The CAPM

(Welch, Chapter 10)

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Did you bring your calculator? Did you read these notes and the chapter ahead of time?

Maintained Assumptions

What is your investors' opportunity cost of capital?

Same assumptions:

- We assume **perfect markets**, unequal rates of return in periods, uncertainty, and risk-aversion.
- What if we want to lean heavily on these *and then some* assumptions? Can we do better than benchmarking?
- Investors care **only** about default, term, and equity premium.
  - See benchmarking CH09: They dislike risk, they are smart, etc.
  + They care about no factors other than the market. The equity premium summarizes all factors (like real-estate, oil, value, etc.).
  + Measure of "how much like equity" is the **market beta**.

Do projects that *add* more risk to investors' portfolio need to provide more reward?

Do projects that have high variance, but whose risk can be diversified away in our portfolio, need to provide more reward?

The CAPM Formula

Assumptions: Perfect markets. Risk-aversion. All assets for sale.

The CAPM formula says that the expected rate of return of every project is linearly related to this project's market-beta:

$$E(r_i) = \#_1 + \#_2 \cdot \beta_{i,M}$$

$\#_1$ and $\#_2$ are two constants that are the same for every project in the economy, i.e., not functions of i.

What asset has a beta of 0? What is the appropriate market rate of return for a security with a beta of 0?

What asset has a beta of 1? What is the appropriate market rate of return for a security with a beta of 1?

Solve for $\#_1$ and $\#_2$.

The CAPM Formula

$$E(r_i) = r_F + [E(r_M) - r_F] \cdot \beta_{i,M}$$

You must memorize the CAPM formula!

You must dream of this formula. You must be able to reproduce it on the spot and without thinking. Am I clear?

- $[E(r_M) - r_F]$ **is the equity premium.**
- Think of the CAPM formula as a line, which relates a project's beta to an appropriate expected rate of return.
  Projects that add more risk to our (market) portfolio (high market-beta) have to offer higher a reward (expected rate of return).
- The inputs, the risk-free rate of return and the equity premium, are the most important numbers in finance—and not just because of the CAPM.
- The CAPM project valuation is relative to (**your** estimate of) the equity premium.
  The risk-free rate and the equity premium pin down the relationships in the economy.
  Then, beta—and beta only—matters.

What CAPM inputs are the same for every project?

What CAPM inputs are specific to your project?

What signs do the intercept and slope have?

Presume that r_F is 3% and $E(r_M)$ is 7%. Under the CAPM, what appropriate expected rate of return must a project offer with a market beta of 1.5? 0.5? –0.5? 0? 1?

In what other contexts might you care about the three CAPM inputs?

If the risk-free rate is positive, would you ever buy a stock with a negative expected return?

Why is there no difference between a zero-beta risky project and the risk-free rate when it comes to expected rates of return?

A corporate zero-bond promises \$1,000 in 1 year. Its market-beta is 0.5. The equity premium is 4%. The risk-free rate is 3%. What is the appropriate bond price today?

Risk Premia and Credit Premia:

- Does the CAPM take care of default risk? Does the use of the CAPM E(r) in the NPV formula take care of default risk?
- Is idiosyncratic default risk "priced"?

IMPORTANT

The CAPM does not provide an appropriate promised rate of return (or cost of capital). It provides the appropriate expected rate of return.

You must take care of default (credit) risk in the numerator of the NPV formula, and use CAPM ER on bottom.

Cost of Capital Decomposition: The CAPM is the first premium that changes the expected rate of return across different projects in a perfect market. Projects with more beta offer a higher expected rate of return.

Cost of Capital Decomposition:

$$\text{Promised RoR} = \text{Time Premium} + \text{Default Premium} + \text{Risk Premium}$$

$$\text{Actual RoR} = \text{Time Premium} + \text{Default Realization} + \text{Risk Premium}$$

$$\text{Expected RoR} = \text{Time Premium} + \text{Expected Risk Premium}$$

Do you know the CAPM inputs? Can you estimate them?

How do you get the correct market beta for the project(s) of a publicly-traded firm?

- Beta is forward-looking. You only have historical data.
- You must use own project beta for each project. Do not use firm beta. Important in M&A. Covered later.
- You must use own asset-class beta for each asset-class financing.

- PS: Beta also has implications for *conditional* expected rate of return, not just *unconditional* expected rate of return used in the CAPM.
- PS: Beta also has implication for overall stock risk (because market risk flows into projects), not just for expected rate of return.

How do you best determine an **equity** market-beta?

- Run a market model time-series regression using **daily** rates of return. Use about 2 years of data (1-5 acceptable). Get OLS b^1.
- For short-term (1 year) project, use

$$b = (1 - 0.3) \times b^1 + 0.3$$

  For long-term (5 years +) projects, use

$$b = (1 - 0.4) \times b^1 + 0.4$$

  Examples:
  - If OLS $b^1 = 2$, then use 1.7 for 1-year project.
    If OLS $b^1 = 0$, then use 0.3 for 1-year project.
- If you only have monthly data (yikes!!), use 0.5 instead of 0.3-0.4.
- If you have no own data (yikes! far worse!), use similarly sized firms.
- Never use monthly data if you have daily data.
- Never use industry data if you have own data.
- If you don't have daily own historical returns, pray. There are methods that claim to do this, but they are lousy.

Debt and CAPM

The profits generated by a firm's assets are distributed to its debt and equity holders. Therefore, one can think of a firm's assets as consisting of a portfolio of debt and equity.

DT	dollar value of the firm's debt.
EQ	dollar value of the firm's equity.
FM	dollar value of the firm's total assets.

By definition (omitting non-financial liabilities)

$$(DT + EQ) \equiv FM$$

Now use your portfolio formula to generate the following relationship. $DT/(DT+EQ)$ is the percentage of the "Firm Asset" portfolio in debt ($w_{DT} = DT/(DT+EQ)$), and $EQ/(DT+EQ)$ is the percentage in equity ($w_{EQ} \equiv 1 - w_{DT} = EQ/(DT+EQ)$). By definition, $w_{DT} + w_{EQ} = 1$. Thus,

$$\beta_{FM} = \left(\frac{DT}{(DT+EQ)}\right) \cdot \beta_{DT} + \left(\frac{EQ}{(DT+EQ)}\right) \cdot \beta_{EQ}$$

What is the beta for debt?

For reasonably small debt levels, close to 0. It will almost certainly be paid up, so there is not much variation or covariation.

Suppose the firm's debt is risk free. Then one can write the beta of its equity as

$$\beta_{FM} = \left(\frac{EQ}{(DT+EQ)}\right)\cdot\beta_{EQ}$$

$$\Longrightarrow \beta_{EQ} = \beta_{FM}\cdot\left(\frac{(DT+EQ)}{EQ}\right) = \beta_{FM}\cdot\left(\frac{FM}{EQ}\right) = \beta_{FM}\cdot\left(\frac{FM}{(FM-DT)}\right)$$

Holding the value of the assets constant, as the firm alters its debt-equity mix, the beta of its assets does not change and neither does the value of its assets. **The above equation therefore implies that the more debt a firm issues, the higher is its equity beta.**

The linkage between firm's equity beta and its debt-equity mix is often overlooked. Financial "experts" often tell firms it is cheaper to issue debt because the return on debt is lower. This is not true. Using debt raises the equity beta, thereby eliminating the presumed savings.

Now let's illustrate what we know about β_{EQ} (and r_{EQ} if the CAPM holds) numerically. An example: $\beta_{FM} = 2$, FM = \$100 (assets are constant: when you issue debt, you retire equity), $r_F = 0.05$, $E(r_M) - r_F = 0.10$.

DT	\$0	\$10	\$50	\$90
β_{EQ}	2	2.2	4	20
$E(r_{EQ})$	25%	27%	45%	**205%**

If very levered, a small increase in its debt can cause a large increase in $E(r_{EQ})$!

Firm (Asset-) Beta vs. Equity Beta

1. Use comparable publicly-traded firms' betas.
2. Adjust the leverage:

$$\text{FM} = w_{\text{DT}} \cdot \text{DT} + w_{\text{EQ}} \cdot \text{EQ}$$

$$\beta_{\text{FM,M}} = w_{\text{DT}} \cdot \beta_{\text{DT,M}} + w_{\text{EQ}} \cdot \beta_{\text{EQ,M}}$$

Often, $\beta_{\text{FM,M}} \approx w_{\text{EQ}} \cdot \beta_{\text{EQ,M}}$.
Leverage Intuition: Unlevered beta is 1. Market $\pm 5\%$.

Debt $= \$0$: $\$100 \to \$95, \$105$ $\quad$ $R \approx \pm 5\%$.
Debt $= \$80$: $\$20 \to \$15, \$25$ $\quad$ $R \approx \pm 25\%$.

(Draw the beta line.)

3. Outcome: Same as in Benchmarking.

$$E(R_{\text{FM}}) = w_{\text{DT}} \cdot E(R_{\text{DT}}) + w_{\text{EQ}} \cdot E(R_{\text{EQ}})$$

Cost-of-Capital Linear Averaging

- The fact that the expected cost of capital on debt plus equity is that of the firm is much more general than CAPM. Any linear model allows for cost of capital averaging. It does not have to be the CAPM.
- For example, regardless of what you think of the CAPM, longer-horizon cash flows typically demand higher expected rates of return. (We called this term premia. You can see it in Treasuries, too. If anything, term premia are steeper in corporates.) Thus, you cannot simply assume that all cash flows regardless of horizon have the same cost of capital.

From a Merrill-Lynch interviewing question in 2000: You are a consultant to a gas exploration company. Gas is a very pro-cyclical commodity and has a very high beta. (Where would you get it?) You are exploring a field and you are certain that it has a capacity of x million cubic meters of gas. You have sold the production schedule in the forward market for \$20 million. It costs \$10 million to set up the drill, and 9 out of 10 times, this works the first time. 1 out of 10 times, you must try again, and this again has a 90% chance of success (and so on). In 3 minutes or less, face-to-face with the client: how would you advise the client to value this project? What is the rough value?

Another ML interviewing question: briefly describe a recent merger and what you think about it.

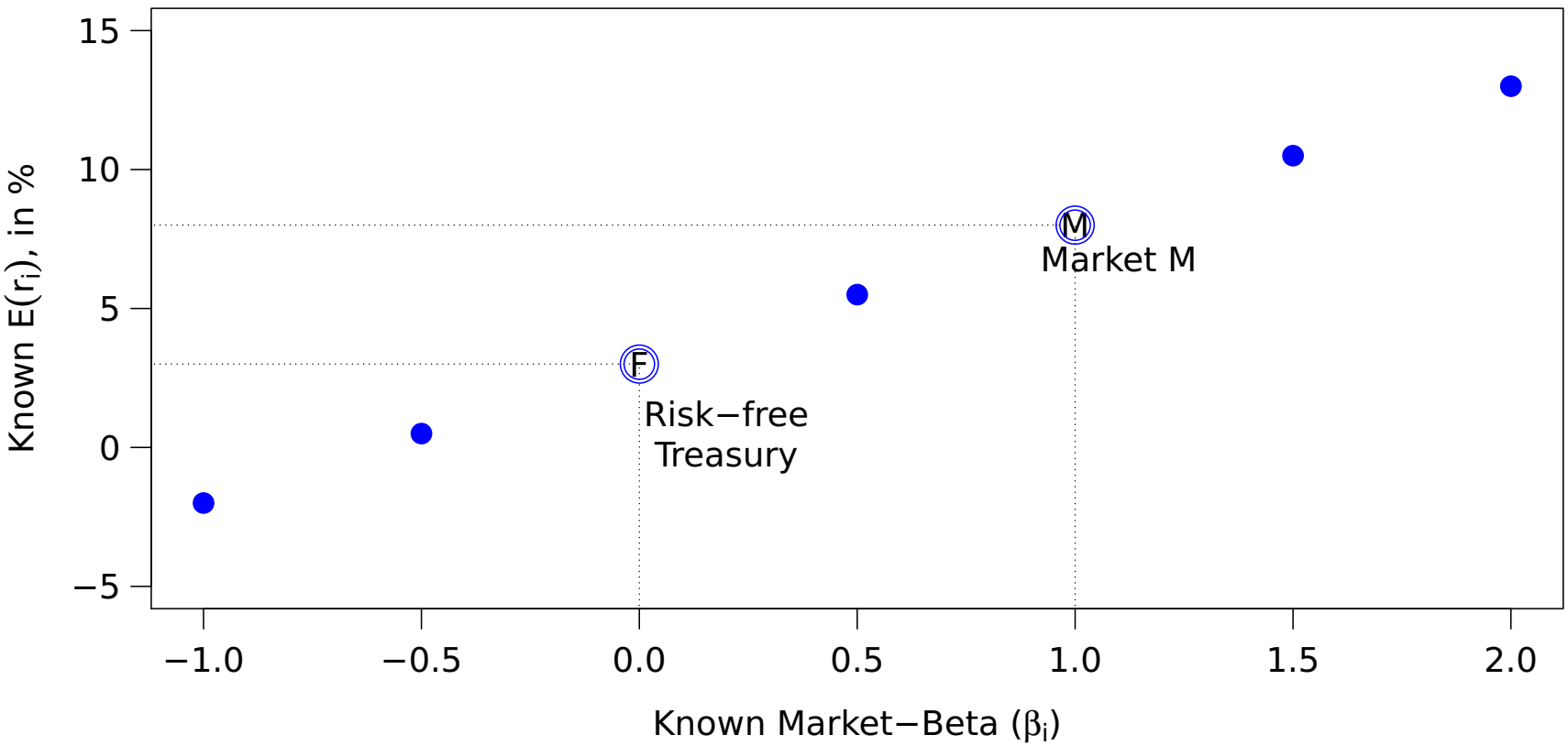
It is the year 1675 and you can buy a spice ship in India. If you sail, there is a 60% chance the ship will sink before it can return to England. If the ship does not sink, you can sell the spices in one year. Spice prices are related to market events and have a β of 2. The spices cost \$1,000, the ship costs \$10,000. If the ship makes it back, you expect to sell the spices for \$30,000 (uncertain, depends on market) and you can sell the ship for \$10,000 (for certain), too. Should the ship set sail if $r_F = 5\%$ and $E(r_M) = 15\%$?

Is the CAPM True?

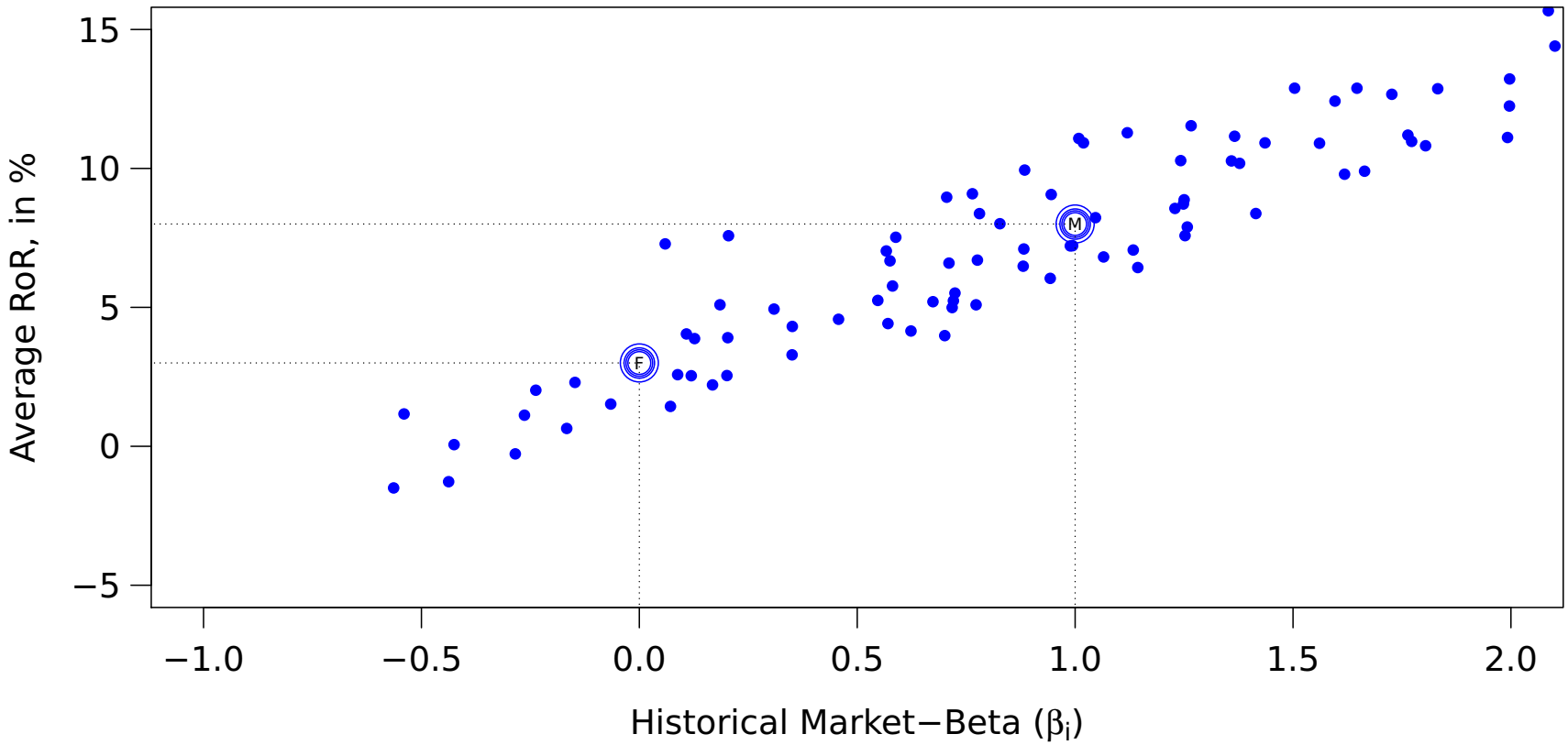
Do the assumptions seem reasonable?

Do high-beta stocks outperform low-beta stocks by about 2-4% per annum?

If the CAPM works: How should the SML look like if you knew the inputs?

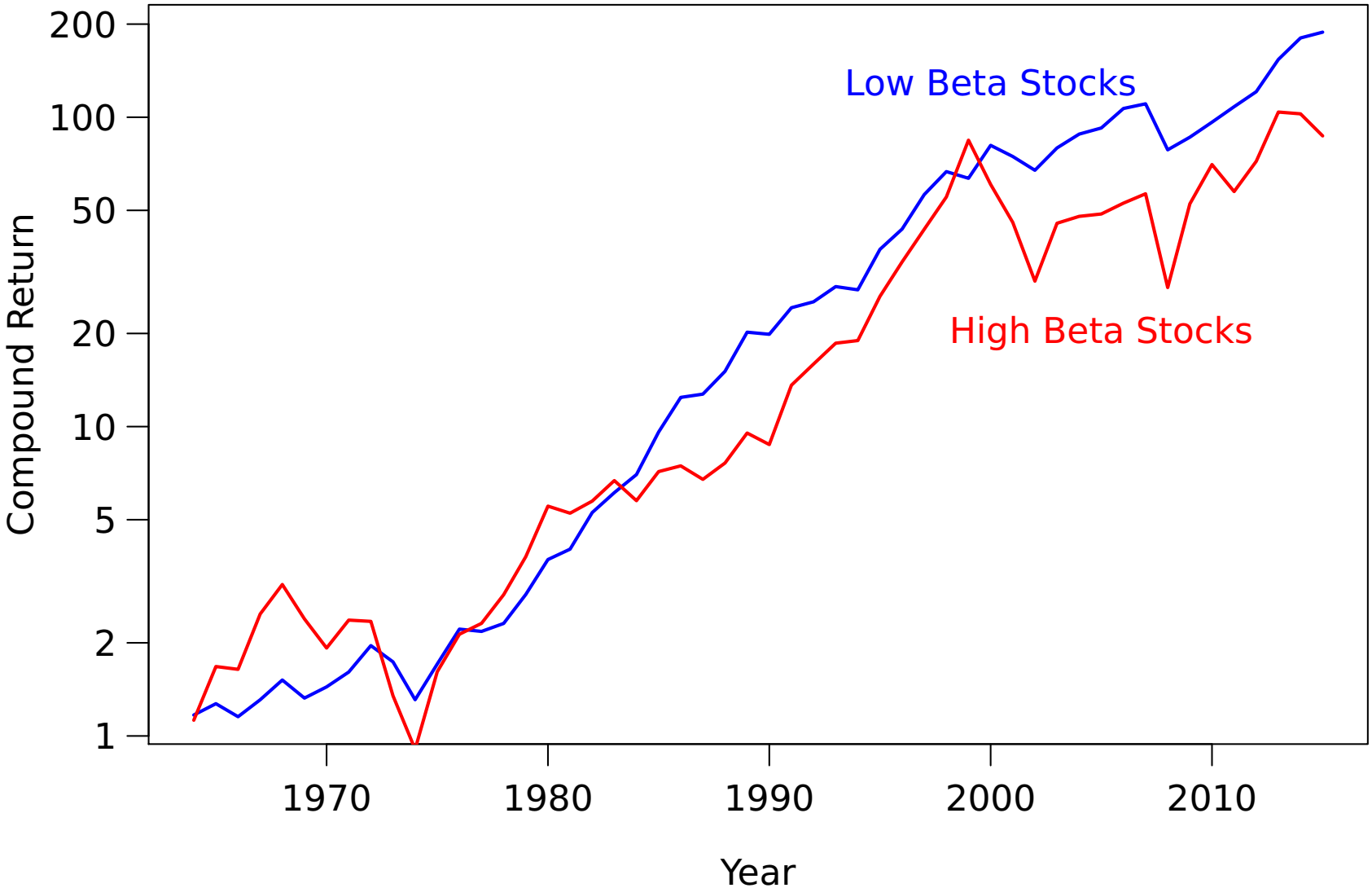


If the CAPM works: How should the CAPM SML look like if you had to estimate the CAPM inputs first?



In real life, it looks flat, but other factors matter.

History



- Stock Quintile Portfolios Sorted on Beta
- Plus, many other factors seem to matter, such as momentum, profitability, etc. have mattered.
- And for corporate CoC estimates, how good are the point estimates??

But Shouldn't It Have Held?

Not necessarily.

- Do you care about house wealth? Hedge it!
- Do you care about labor income? Hedge it!
- Is the market near perfect?

- No strong market-correcting forces. No easy way to take advantage. Only slightly better bets for CAPM-like investors.

Why must you know and sometimes use the CAPM?

- The CAPM sometimes gives reasonable cost of capital estimates. Think stopped clock twice a day.
- It gives good intuition. It makes internal sense (under some strong assumptions, such as tradeability of all goods).
- There are no great alternatives. (It takes a model to beat a model.)
  - As for me, I use "assset-class based capital budgeting." I presume that debt and equity have modestly different costs of capital, and the cost of capital is strongly horizon-dependent. This is not widely common, but well backed up by data.
- Who is using the CAPM? CFOs, courts, almost everyone.
  - In surveys, **73% of all firms say the CAPM is what they use**.
  - The next-most commonly used measure for the cost of capital are "ad-hoc historical returns" with 39% frequency, then various modified CAPM models with 34% frequency. Then you get down to 15% ("Gordon model," and "Whatever our investors are telling us"—whatever that may mean).
- CAPM use is widely considered "best practice."
- If you don't understand the CAPM, you will be considered an uneducated noob. In reality, it may well be the actual users of the CAPM that are the noobs. But it is often the noobs who are in charge now—most were educated in B-schools 20-40 years ago, when we still believed that the CAPM worked.

Cynical View

The real reasons why the CAPM is still in use:

- Hazing—not by professors, but by practitioners.
- Wishful thinking. Reality Deniers.
- Ignorance.

Warnings

- Never expect much accuracy from the CAPM. In practice, it is at best a very mediocre model.
- Use the CAPM only for ballpark cost-of-capital estimates.
- Never use the CAPM for investment decisions.
- Don't use it for short-term predictions, and don't use it for long-term predictions.

Don't use the CAPM unless forced.

Disagreements over NPV Quantitative Estimates

- Equity Premium estimates are tough.
- Beta estimates often stink—even if they could be better.
- Most uncertainty sits in expected cash flows.

And you don't know either the right model or benchmark, either.

Omitted Appendices

1. Certainty Equivalence: Used when price today is not fair, efficient market price.
2. Logic: How the CAPM Comes About.
   - Portfolio Separation: combining two MVE portfolios are MVE.
   - MVE portfolios obey SML-type (CAPM-type) relationships.
   - Entire CAPM: Market portfolio is efficient.
3. Alternatives: Multi-Factor Type Models. Not just beta, but potentially exposure to other factors. (Controversy: could be characteristics and market inefficiency.)
   - Arbitrage Pricing Theory (APT).
   - Fama-French-Momentum-Freeforall. Factors keep moving around or disappearing.

   Alas, these alternative are pretty lousy forward-looking, too.

Benchmarking

- If the CAPM had held, benchmarking would still have worked. Maybe noisier, but just fine.
- When the CAPM does not hold, benchmarking can still work. Alas, you need to have good benchmarks.