Asset Pricing Implications

Of Markowitz's Modern Portfolio Theory

Markowitz’s Key Insight

- The only risk important to investors is portfolio risk, because firm-specific risks can be completely eliminated through diversification.

- The developers of the Capital Asset Pricing Model (CAPM), Treynor, Sharpe, Lintner and Mossin, realized that, by extension, if all investors agree on the best portfolio then this fact has implications for the compensation we demand for holding risky assets (a.k.a. “Asset Pricing”).

How do we calculate expected return?

$E[\tilde{r}]$ = reward for time + reward for risk.

- What's the reward for time?

  r_f

- What's the reward for risk?

  $E[\tilde{r}] - r_f$ ☺

  risk premium

Finding the Price of Assets ≠ Asset Pricing

$$P = \sum_{t=1}^{\infty} \frac{E[\widetilde{CF}_t]}{(1 + E[\tilde{r}])^t}$$

Asset Pricing is only about explaining $E[\tilde{r}]$ and not even all of $E[\tilde{r}]$, but only the risk premium.

$$E[\tilde{r}] - r_f$$

The Capital Asset Pricing Model:
a.k.a CAPM

The Plan

- We've seen index models, theory-less statistical models of asset returns that are of the form:

$$r_{i,t} - r_{f,t} = \alpha_i + \sum_{k=1}^{K} \beta_{i,k}\left(r_{k,t} - r_{f,t}\right) + e_{i,t}$$

- Now we will build out the theory and focus on the intuition behind the economic forces making these models work.

- The main idea: Investors in a competitive market will only get compensation (on average) for risks that are impossible to avoid.

The Plan - CAPM

- We will start with the Capital Asset Pricing Model (CAPM), as single factor model:

$$E[\tilde{r}_i] - r_f = \beta_i \left(E[\tilde{r}_M] - r_f \right)$$

- We will build out the intuition why the market is the only factor.

- Later we will examine other multi-factor models, but the same basic intuition will apply to all factor models: we only get compensated for risks we cannot avoid.

Development of the CAPM

- Treynor, Sharpe & Lintner and Mossin
  - Together: Nobel Prize... Well, William Sharpe, anyway.

- The CAPM uses more assumptions and
  carries on to give predictions
  about the relationship between risk & expected return

Assumptions of the CAPM

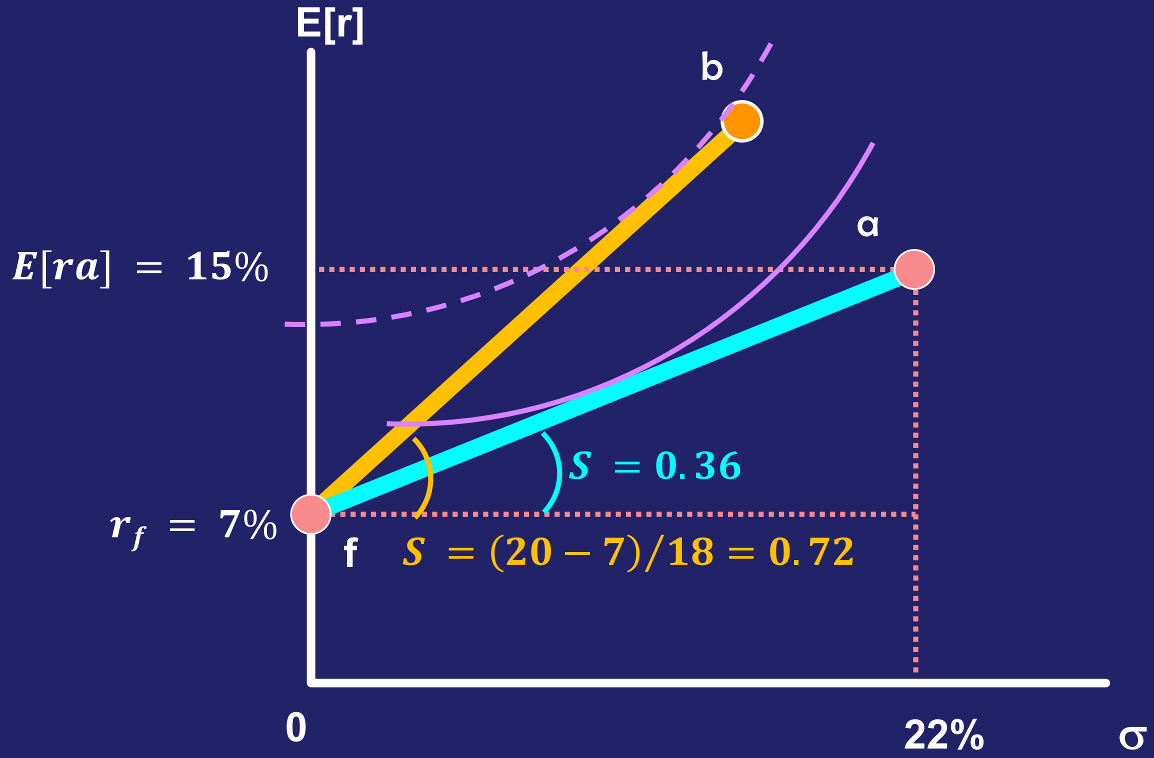
1. *Perfect competition*: Markets are large and investors are price takers
2. *All investors* plan for one identical holding period
3. *Complete markets*: <u>All</u> risky assets are publicly traded and *Unlimited borrowing and lending* at the risk-free rate (or unlimited shorting)
4. *Frictionless markets*: no taxes and no transactions costs
5. Investors are rational and follow the *mean-variance criterion*
   – *a bit over simplified, but I don't want to test you on the accurate version.*
6. *Homogenous expectations*: Everyone sees the same efficient frontier, because everyone holds the same beliefs about expected returns, variances and covariances

From Assumptions to CAPM

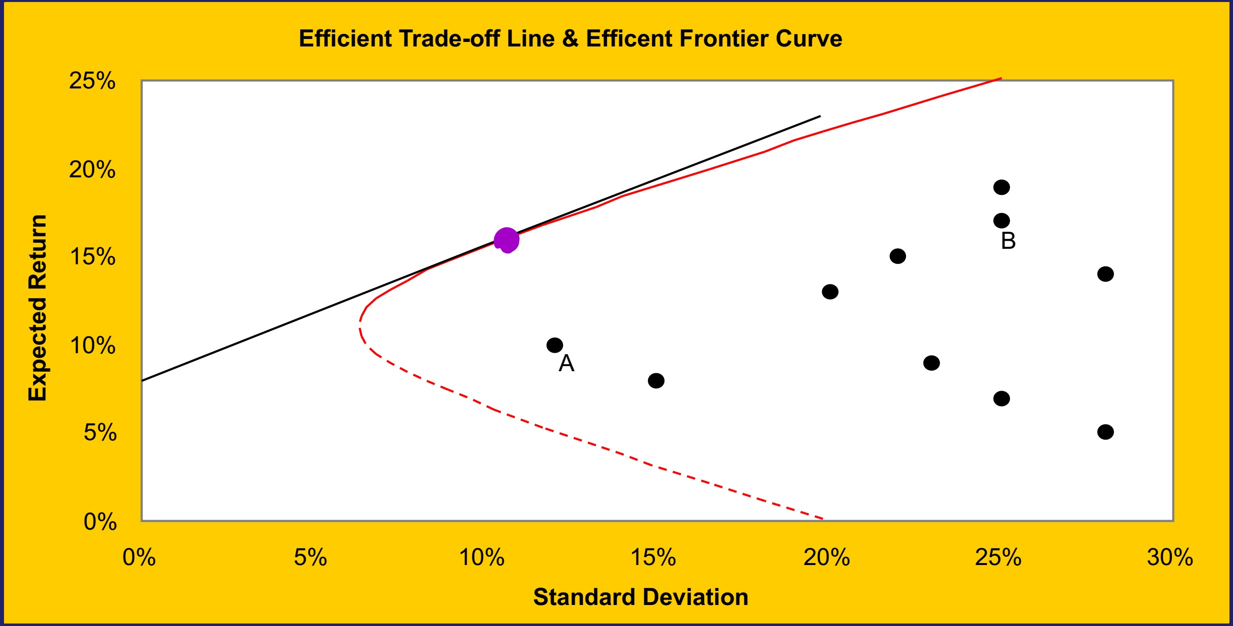
1. Raise the capital allocation line
   – Mean variance criterion
2. Maximum diversification
   – Frictionless markets
3. Investors choose the same optimal portfolio
   – Homogeneous expectations, perfect competition, complete markets, and unlimited borrowing and lending at the risk-free rate
4. Only systematic (market) risk is important
   – Only covariance risk matters
   – Only one price of risk

everyone is only exposed to portfolio risk
for that optimal portfolio

1. Raise the CAL – investors follow the Mean-Var Criterion

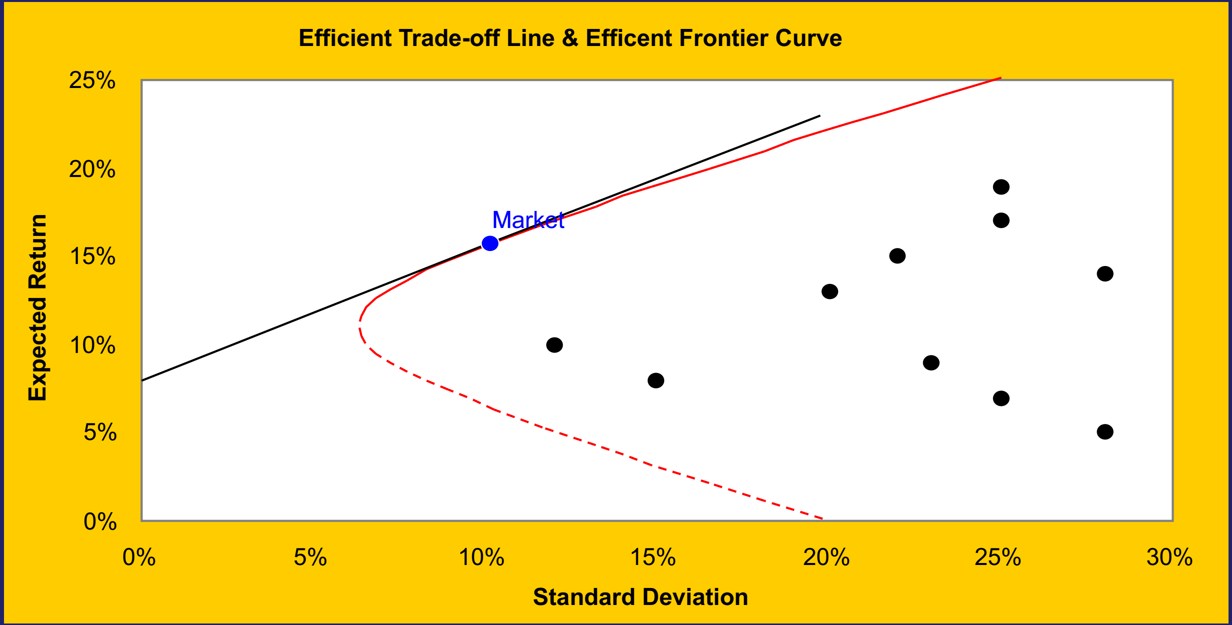


2. Maximum Diversification – due to Frictionless market



3. ALL Investors choose the same optimal portfolio

Due to: Homogeneous expectations, perfect competition, complete markets, and unlimited borrowing and lending at the risk-free rate



Why is this the market?

- ”The Market” is defined as every asset that generates return.

- If trading costs are low, why would you stop diversifying at 10 assets?

- Everyone would keep buying assets till
  - everything is bought up (i.e., the entire market) and
  - you get no more reduction in variance.

CAPM: the entire market

Question

- If everyone:
  - Prefers more return to risk
  - Knows of the same assets and is able to trade them
  - Has the same expectations about return, variance and covariance

- What if there were an asset that had
  - Higher expected return
  - Lower variance

- Would you prefer that asset to the well diversified optimal portfolio?
  - Of course, and so would everyone else.

What would happen to the price of that asset?

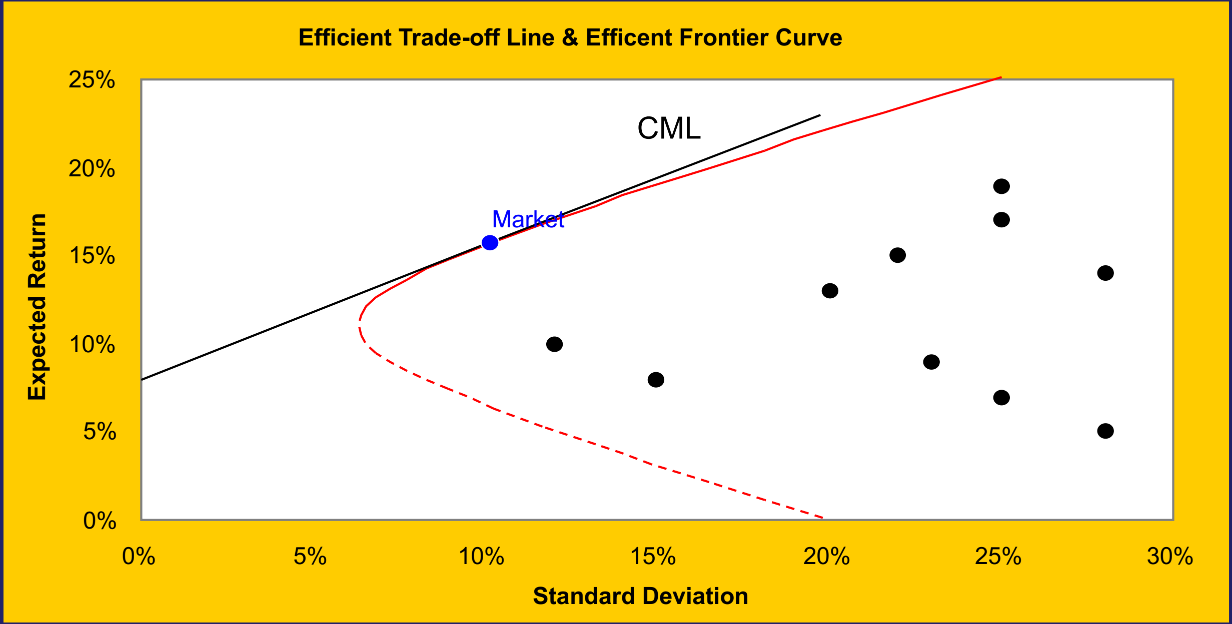
- Since everyone likes it, either
  - Everyone values it more and the price will be higher

- Implication: The optimal (market) portfolio will include all assets in proportion to their value.
  - Those assets that contribute more to lower risk and higher return will be worth more and be a larger fraction of the portfolio
  - Those assets that contribute less to lower risk and higher return will be worth less and a smaller fraction of the portfolio

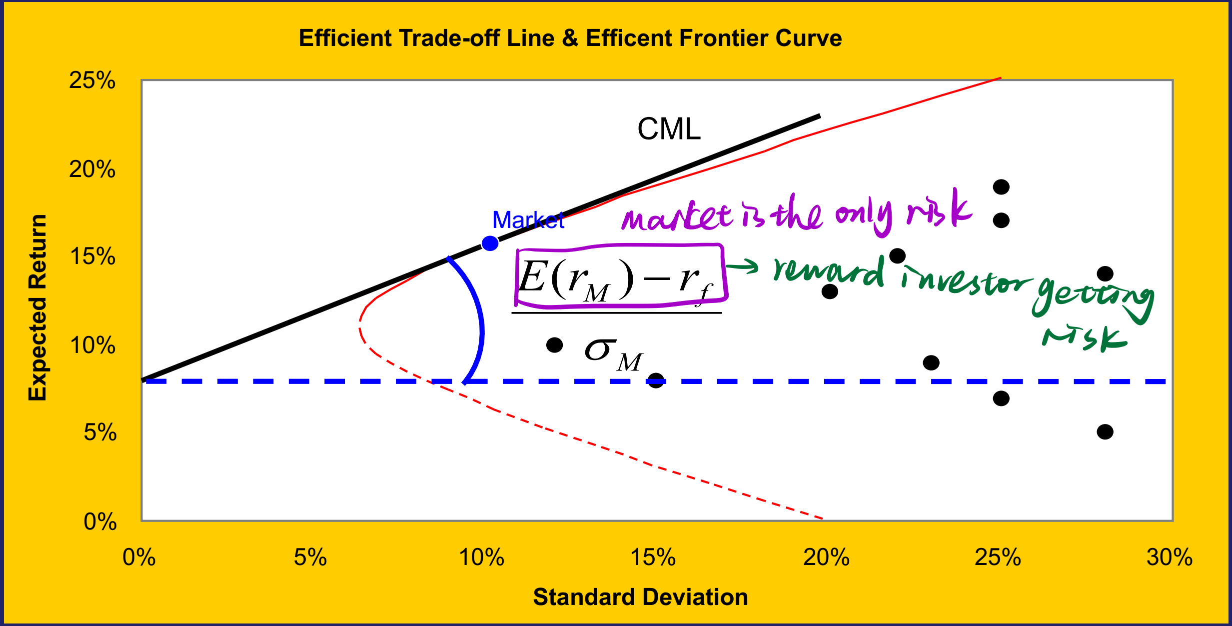
Capital Market Line (CML)

- Only one portfolio is best
  - The market portfolio
- Only one Capital Allocation Line (CAL) is best
  - The one through the market
  - Highest reward for risk (Sharpe Ratio)
- The best CAL is called the Capital Market Line (CML)

Capital Market Line (CML)



One Price of Market Risk



One Market Price of Risk:
but which risks are compensated?

If we are thinking about valuing a stock

- Do our expectations about a stock's dividends and other cash flows matter?

- Yes

- Does their standard deviation matter?

- No, contributes nothing to large portfolios

- To see this mathematically consider: (next slide)

Many Risky Assets

- For a portfolio of *N* risky securities, variance is:

$$\sigma_p^2 = \sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{\substack{j=1 \\ j \neq i}}^{N} w_i w_j \sigma_{i,j}$$

- The first term sums *N* variances;
- The second term captures *N*x(*N*-1) covariances.

- As *N* gets large, which of the two dominates?
  - The variances are “overwhelmed”….
  - *Nx(N-1)* gets much larger than *N*

Simulation: Contributors to Portfolio Variance

Avg. Std. Dev.	30%
Avg. Correlation	0.2

# of Assets	Portfolio Std. Dev.	Due to Variances	Due to Covariances
2	23.24%	83.33%	16.67%
3	20.49%	71.43%	28.57%
4	18.97%	62.50%	37.50%
100	13.68%	4.81%	95.19%
1000	13.44%	0.50%	99.50%
10000	13.42%	0.05%	99.95%

N↑ fraction↓ N↑ fraction↑

What Should We Care About?

- We should care about the variance of our portfolios.
  - This is the key insight of Markowtiz's (1952) Portfolio Theory

- If you are able to complete diversify away firm-specific risk,
- Then, you, as a rational investor will completely diversify away firm-specific risk.

- If for no other reason than, because no one will be willing to pay you for taking that risk….

Consider a modified game of roulette

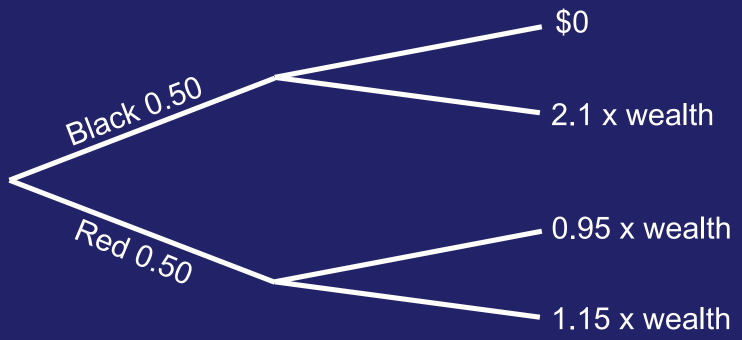
Modified Game of Roulette

- No Green: half the spaces are red and half back.

- Lands on Black:
  - 50% chance you lose everything
    - No money, no job, your family disowns you, your friends won’t help you, you lose your visa and citizenship and you get sent to Manus Island.
  - 50% chance your wealth is 110% higher.

- Lands on Red:
  - 50% chance your wealth is -5% lower
  - 50% chance your wealth is 15% higher

Modified Roulette - Payouts



What is your $E[\tilde{r}]$, conditional on

- Black

$$E[\tilde{r}|black] = 0.5(-100\%) + 0.5(110\%) = 5\%$$

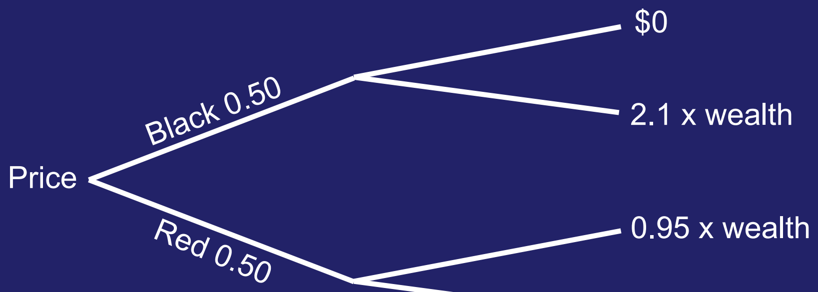
- Red

$$E[\tilde{r}|red] = 0.5(-5\%) + 0.5(15\%) = 5\%$$

- Expected return to the gamble?

$$E[\tilde{r}] = 0.5(5\%) + 0.5(5\%) = 5\%$$

Modified Roulette - Payouts



- What price would you pay?

How many would pay for this gamble?

- Lands on Black:
  - 50% chance you lose everything
    - No money, no job, your family disowns you, etc.
  - 50% chance your wealth is 110% higher.
- Lands on Red:
  - 50% chance your wealth is -5% lower
  - 50% chance your wealth is 15% higher
- What if the gamble were free?
- What if I paid you 5% of your wealth to take the gamble?

Let's change the gamble?

- ONLY IF YOU WANT:
- ~~Lands on Black:~~ Every space is red.
  - ~~50% chance you lose everything~~
    - ~~No money, no job, your family disowns you, etc.~~
  - ~~50% chance your wealth is 110% higher.~~

- Lands on Red:
  - 50% chance your wealth is -5% lower
  - 50% chance your wealth is 15% higher

- What if the gamble were free?
- What if I paid you 5% of your wealth to take the gamble?

Are we compensated for diversifiable risk?

- Diversifiable risk is like the possibility of landing on the black spaces
- You may choose to be exposed to that risk, BUT there is an easy way to get rid of that risk.
- Are we compensated for diversifiable risk?

But can’t I make a lot of money betting on firm-specific risk?

- YES!
  - But let’s be clear, it is not compensation for risk. It is luck.

- Compensation for risk is a return you receive in EXPECTATION
  - A return that you receive on average over time.

- The return to firm specific risk on average and in expectation is…

ZERO!

CAPM: Only Covariance Risk is Important

The CAPM Equation: The Security Market Line

Measuring Systematic Risk

- Could use: $Cov(\tilde{r}_{stock} - r_f, \tilde{r}_{market} - r_f)$
  BUT:
  - the units are difficult to interpret with cov().

- We need a measure of a stock's systematic risk ***only***.

- This is beta (β), which is unitless:

$= \beta_i = \frac{Cov(\tilde{r}_i, \tilde{r}_M)}{var(\tilde{r}_M)}$

if rf is constant

$$\beta_i = \frac{Cov(\tilde{r}_i - r_f, \tilde{r}_M - r_f)}{var(\tilde{r}_M - r_f)}$$

Risk of the asset

Risk of the market

beta: how much riskier than the market our asset is

Reward for Risk: The CAPM Security Market Line (important!)

$$E[\tilde{r}_i] - r_f = \beta_i\left(E[\tilde{r}_M] - r_f\right)$$

- Or

$$E[\tilde{r}_i] = r_f + \beta_i\left(E[\tilde{r}_M] - r_f\right)$$

No a, everyone have the same price, no disagreement and no misprice

CAPM: more accurately

$$E[\tilde{r}_i] - r_f = \beta_{i,W}\left(E[\tilde{r}_W] - r_f\right)$$

Previously we called this "the market", but "portfolio of wealth" is really what we mean when we say "the market" with CAPM

- $\tilde{r}_W$ is the return to current wealth – NOT just the market. Includes:
  - Labor income
  - Real estate
  - Any private property
  - All public property (parks, lakes, roads, bridges)

- One period model (ignores time)

CAPM – modelling a wealth portfolio

- In theory we should combine all assets in one portfolio, but
- As a practical matter, one may use a stock market index and then add other measures to more completely reflect changes in wealth, particularly for non-traded assets, such as:
  - Aggregate labor income growth
  - Returns to real estate

Properties of the CAPM

- In equilibrium, every asset must fall onto the SML
  - An asset's expected risk premium is a function of
  - the *market risk premium*,
  - the *market variance* and
  - the asset's *covariance with the market*

$$E[\tilde{r}_i] - r_f = \beta_i \left(E[\tilde{r}_M] - r_f \right)$$

① $$\frac{E[\tilde{r}_i] - r_f}{cov(\tilde{r}_i - r_f, \tilde{r}_m - r_f)} = \frac{E[\tilde{r}_m] - r_f}{var(\tilde{r}_m - r_f)}$$

$$\underline{E[\tilde{r}_i] - r_f} = Cov(\tilde{r}_i - r_f, \tilde{r}_M - r_f) \frac{\left(E[\tilde{r}_M] - r_f \right)}{Var(\tilde{r}_M - r_f)}$$

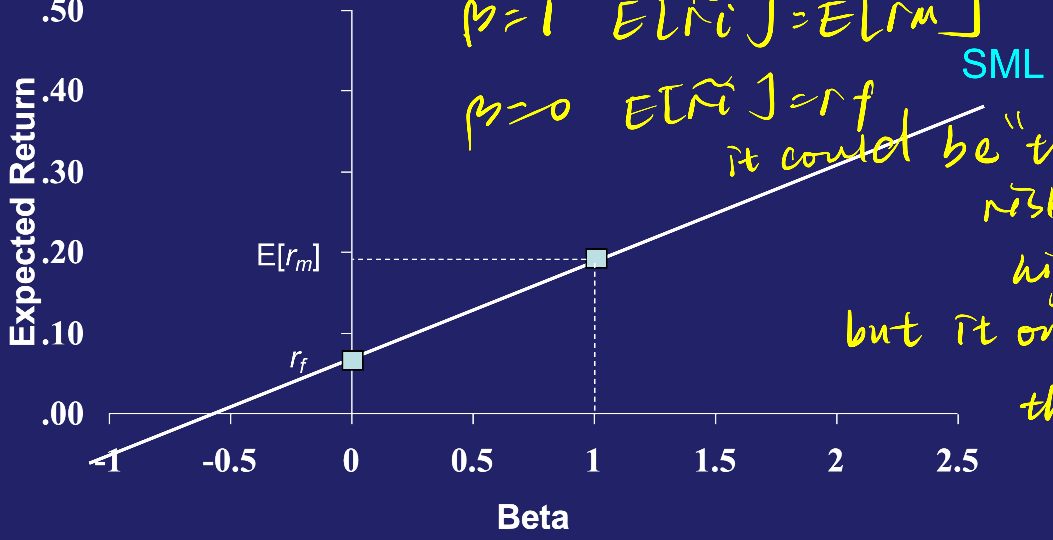
Market Price of Risk

CAPM Reward and Risk: Security Market Line

$$E[\tilde{r}_i] = r_f + \beta_i\left(E[\tilde{r}_M] - r_f\right)$$

$\beta = 1 \quad E[\tilde{r}_i] = E[\tilde{r}_m]$

$\beta = 0 \quad E[\tilde{r}_i] = r_f$



it could be "the total risk is quite high, but it only earns the risk-free risk"

What's the slope of the SML?

$$Slope = T_p = \frac{E[r_p] - r_f}{\beta_p}$$

reward for systematic risk

T= Treynor measure

CAL vs. CML vs. SML vs. Security Characteristic Line

- The Capital Market Line (CML) is the best Capital Allocation Line (CAL) possible that is formed with the best tangent portfolio, i.e. the market portfolio.
  - The CML shows the relation between total risk and expected return

- The Security Market Line (SML) is the CAPM equation
  - The SML shows the relation between covariance (beta) risk and expected return.

is about realization, not expectation

- The Security Characteristic Line is the result of an estimation of the relation between the realized stock risk premium and the market risk premium

Decomposing total realized (historic) risk

- As with index models, total risk can be broken into:
  - systematic risk and
  - unsystematic risk

$$\underbrace{\sigma_{r_i}^2 = \beta_{i,M}^2 \sigma_{r_M}^2}_{\text{Systematic Undiversifiable Market Risk}} + \sigma_{e_i}^2 \left\{ \begin{array}{l} \text{Unsystematic} \\ \text{Firm specific} \\ \text{Idiosyncratic} \\ \text{Diversifiable} \end{array} \right.$$

- Treynor, Sharpe, Lintner and Mossin's insight was that only covariance with the market is important and enters the CAPM
  - Because we can eliminate firm-specific risk with diversification, no matter how risky, ***unsystematic risk*** is NOT rewarded by increased return!

Examples with CAPM

Market Beta

What's the market's beta??

$$\beta_i = \frac{Cov(\tilde{r}_i - r_f, \tilde{r}_M - r_f)}{var(\tilde{r}_M - r_f)}$$

Replace *i* with *M*:

$$\beta_M = \frac{Cov(\tilde{r}_M - r_f, \tilde{r}_M - r_f)}{var(\tilde{r}_M - r_f)}$$

$$\beta_M = \frac{var(\tilde{r}_M - r_f)}{var(\tilde{r}_M - r_f)}$$

$$\beta_M = 1$$

Beta of the risk free

What's the risk free asset's beta??

$$\beta_i = \frac{Cov(\tilde{r}_i - r_f, \tilde{r}_M - r_f)}{var(\tilde{r}_M - r_f)}$$

Replace *i* with r_f:

anything with $\beta = 0$
has expected return $= r_f$

$$\beta_f = \frac{Cov(r_f - r_f, \tilde{r}_M - r_f)}{var(\tilde{r}_M - r_f)}$$

$$\beta_f = \frac{Cov(0, \tilde{r}_M - r_f)}{var(\tilde{r}_M - r_f)}$$

$$\beta_f = 0$$

Example 1

- What's the Expect Return on an Asset if its β_A= 1.25, the expected return on the market is 9% and r_f=5%?

5% + 1.25 × 4%

$$E[\tilde{r}_i] = r_f + \beta_i\left(E[\tilde{r}_M] - r_f\right)$$

$$E[\tilde{r}_A] = .05 + 1.25(.09 - .05)$$

$$E[\tilde{r}_A] = .10$$

Combining Beta

- Every asset (or group of assets) will be assessed by people according to its ***beta***.

$$\beta_i = \frac{Cov(\tilde{r}_i - r_f, \tilde{r}_M - r_f)}{var(\tilde{r}_M - r_f)}$$

- Beta is quite handy-- it combines like $E[\tilde{r}]$ does. Suppose we have a portfolio of assets *A* and *B* and put w_A% of our money in *A*:

$$E[\tilde{r}_{portfolio}] = w_A E[\tilde{r}_A] + w_B E[\tilde{r}_B]$$

$$\beta_{portfolio} = w_A \beta_A + w_B \beta_B$$

Example 2

Market Risk Premium = 10%, r_f=10%

β_A= 0.6 β_B= 1.2

$E[\tilde{r}_A]$ = ? $E[\tilde{r}_B]$ = ? 10% + 1.2 × 10% = 22%.

10% + 0.6 × 10% = 16%

What's the beta of a portfolio

2/3 A and

1/3 B?

Example 2 Continued:

$$\beta_{portfolio} = w_A \beta_A + w_B \beta_B$$

$$\beta_{portfolio} = \frac{2}{3} 0.6 + \frac{1}{3} 1.2$$

$$\beta_{portfolio} = .4 + .4$$

$$\beta_{portfolio} = .8$$

What is Stock A's Beta if

- $E[\tilde{r}_M] = 12\%$ r_f=4% and E[r_A]=10% ?

$$E[\tilde{r}_i] - r_f = \beta_i\left(E[\tilde{r}_M] - r_f\right)$$

$$.10 - .04 = \beta_A(.12 - .04)$$

$$.06 = \beta_A(.08)$$

$$\beta_A = \frac{.06}{.08} = 0.75$$

Your turn 1

- What's the beta of a portfolio (p) with:

$$E[\tilde{r}_p] = 30\%$$

$$r_f = 5\%$$

$$E[\tilde{r}_M] = 10\%$$

25% = β · 5%.

β = 5

Your turn 1 answer

- What's the beta of a portfolio (p) with:

$E[\tilde{r}_p] = 30\%$ $\quad r_f = 5\%$ $\quad E[\tilde{r}_M] = 10\%$

$$E[\tilde{r}_p] - r_f = \beta_p\left(E[\tilde{r}_M] - r_f\right)$$

$$.3 - .05 = \beta_p(.10 - .05)$$

$$\beta_p = 5$$

Your turn 2

- What's the tight expected return of a stock with a beta of zero if

  $r_f = 7\%$, and $E[\tilde{r}_M] = 13\%$?

$\beta = 0$

$E[\tilde{r}_z] = r_f = 7\%$

What's the variance of this stock with $\beta = 0$?

Applications of and Estimating the CAPM

Applications of CAPM

- CAPM $E[\tilde{r}]$ is the cost of capital
  - Equivalently it is the hurdle rate.

?

- CAPM $E[\tilde{r}]$, more to the point α, can be used in performance evaluation.

$$r_{i,t} - r_{f,t} = \alpha_i + \beta_i\left(r_{M,t} - r_f\right) + \varepsilon_{i,t}$$

- In principle CAPM $E[\tilde{r}]$ can also be used for return forecasting for asset allocation. But there are at least two problems:
  1. If you believe the CAPM, then there is no point. Invest in the market.
  2. CAPM $E[\tilde{r}]$ doesn't do a good job forecasting future returns.
     - CAPM is just a 1-period model and betas and market risk premia might be time varying.
     - Or maybe CAPM isn't a very good model.

Application Question

Suppose 2 firms have the same expected cash flows, which has the higher price?

$E[\widetilde{CF}] \neq E[\tilde{r}]$

- The high beta stock?

Or

- The low beta stock?

Answer:

$$P = \sum_{t=1}^{\infty} \frac{E[\widetilde{CF}_t]}{(1 + E[\tilde{r}])^t}$$

$$= r_f + \beta_i(E[\tilde{r}_M] - r_f)$$

low price stock are those with high expected return

$$\beta \uparrow \Longrightarrow E[\tilde{r}] \uparrow \Longrightarrow P \downarrow$$

$$\beta \downarrow \Rightarrow E[\tilde{r}] \downarrow \Rightarrow P \uparrow$$

How Do We Estimate CAPM?

The Market Model or Index Model

- Just like with index model, CAPM betas are measured statistically using historical returns on the security and the market portfolio proxy, e.g. ASX200

- Run an OLS regression of the *Market Model (a.k.a. index model), typically we allow the possibility of an alpha:*

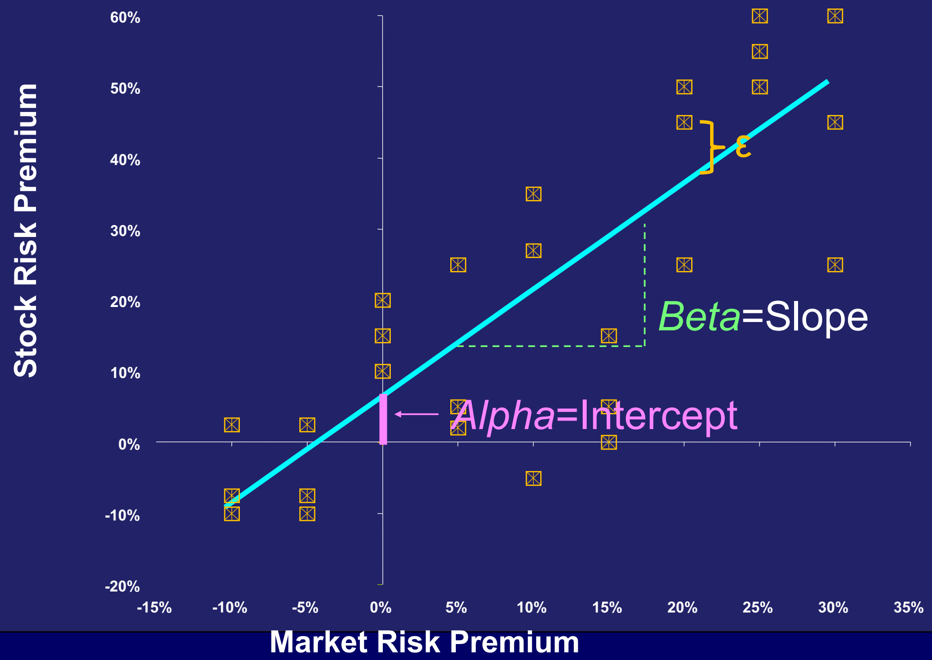
$$r_{i,t} - r_{f,t} = \alpha_i + \beta_i\left(r_{M,t} - r_f\right) + \varepsilon_{i,t}$$

- Apply this to a particular stock, and you get a *Security Characteristic Line* (we saw this during the last lecture)

Security Characteristic Line (SCL)

Equation of the Security Characteristic Line:

$$E\left[\tilde{r}_i - \tilde{r}_f \mid r_M - r_f\right] = \hat{\alpha}_i + \hat{\beta}_i\left(r_M - r_f\right)$$



What if you have no data to estimate β?

- Comparables:
  - Find a similar company that is traded on the stock exchange and use its beta
  - Use the average beta from the industry of the firm
  - Use firm characteristics:
    - Industry
    - Size (Market Capitalization)
    - Financial Leverage
    - Operating leverage
    - Growth/value

CAPM in Practice

Based on Darden's Case Note: "Applying the Capital Asset Pricing Model"

And

2020AFP Current Trends in Estimating and Applying the Cost of Capital

Who uses CAPM?

- Financial Planners
  - Use CAPM to calculate the expected return, $E[\tilde{r}]$, for the purposes of strategic allocation → asset allocation
    - A strategic allocation is the target allocation of investments across stock or classes of risk. Because it is the target allocation and returns are not usually what was expected, periodically the portfolio must be rebalanced to return to the original strategic allocation.

eg. originally 9:1 bond : stock
due to covid 10:0 rebalance

- CFOs use CAPM to calculate the cost of capital, k ($k = E[\tilde{r}]$), for projects the CFO's firm is considering.

How many use CAPM? (AFP's 2020 survey)

- 90% of financial professions use the CAPM calculate *k* or $E[\tilde{r}]$!

- There are several parts of CAPM that need to be estimated or calculated:

$$E[\tilde{r}_i] = r_f + \beta_i\left(E[\tilde{r}_M] - r_f\right)$$

- What is:
  - The risk-free rate
  - Beta
  - Market Risk Premium?

CAPM in practice: which risk free rate?

- The most risk free are very short-term rates.
  - Theoretically, 90-day treasury notes or other similar short-term rate is good.

    lowest risk
  - 16% in the survey use 90-day rates

10 year investment → 10 year risk free rate

- But since most investment are for longer than 90 days, and the risk-free rate is a compensation for time:
  - Most (46%) use 10-year treasury rates, or similar.
  - The remaining use 5- and 30-year treasury rates.
- 47% use current risk-free rates.
- 35% use historic averages. 16% use forecasts of rates.

Which Beta?

- There are several choices when calculating beta:
  - What frequency? Daily, weekly, monthly?
  - How long a time period?

- 27% use 5 years of monthly data
- 23% use 1 year of monthly data (?!?!)
- <23% use 3 years of monthly data or 5 years of weekly

- 57% use adjusted betas.

- 59% get Beta from Bloomberg and 10% from Ibbotson

What's the market risk premium? ($E[r_m]-r_f$)?

- 49% use 5 to 6%
- 23% use 3 to 4%
- 17% use 7% or more
- Slightly more than 10% use <3%

the project will have a high value

- So what does all this mean?
  - 55% believe that their cost of capital estimates are off by more than 0.5% (50 basis points).

CAPM vs. Reality

CAPM vs. Reality: $E[\tilde{r}_p] - r_f = \beta_p(E[\tilde{r}_M] - r_f)$

- CAPM is hard to test (Roll's Critique)
  - The market is absolutely everything we can derive benefit from – that's very hard to measure. (Market= Stocks, Bonds, Human Capital, Parks…)
  - Any mean-variance efficient portfolio (even if not the market) will satisfy the CAPM equation. Because, after the fact with historic data, we can always find a mean variance efficient portfolio, we can always find a portfolio for which the CAPM will work.

- CAPM Beta does not have a strong association with future returns. (Fama and French, 1992)

- Other factors appear to help explain returns (Fama and French, 1993, 1996, and hundreds of other authors).

SML: Linear Relation b/twn Beta and Reward for Market Risk

$$E[\tilde{r}_p] - r_f = \beta_p \left(E[\tilde{r}_M] - r_f \right)$$

- A high beta should predict high returns (on average)
- A low beta should predict low returns (on average)

- Fama and French (1993):

	All	Low-β	β-2	β-3	β-4	β-5	β-6	β-7	β-8	β-9	High-β
Panel A: Average Monthly Returns (in Percent)											
All	1.25	1.34	1.29	1.36	1.31	1.33	1.28	1.24	1.21	1.25	1.14

- Not good for CAPM

Only beta should matter? (from Fama-French, 1993)

- Run CAPM regressions using 342 months of data for 25 size and book-to-market portfolios

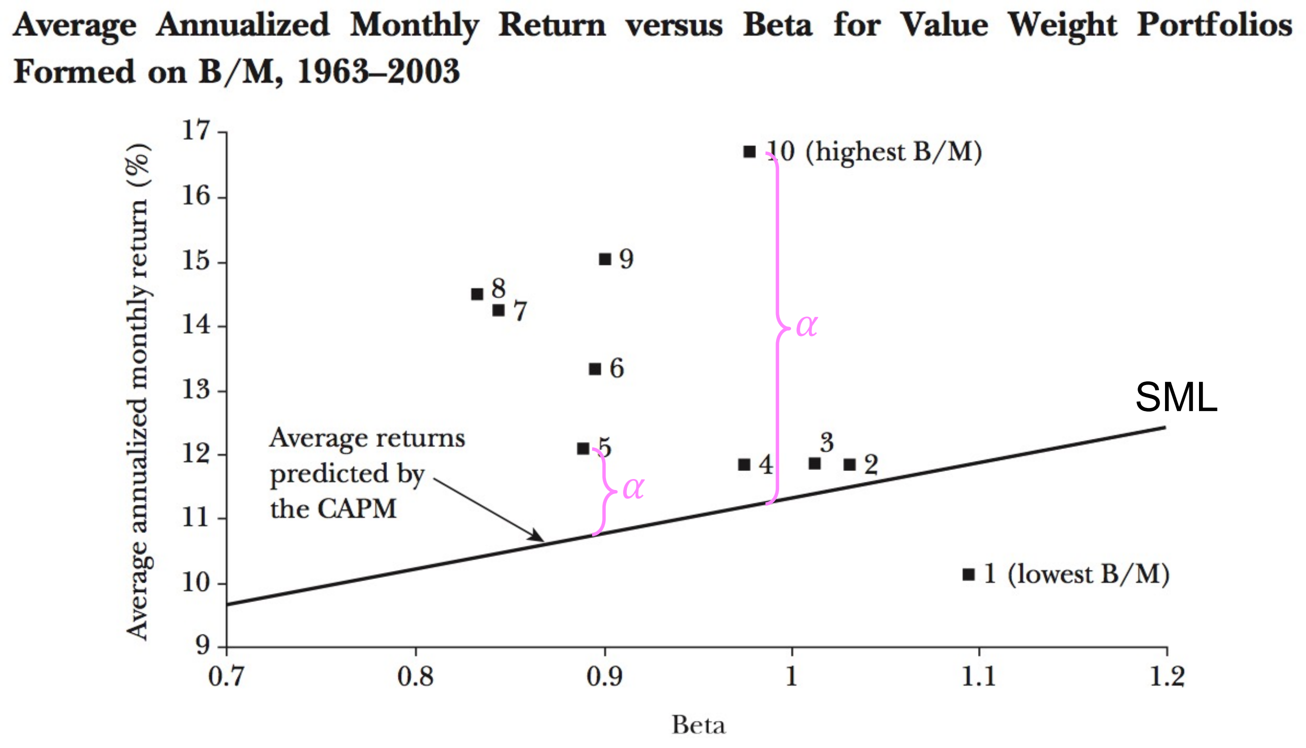
$$E[\tilde{r}_p] - r_f = \alpha_p + \beta_p\left(E[\tilde{r}_M] - r_f\right)$$

Intercepts from excess stock return regressions for 25 stock portfolios formed on size and book-to-market equity: July 1963 to December 1991, 342 months.[a]

Book-to-market equity (BE/ME) quintiles

Size quintile	α: Low	α: 2	α: 3	α: 4	α: High	t-stat: Low	t-stat: 2	t-stat: 3	t-stat: 4	t-stat: High
			(ii) $R(t) - RF(t) = a + b[RM(t) - RF(t)] + e(t)$							
Small	−0.22	0.15	0.30	0.42	0.54	−0.90	0.73	1.54	2.19	2.53
2	−0.18	0.17	0.36	0.39	0.53	−1.00	1.05	2.35	2.79	3.01
3	−0.16	0.15	0.23	0.39	0.50	−1.12	1.25	1.82	3.20	3.19
4	−0.05	−0.14	0.12	0.35	0.57	−0.50	−1.50	1.20	2.91	3.71
Big	−0.04	−0.07	−0.07	0.20	0.21	−0.49	−0.95	−0.70	1.89	1.41

Graphically: Does only beta matter? (from Fama-French, 1993)



What else does alpha tell us?

- Alpha tells us the return we get that is unrelated to measured risks.

$$E[\tilde{r}_p] - r_f = \alpha_p + \beta_p\left(E[\tilde{r}_M] - r_f\right)$$

Alpha could be telling us:

- The model doesn't work or
- There are missing factors
- Markets are not efficient (Prices are not correct)
  – If a managed fund manager can successfully pick good stocks, what kind of alpha should she earn?

Possible Explanations for failure of CAPM

1. Wrong measure of the "Market"
   - In CAPM "market" risk is the risk that your <u>wealth</u> with change.
     - Is all of your wealth from the stock market?
     - This is known as "Roll's Critique" after Richard Roll, who pointed this problem out.

2. Time variation in Betas and Risk – CAPM is one-period model.

3. SML is a *predictive* relationship.

$$E[\tilde{r}_p] - r_f = \beta_p\left(E[\tilde{r}_M] - r_f\right)$$

It does not say how things *will* turn out, only the <u>mean</u> of the possible outcomes.

noise !

The cutting edge: Possible Explanations for failure of CAPM

firm-specific risk

4. High non-market-related volatility makes the SML hard to see.
   – CAPM works on macroeconomic news days (Savor and Wilson, 2017)
     • 60% of annual stock returns occur on macroeconomic news days (Savor and Wilson, 2013)
     • Particularly central bank rate-change announcement days (Cieslak, Morse, Vissing-Jorgensen, 2019)
   – CAPM is priced for jumps in prices, but not continuous prices (Bollerslev, Li, and Todorov, 2016)
     • Continuous price changes are easier to hedge

bet aginst beta : long on low beta and short on high beta.

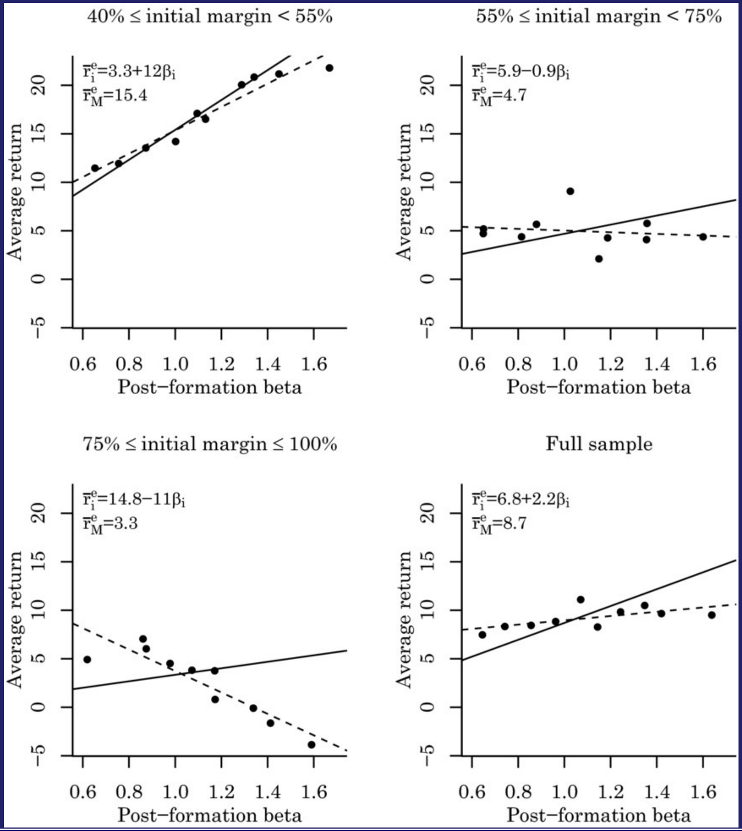
5. Frictions: Inability to borrow at the risk-free rate
   – investors who desire high expected return to shift to high beta stocks, boosting their price and lowering return (Black, 1972; Frazzini and Pederson, 2014; Jylha, 2018)

Ability to buy on margin affects the CAPM SML

easy to buy on margin →

hard to buy on margin →

shift to ↑ stock → bid up price → lower return



Source: Jylha (2018)

Prelude to multi-factor models

- If only Beta matters then no other risks should matter
  – Are changes in the market portfolio really the only threat to our wealth?

- Other possible sources of risk
  – Labor income
  – Inflation
  – Energy Price Risk
  – Reinvestment risk (changes in long and short term interest rates)
  – Liquidity Risk