

CAPITAL MANAGEMENT AND RISK MANAGMENT

SOCIETY OF ACTUARIES

Neil Doherty

ENTERPRISE RISK MANAGEMENT

- BASIC ISSUE
 - BY WHAT MECHANISMS DOES RISK DEplete FIRM VALUE?
 - HOW CAN WE INTERVENE TO RESTORE VALUE
- MECHANISMS
 - TAXATION INCREASES WITH RISK
 - RISK INCREASES COSTS OF FINANCIAL DISTRESS EX ANTE AND EX POST
 - RISK ENHANCES COSTS OF FUNDING NEW INVESTMENT
 - RISK AND SIGNALING

RISK AND CAPITAL 2 SIDES – SAME COIN

- COSTS OF RISK INCREASE WITH FINANCIAL LEVERAGE
- OR
- COST OF FINANCIAL LEVERAGE INCREASE WITH RISK
- THUS, MANAGING RISK AND MANAGING CAPITAL ARE SUBSTITUTES
 - E.G. COSTS OF DISTRESS CAN BE REDUCED BY HEDGING OR REDUCING LEVERAGE
 - COST OF CAPITAL CAN BE LOWERED BY LOWERING RISK OR CHANGING CAPITAL STRUCTURE
 - IN INSURANCE EQUITY AND REINSURANCE ARE SUBSTITUTES

CAPITAL AND RISK MANAGEMENT

- **COST OF CAPITAL ISSUES**
 - RAROC OR CAPM ?
 - RISK MANAGEMENT AND THE WEIGHTED AVERAGE COST OF CAPITAL
- **MEASURING RISK CAPITAL**
- **ALLOCATING CAPITAL**
- **HOW MUCH CAPITAL?**

RAROC OR CAPM

General forms of Cost of Capital

- 1. Models specifying underlying asset pricing model

- Cost of capital, k , = function of cash flow properties
- E.g. with multi factor asset pricing model (Fama French)

$$E(r) = r_f + \sum_i \beta_i [E(r_i) - r_f]$$

- 2. Cost of capital as weighted average of Debt, Equity, etc

$$k = k_e \frac{E}{V} + k_d \frac{D}{V}$$

- 3. Implicit form for cost of capital

$$E(r) = r_f + \sum_i \beta_i [E(r_i) - r_f]$$

- or

$$k = k_e \frac{E}{V} + k_d \frac{D}{V}$$

- 4. Explicit form - e.g. Net Present Value Analysis

$$V = \frac{E(T) - \frac{\sum COV(T; r_i)}{VAR(r_M)} [E(r_i) - r_f]}{1 + r_f}$$

INSURANCE LIABILITIES ARE INSURER'S DEBT

- For non insurance firms, cost of capital is weighted average of debt and equity
- Insurer is leveraged investor.
 - Cost of equity as with non insurance firms
 - Debt can be measured as conventional debt and liability to policyholders
 - Cost of debt is opportunity cost of holding policyholder funds

	IMPLICIT FORM	EXPLICIT FORM
EXPRESSED AS WEIGHTED AVERAGE OF SOURCES OF CAPITAL	$k = k_E \frac{E}{V} + k_D \frac{D}{V}$	$V = E(T) - k_E E - k_D D$
EXPRESSED AS ASSET PRICING MODEL	$E(r) = r_f + \sum_i \beta_i [E(r_i) - r_f]$	$V = \frac{E(T) - \frac{\sum COV(T; r_i)}{VAR(r_M)} [E(r_i) - r_f]}{1 + r_f}$

These various forms are encountered in RISK MANAGEMENT AND THE COST OF CAPITAL

ACCOUNTING FOR RISK IN THE COST OF CAPITAL: 1, RAROC

- **1. RAROC.** is the ratio of the after tax expected income to the economic capital over the life of the activity

- BANKING RAROC

- Y = net income
- L = actual loss
- E(L) = expected loss
- i = interest on capital
- EC = economic capital

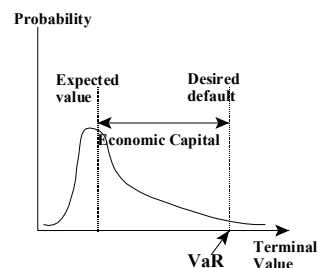
$$R^R = \frac{Y + (L - E(L)) + i}{EC}$$

$$R^R = \frac{P - PV(E(L)) - PV(X) + i}{EC}$$

- e.g. INSURANCE RAROC

- P = premiums
- L = insurance claims
- X = expenses
- i = interest on capital
- EC = economic capital

- Key is ECONOMIC CAPITAL. Amount of capital required to deliver given level of safety



ACCOUNTING FOR RISK IN THE COST OF CAPITAL: 2, ASSET PRICING MODELS

- CAPITAL ASSET PRICING MODEL

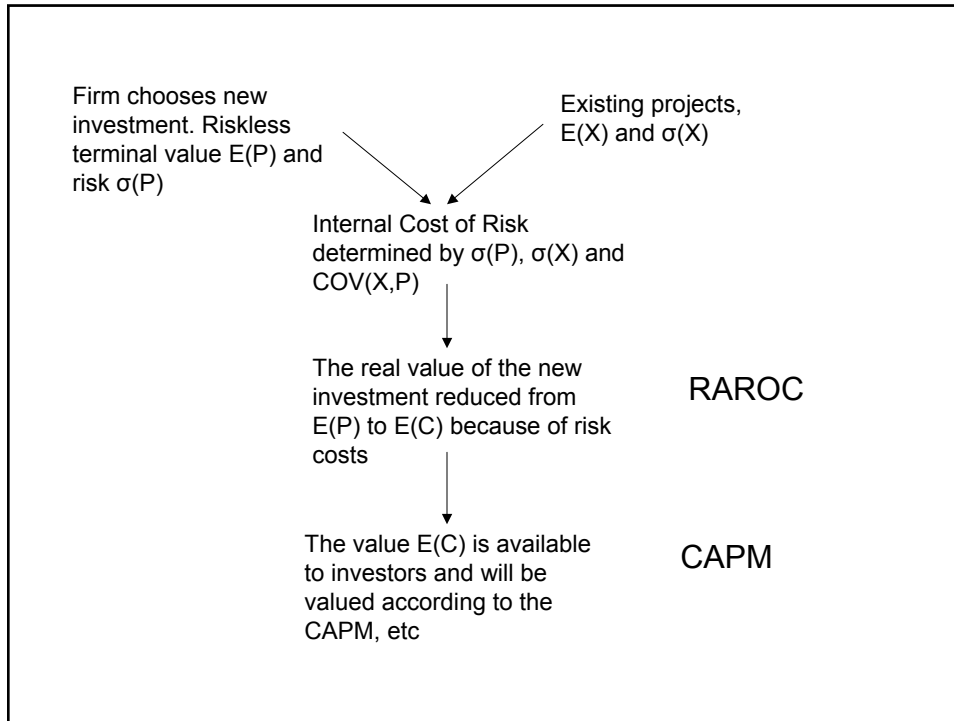
$$R_C = R_f + \beta(E(R_m) - R_f)$$

- MULTI FACTOR PRICING MODEL

$$R_C = R_f + \sum \beta_i E(R_i)$$

RAROC OR CAPM ?

- RAROC reflects the corporate cost of risk or *risk tolerance*. RAROC discounts TOTAL risk. Measures INTERNAL costs of risk.
 - Costs of distress
 - Asset substitution
 - Signaling costs etc
- CAPM etc measures the cost of bearing risk IN THE CAPITAL MARKET. It is the risk cost to the diversified investor.
 - After firm delivers income (which will reflect internal costs of risk) to investors, investors will still discount for β risk
- RISK COST ARE INCURRED **BOTH** WITHIN THE FIRM AND IN THE CAPITAL MARKET. WE SHOULD USE **BOTH**.



RISK AND THE W.A.C.C.

RISK AND THE W.A.C.C.

1A. DOHERTY 1985, chapter 10

Cost of capital shown as *function of cash flow characteristics*

Total value = value of “business” and “risk management” cash flows

- $V = V_B + V_H$

Suppose that the risky cash flow is hedged or insured. The Value V_H would be the *cost of the insurance or hedge*. Thus V_H is **RISK CAPITAL** similar to Merton & Perold below.

Illustrating with CAPM (Easily extended to other asset pricing models)

- **EXPLICIT** or **IMPLICIT FORM**

$$k = k_B \frac{V_B}{V} + k_H \frac{V_H}{V}$$

$$k = r_f + \beta(E(r_M) - r_f)$$

$$\beta = \beta_B \frac{V_B}{V} + \beta_H \frac{V_H}{V}$$

$$V = \frac{E(T_B) - \frac{COV(T_B; r_M)}{VAR(r_M)} [E(r_M) - r_f]}{1 + r_f} + \frac{E(T_H)}{1 + r_f}$$

RISK AND THE W.A.C.C.

1B. MERTON AND PEROLD 1993

RISK CAPITAL is the **MINIMUM** amount of capital needed to guarantee the net assets of the firm. Risk capital can comprise

- •equity
- •insurance or derivative (e.g. reinsurance)
- •guarantee by parent (Berkshire accepts to bail out GRE)
- •risk premium paid to lender to accept credit risk

RISK CAPITAL IS A USE OF CAPITAL (NOT A SOURCE); I.E., INSURANCE (ETC) MUST BE FUNDED FROM DEBT, EQUITY, ETC.

CAPITAL = OPERATIONAL CAPITAL + RISK CAPITAL

- $C = O + R = E + D = V$

$$ROE = \frac{NET_INCOME}{O + R}$$

$$WACC = k_E \frac{E}{V} + k_D \frac{D}{V}$$

$$= k_E \frac{E}{O + R} + k_D \frac{D}{O + R}$$

Risk and the W.A.C.C.

C. SHIMPI 2000 (THE "INSURATIVE" MODEL)

TOTAL CAPITAL

= PAID UP CAPITAL + OFF BALANCE SHEET

= DEBT + EQUITY + INSURANCE (HEDGE)
CAPITAL

NOTE:

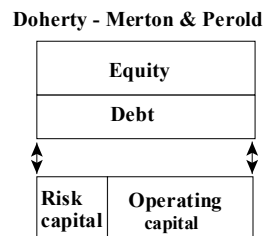
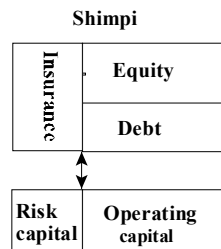
*HEDGE CAPITAL IS THE CAPITAL
RELEASED BY THE HEDGE AT A
GIVEN RUIN PROBABILITY*

- off-balance-sheet capital is a SOURCE of capital
- **TACC = TOTAL AVERAGE COST OF CAPITAL**
-
- WHERE "H" IS THE CAPITAL RELEASED FROM INSURANCE
- AND k_H IS THE "COST OF HEDGE CAPITAL" DEFINED AS PREMIUM/H

$$TACC = k_E \frac{V_E}{V} + k_D \frac{V_D}{V} + k_H \frac{H}{V}$$

COMPARISON OF w.a.c.c. MODELS

- Shimpi and Doherty - Merton Perold models



**ILLUSTRATION OF FRICTIONLESS MODELS
(Base model from SHIMPI)**

BASIC ASSUMPTIONS

Firm has assets	=	1500	earning 16% RISKY
Debt	=	500	@ 10%
Equity	=	1000	

WITHOUT INSURANCE

EARNINGS 16% OF 1500	=	240
INTEREST	=	50
NET INCOME	=	190

$$ROE = 190/1000 = 19\%$$

WITH INSURANCE

Premium 10 paid from income (or single up front premium = 50)

Releases 500 in equity capital

Assumptions

1. Modigliani Miller world
2. The return on assets released by insurance is 16%. The insurance would affect the terms of operational transactions (e.g. remove risk premia). This is ignored here. This would have similar impact on models.
3. Firms operating returns are competitive. Thus total return just sufficient to cover cost of capital

SHIMPI AND INSURATIVE MODEL

EARNINGS 16% OF 1000	=	160
INSURANCE PREMIUM	=	10
INTEREST	=	50
NET INCOME	=	100

$$ROE = \frac{100}{500} = 0.20$$

Now since $H = 500$ and $k_H = 10/500 = 0.02$

$$TACC = 0.1 \frac{500}{1500} + 0.20 \frac{500}{1500} + 0.02 \frac{500}{1500} = 0.1067$$

NOTE THAT THE VALUE OF THE FIRM IN THIS MODEL IS 1500.

DOHERTY AND MERTON & PEROLD

TREAT RISK CAPITAL AS ACTUAL OR LOWEST COST OF HEDGE i.e., PREMIUM OF 10
PREMIUM HAS TO BE FUNDED UP FRONT THEREFORE.
THE COST OF UP FRONT FUNDING OF SINGLE PREMIUM IS 50

DEBT = 500
EQUITY = 550
TOTAL CAPITAL = 1050

EARNINGS 16% OF 1000 = 160
INTEREST = 50
NET INCOME = 110

$$ROE = \frac{110}{550} = 0.2$$

$$WACC = 0.1 \frac{500}{1050} + 0.2 \frac{550}{1050} = 0.152$$

NOTE THAT THE VALUE OF THE FIRM IS 1050

DIFFERENCES BETWEEN APPROACHES

SHIMPI TREATS RISK CAPITAL AS CAPITAL RELEASED BY HEDGE
M&P TREATS RISK CAPITAL AS LOWEST COST OF HEDGE
DOHERTY TREATS RISK CAPITAL AS COST OF HEDGE

SHIMPI TREATS RISK CAPITAL AS SOURCE OF CAPITAL
M&P TREATS RISK CAPITAL AS USE OF CAPITAL
DOHERTY TREATS RISK CAPITAL AS USE OF CAPITAL

if we assume that hedging is value enhancing

SHIMPI MEASURES ROE AND TACC AGAINST INEFFICIENT (RISK RETENTION) CAPITAL USE
M&P MEASURES ROE AND WACC AGAINST EFFICIENT CAPITAL USE
DOHERTY MEASURES ROE AND WACC AGAINST ACTUAL CAPITAL USE

as consequence

SHIMPI DENOMINATES COST OF CAPITAL AGAINST EXAGGERATED FIRM VALUE
M&P DENOMINATES COST OF CAPITAL AGAINST EFFICIENT FIRM VALUE
DOHERTY DENOMINATES COST OF CAPITAL AGAINST ACTUAL FIRM VALUE

WHICH IS THE “CORRECT” MODEL?

START FROM SHIMPI'S CALCULATIONS

ROE = 20%; TACC = 0.1067; FIRM VALUE = 1500

AND ASSUME THAT *YOU CAN NOW BUY THE FIRM*.
YOU ALSO NOTE THAT THE FIRM HAS IMPLEMENTED AN EFFICIENT
RISK MANAGEMENT STRATEGY (i.e. IS HEDGING THE RISK INSTEAD
OF ALLOCATING AN ADDITIONAL 500 IN EQUITY TO RETAIN THE
RISK).

YOU COULD NOW

BUY THE FIRM FOR 1050 (COMPETITIVE PRICE)

FUND THE PURCHASE WITH 500 DEBT AND 550 EQUITY

IN WHICH CASE, THE WACC IS:

INCOME / PURCHASE PRICE

$$=160/1050 = 0.152$$

WHICH IS THE RESULT OF THE DOHERTY AND M&P i.e.,

$$WACC = 0.1 \frac{500}{1050} + 0.2 \frac{550}{1050} = 0.152$$

RISK CAPITAL(Merton/Perold)

- Risk capital is capital that “insurers” net assets of firm relative to riskless investment of those net assets.
- Risk capital can be:
 - shareholder guarantee shareholders capital at risk to pay losses
 - cost of reinsurance
 - cost of asset insurance
 - loss of revenue from sale of risky policies (default sensitive premiums)

Risk capital

- MERTON PEROLD APPROACH

- Gross Assets at time t A_t
- value of liabilities L_t
- Net assets $A_t - L_t$
- If they were invested risklessly $(A_0 - L_0)e^{rT}$

- Shortfall of net assets relative to riskless investment

$$(A_0 - L_0)e^{rT} - A_t - L_t$$

- This is how much “insurance” or risk capital you need to ensure performance. This is in fact an option and can be valued by Black-Scholes. A simplified (approximate) version of the pricing model is

- $\text{RISK CAPITAL} = 0.4A_0 \sigma$

CAPITAL ALLOCATION

- **WHY DO WE WISH TO ALLOCATE CAPITAL?**

- **VALID REASONS**

- CAPITAL BUDGETING: TO ENSURE PROPER MACRO CAPITAL BUDGETING DECISIONS;
- PRICING: TO ENSURE THAT THE CAPITAL EMBEDDED IN THE SUPPLY OF EACH PRODUCT IS PROPERLY PRICED

- **INVALID REASON**

- CAPITAL MUST BE “PARKED” SOMEWHERE.
- THE TROUBLE WITH “PARKING IS THAT IS AFFECTS INCENTIVES

MARGINAL CAPITAL ALLOCATION APPROACHES

- **MERTON/ PEROLD**
- INSURERS CAN DIVERSIFY RISK.
- AS MORE POLICIES ARE ADDED TO A PORTFOLIO, RISK INCREASES AT A SLOWER RATE THAN THE INCREASE IN POLICIES. AVERAGE RISK PER POLICY FALLS WITH "n"
- SUPPOSE THE FIRM WISHES TO KEEP THE RISK PER POLICY CONSTANT. THEN IT CAN MAINTAIN THIS TARGET BY INCREASING EQUITY AT A LOWER RATE THAN THE INCREASE IN POLICIES
- SO WE CAN THINK OF THE CAPITAL "ATTRIBUTED" TO EACH LINE OF BUSINESS AS THE **ADDITIONAL CAPITAL THAT IS NEEDED TO MAINTAIN THE DEFAULT RISK WHEN THAT LINE IS ADDED TO ALL PRE-EXISTING LINES OF BUSINESS.**
- A LOGICAL CONSEQUENCE OF DIVERSIFICATION IS
- **SUM OF CAPITAL SO ALLOCATED TO THE LINES IS LESS THAN THE TOTAL CAPITAL OF THE FIRM**
- UNALLOCATED CAPITAL

ILLUSTRATIONS OF UNALLOCATED CAPITAL

- "n" business units each with gross assets having value of 1000, standard deviation = 0.375. correlation coefficient = 0.1;
 - **TABLE 1 - ALL BUSINESS UNITS HAVE CORRELATION OF 0.1**
- | | gross
assets | capital | marginal
capital | capital
allocated | %
allocated |
|--------|-----------------|---------|---------------------|----------------------|----------------|
| • 1 | 1000 | 150 | | | |
| • 2 | 2000 | 222 | 72 | 144 | 64.8 |
| • 3 | 3000 | 285 | 63 | 189 | 66.3 |
| • 4 | 4000 | 342 | 57 | 228 | 66.6 |
| • 5 | 5000 | 397 | 55 | 275 | 69.3 |
| • 6 | 6000 | 450 | 53 | 318 | 70.6 |
| • 7 | 7000 | 502 | 52 | 364 | 72.5 |
| • 100 | | | | 95.9 | |
| • 1000 | | | | 99.6 | |

DANGER OF ALLOCATING ALL CAPITAL

TWO INCUMBENT DIVISION A AND B

DIVISION	EXPECTED LIABILITIES	CASH FLOW	CAPITAL CONSTANT DEFAULT	ROE
A + B	200	16	100	16%
C	100	4		
A+B+C	300	20	125	16%

ALLOCATE ALL CAPITAL

ALL DIVISIONS ARE IDENTICAL IN RISK AND CROSS CORRELATIONS -
THEREFORE ALL WOULD HAVE SIMILAR CAPITAL ALLOCATIONS OF
 $125/3 = 41.667$ EACH

CAPITAL BUDGETING DECISION WITH FULL ALLOCATION

CAPITAL ALLOCATED TO C	41.667
CASH FLOW	4
ROE	0.96 < 12.5 REJECT

MERTON PEROLD

MARGINAL CAPITAL OF C IS $125 - 100 = 25$

CAPITAL ALLOCATED TO C	25.00
CASH FLOW	4
ROE	0.16 > 12.5 ACCEPT