists when enterprise DE is negative; allows for offsets from a LOB with positive DE in a particular simulation**

***** Enterprise infusion = min(0, |enterprise DE|)**

ERM
ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Simulation Results

- Average asset and infusion values for each LOB: A_1, A_2, A_3 & I_1, I_2, I_3
- *Distribution of* DE_{ENT} (CDF of enterprise DE)
- Assume: 1^{st} percentile of DE_{ENT} is a negative value and find $I = |1^{st}$ percentile of $DE_{ENT}|$
- Typically $I \neq I_1 + I_2 + I_3$

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Sample Numerical Results

- $A_1 = 500$, $A_2 = 1000$, $A_3 = 2400$
- $I_1 = 20$, $I_2 = 30$, $I_3 = 50$
- 1st percentile of enterprise DE is $I = 80$
- Note that $I = 80 < I_1 + I_2 + I_3 = 100$

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Economic Capital

- Economic capital (EC): amount of capital sufficient to ensure:
  - business can continue to function under stress scenarios, specific percentile or CTE, and (possibly also…)
  - meet other company specific goals or constraints, e.g. rating agency or regulator target capital levels
- EC often regarded as “scarce” resource to be allocated through a risk-reward lens

ERM
ENTERPRISE RISK
MANAGEMENT SYMPOSIUM

A Risk Buffer
(or the Rainy Day Fund)

- Corporate will hold a risk *buffer* ($B) to cover potential LOB *infusion* needs

- Recall, enterprise 1st percentile infusion = I:
  - $I = 80 < I_1 + I_2 + I_3 = 100$
  - Buffer mitigates this infusion risk
  - Company policy: $I \leq \text{buffer} \leq I_1 + I_2 + I_3$

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Enterprise and LOB EC

- For a fixed choice of B (e.g. *90*) define
  - Enterprise EC = EC_{ENT} = $A_1 + A_2 + A_3 + B$ = 500 +1000 + 2400 +*90* = 3990
  - Each LOB's proportionate *share of buffer B* is: $\alpha_j = I_j / \sum I_k$ for each j = 1, 2, 3
- Define EC for LOBs using the above:
  - $EC_1 = A_1 + \alpha_1 B = 500 + 20\% * 90 = 518$
  - $EC_2 = A_2 + \alpha_2 B = 1000 + 30\% * 90 = 1027$
  - $EC_3 = A_3 + \alpha_3 B = 2400 + 50\% * 90 = 2445$
  - So $EC_{ENT} = EC_1 + EC_2 + EC_3$

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

LOB DE as a Function of Allocated EC

- Often more risk, as measured by EC, can lead to greater expected reward (DE)

- A larger EC allocation to a LOB means a larger value for some values among A, α, or B

- Based on LOB Plan values for DE_i and EC_i we find approximate linear relations:
  - $DE_i \approx a_i * EC_i + b_i$ for each LOB i=1,2,3

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Return on Economic Capital

- Return on EC (ROEC) = enterprise DE/enterprise EC = $(DE_1 + DE_2 + DE_3)/(EC_1 + EC_2 + EC_3)$
- Write this as $(DE_1 + DE_2 + DE_3)/(x_1 + x_2 + x_3)$
- Recall each DE_i in the numerator can be replaced as a linear function of its respective capital level, x_i
- So we may write ROEC =

$$(a_1x_1 + b_1 + a_2x_2 + b_2 + a_3x_3 + b_3) / (x_1+x_2+x_3)$$

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

A ROEC Optimization

Maximize:

$$ROEC = (a_1x_1 + a_2x_2 + a_3x_3 + b) / (x_1 + x_2 + x_3)$$

Subject to:

$$m_1 \leq x_1 \leq M_1$$

$$m_2 \leq x_2 \leq M_2$$

$$m_3 \leq x_3 \leq M_3$$

$$x_1 + x_2 + x_3 \leq EC_{MAX}$$

- ***A so-called "fractional-linear programming problem"***
- ***A substitution transforms it into a linear programming problem***
- ***An exact solution is found easily through matrix operations or free applications***

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Investor Point of View

- Investors are not typically concerned with EC or its allocation
- Company earnings and its volatility drive company valuation (e.g., stock value)
- Harry Markowitz: *"Semivariance seems more plausible than variance as a measure of risk, since it is concerned only with adverse deviations."*

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Semivariance & Semicovariance

For a fixed benchmark (hurdle) return B:

$$\text{semivariance}_i \approx (1/T) \sum [\min (R_{it} - B, 0)]^2$$

$$SC_{ij} = \text{semicovariance}_{ij} \approx$$
$$(1/T) \sum [\min (R_{it}\text{-}B, 0) * \min (R_{jt}\text{-}B, 0)]$$

$$\text{portfolio semivariance} \approx$$
$$\sum_i \sum_j w_i w_j SC_{ij}$$

T = number of time periods for which returns observed
Periods denoted t=1, 2, …, T
R_{it} = return for asset i during period t *Note: "Sc_{ii}" is semivariance of asset i*

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Efficient Frontier

- Classic Version: For a benchmark/target portfolio return “B”, what allocation to a given set of investable assets produces the portfolio of minimum variance with expected return B?

- Levine Version: For a benchmark/target company return “B”, what allocation to a given set of LOBs produces the product portfolio of minimum semivariance with expected return B?

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Stating the Problem (1 of 2)

- Must define what is meant by asset (product) *return*
- Candidates include ROEC, ROA, ROE, etc.
- Necessary assumptions and parameters:
  - Resource to allocate and allocation buckets
  - Expected return and semivariance for each “asset” (e.g., product line or LOB)
  - Semicovariances between pairs of assets

Stating the Problem (2 of 2)

Given a benchmark return B, find the allocation weights $(w_1, w_2, \ldots, w_N)$ to N "assets" with respective expected returns $(r_1, r_2, \ldots, r_N)$ which will:

Minimize: (appx.) portfolio semivariance $\sum_i \sum_j w_i w_j s_{ij}$

Subject to:

$\sum w_i = 1$ (the "budget constraint")

$\sum w_i r_i = B$ (the return constraint)

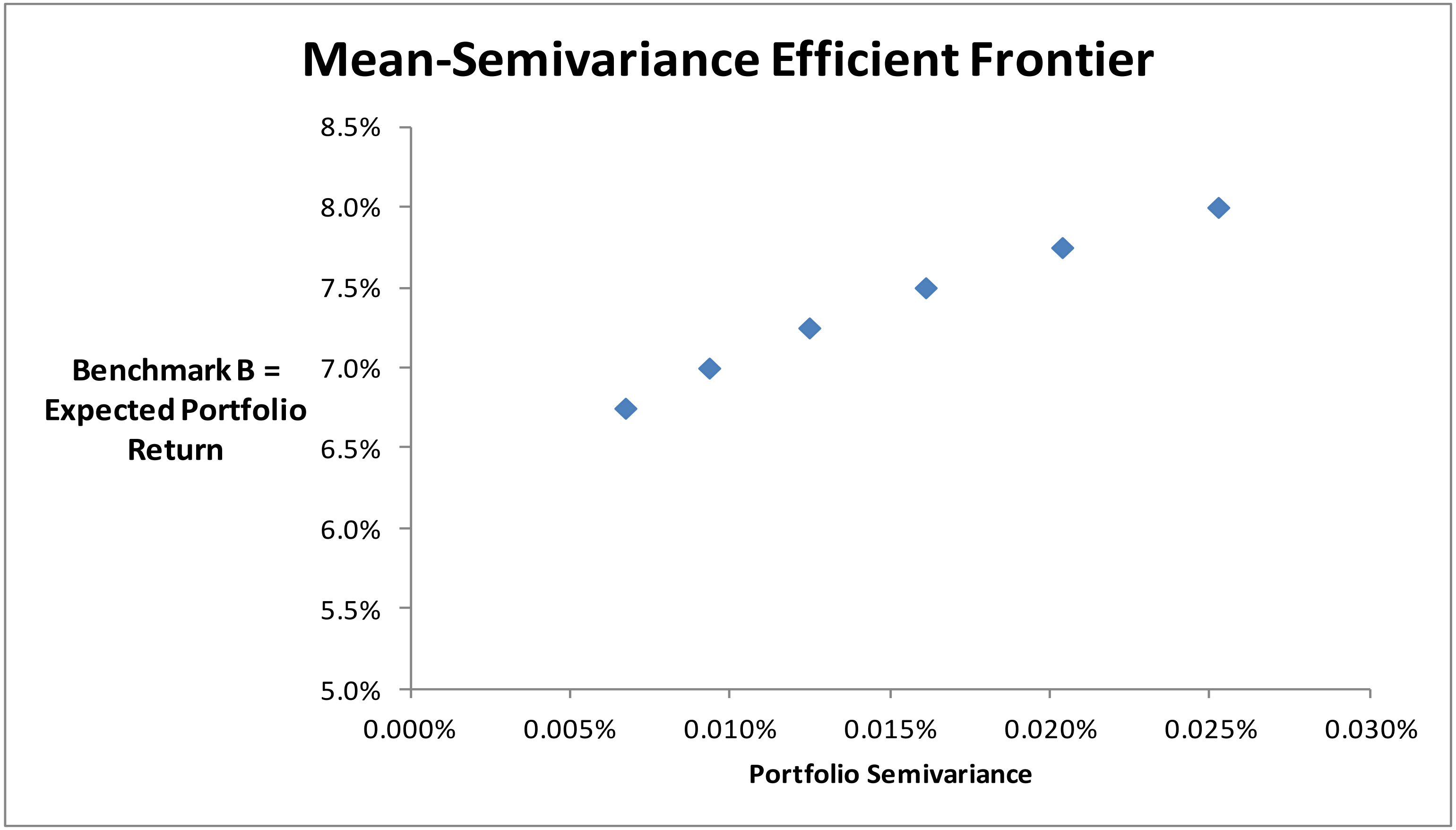
ENTERPRISE RISK MANAGEMENT SYMPOSIUM

Problem Solution

- The decision variables are $\{w_i\}$
- The objective function and constraints are functions of the $\{w_i\}$
- The constraints are *equality* constraints.
- Continuous first partial derivatives with respect to each of the weights exist for the objective function and the constraints
- Therefore, Lagrange Multipliers give solution!

ENTERPRISE RISK MANAGEMENT SYMPOSIUM

MSV Efficient Frontier



The Impossible Frontier

- For many semicovariance matrices the optimal portfolio for a given benchmark return contains short positions (negative weights) for some assets
- Such allocations are typically impossible to implement (other than at long-short equity hedge funds)
- Numerical methods may be used to find (near?) optimal long-only portfolios

ERM
ENTERPRISE RISK
MANAGEMENT SYMPOSIUM

More in the Paper

- A (much!) slower build-up of concepts
- Step-by-step worked out examples and illustrative simulation output
- State of ERM and conflicting stakeholder expectations
- Link to financial planning process, product allocation, risk-adjusted performance measures, and compensation

ENTERPRISE RISK MANAGEMENT SYMPOSIUM