15.482 Healthcare Finance
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Unit 4, Part 2: The CAPM

Unit Outline

- Risk & Reward
- The CAPM
- Applications
- Portfolio Theory
- Risk-Adjusted NPV

The CAPM

Systematic vs. Idiosyncratic Risk

Cost of Capital *R* Is Your Cost of Funds

- Your NPV will be computed with respect to R; investors will expect you to earn at least R
- The two challenges of cost of capital *R* and managing the risk/uncertainty of your revenues and costs (requires domain expertise) are related!
- Risk affects *R* (usually increasing it), but only certain kinds of risk: diversifiable risk does not affect *R*
- Only undiversifiable ("systematic") risk affects *R;* **why**??

Systematic vs. Idiosyncratic Risk

- Payoff of SunGlass Shack: –$100 if rain, +$200 if shine
- Suppose chance of rain/shine is 50%
- How much would you pay for SunGlass Shack today?

$$\text{Cost of Capital } R = \frac{\text{E[Payoff]}}{P_0} = \frac{\$50}{P_0}$$

Systematic vs. Idiosyncratic Risk

- Payoff of Umbrellas-R-Us: $200 if rain, –$100 if shine
- Suppose chance of rain/shine is 50%
- How much would you pay for Umbrellas-R-Us?

$$\text{Cost of Capital } R = \frac{\text{E[Payoff]}}{P_0} = \frac{\$50}{P_0}$$

Systematic vs. Idiosyncratic Risk

- How much would you pay for half of **both** projects?
- If it rains: profit = 0.5(–$100) + 0.5(+$200) = $50
- If it shines: profit = 0.5(+$200) + 0.5(–$100) = $50

$$\text{Cost of Capital } R = \frac{\text{E[Payoff]}}{P_0} = \frac{\$50}{P_0}$$

Systematic vs. Idiosyncratic Risk

- In the real world, Sunglass Shack and Umbrellas-R-Us don't exist (perfect negative correlation is implausible)
- Diversification does work, but most companies' earnings are positively correlated with each other
- What is the most diversified portfolio of all?
  - The portfolio of all stocks, i.e., the **market portfolio**
- Can't diversify any better than the market, hence the market's risk is all **systematic risk**
- Systematic risk requires a "reward", otherwise no one will be willing to be exposed to it

The Capital Asset Pricing Model

William Sharpe (1964):

$$\mathrm{E}[R_p] = R_f + \beta_p(\mathrm{E}[R_m] - R_f) \qquad \beta_p = \frac{\mathrm{Cov}[R_p, R_m]}{\mathrm{Var}[R_m]}$$

Beta

Market Risk Premium ≈ 6.9%

Implications:

- Correlation matters; diversification
- Benchmarks, performance attribution
- Passive investing
- Indexation and hedging
- Portable alpha overlays
- Risk budgeting
- Framework for fiduciary duties
- **Cost of capital estimation and capital budgeting**

The Capital Asset Pricing Model

Risk Decomposition:

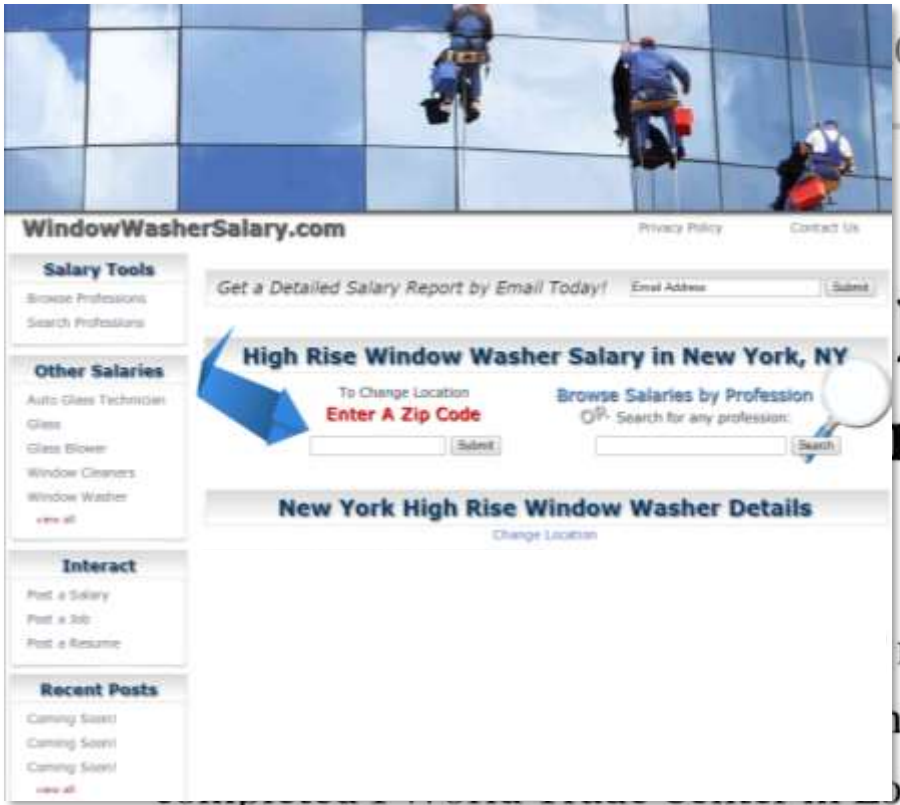
$$\mathsf{E}[R_p] = R_f + \beta_p(\mathsf{E}[R_m] - R_f) \quad , \quad \beta_p \equiv \frac{\mathsf{Cov}[R_p, R_m]}{\mathsf{Var}[R_m]}$$

$$R_p = R_f + \beta_p(R_m - R_f) + \epsilon_p$$

$$\mathsf{Var}[R_p] = \beta_p^2 \mathsf{Var}[R_m] + \mathsf{Var}[\epsilon_p]$$

Total Risk — Systematic Risk — Idiosyncratic Risk

- Only systematic risk contributes to the risk premium



0ZViH6

Rescued From
rade Center

rescued two window washers who
e street while working at the newly
wer Manhattan.

Applications

Weighted Average Cost of Capital

Assets	Liabilities
Cash Capital Intangibles	E D
Value	**Value**

$$V = E + D$$

$$R_a = \omega_e R_e + \omega_d R_d \quad , \quad \omega_e \equiv \frac{E}{E+D}$$

$$E[R_a] = \omega_e E[R_e] + \omega_d E[R_d]$$

$$\mathrm{Cov}[R_a, R_m] = \omega_e \mathrm{Cov}[R_e, R_m] + \omega_d \mathrm{Cov}[R_d, R_m]$$

$$\frac{\mathrm{Cov}[R_a, R_m]}{\mathrm{Var}[R_m]} = \frac{\omega_e \mathrm{Cov}[R_e, R_m]}{\mathrm{Var}[R_m]} + \frac{\omega_d \mathrm{Cov}[R_d, R_m]}{\mathrm{Var}[R_m]}$$

$$\beta_a = \omega_e \beta_e + \omega_d \beta_d$$

$$\beta_e \approx \frac{1}{\omega_e} \beta_a \quad \text{if } \beta_d \approx 0$$

Capital Asset Pricing Model Estimates

Example: (betas from finance.yahoo.com 2/17/17)

Company	Beta	CAPM Cost of Capital	Company	Beta	CAPM Cost of Capital
Eli Lilly	0.24	4.44%	Agios	2.33	16.98%
Gilead	1.03	9.18%	Alexion	1.39	11.34%
GSK	1.07	9.42%	Alnylam	3.16	21.96%
J&J	0.64	6.84%	Axovant*	1.66	12.96%
Merck	0.96	8.76%	Chimerix	2.30	16.80%
Novartis	0.75	7.50%	Editas*	1.63	12.78%
Pfizer	1.02	9.12%	OncoMed	2.69	19.14%
Sanofi	0.76	7.56%	Regeneron	1.69	13.14%

R_f = 3%

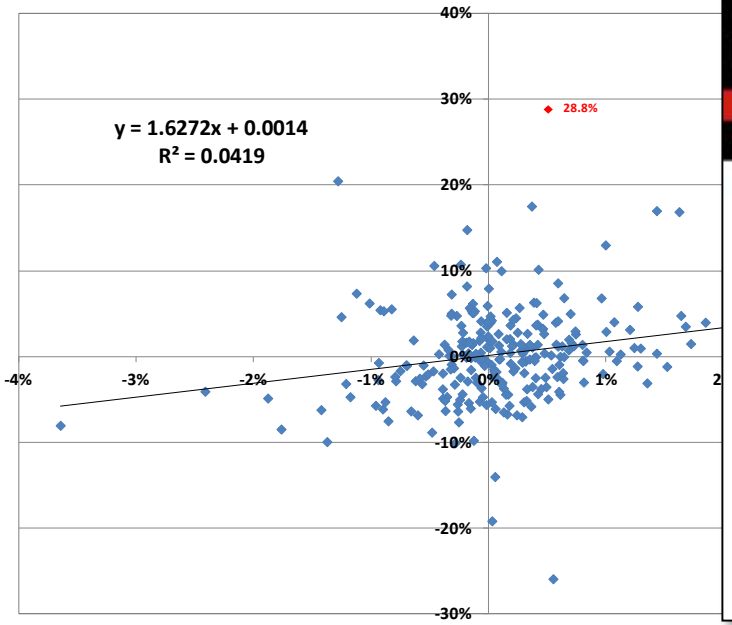
$E[R_m]$ = 9%

$$\mathsf{E}[R_p] = R_f + \beta_p(\mathsf{E}[R_m] - R_f)$$

Capital Asset Pricing Model Estimates

Scatterplot of Editas and VOO Daily Returns

4 Feb 2016 to 17 Feb 2017

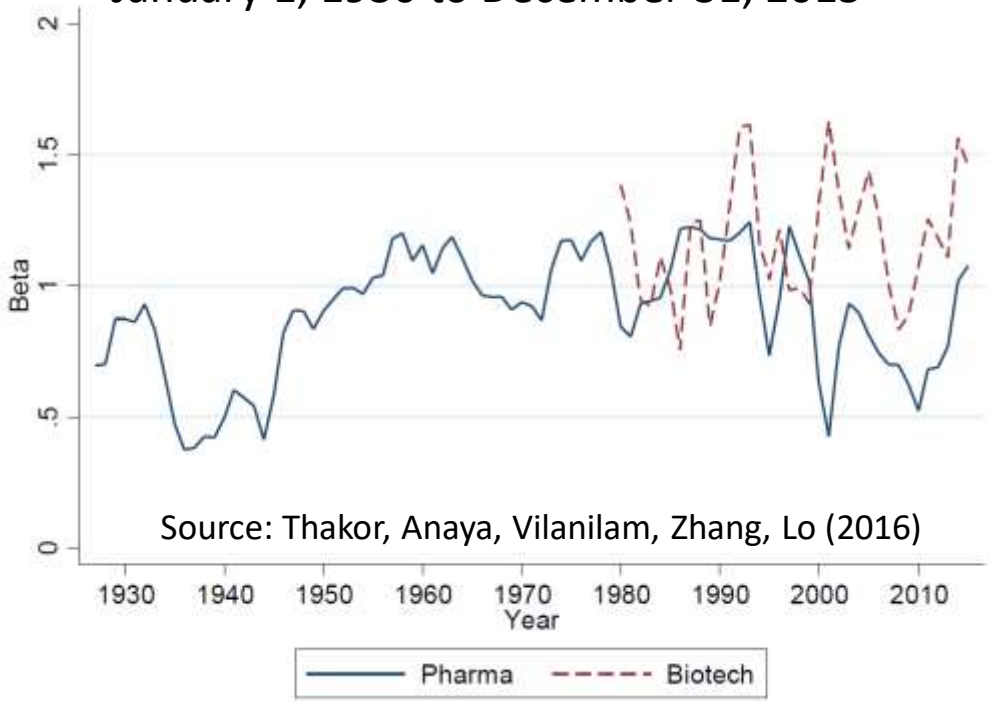


Capital Asset Pricing Model Estimates

Capital Asset Pricing Model Estimates

Comparison of Pharma and Biotech CAPM Betas

January 1, 1930 to December 31, 2015



Source: Thakor, Anaya, Vilanilam, Zhang, Lo (2016)