Corporate Finance

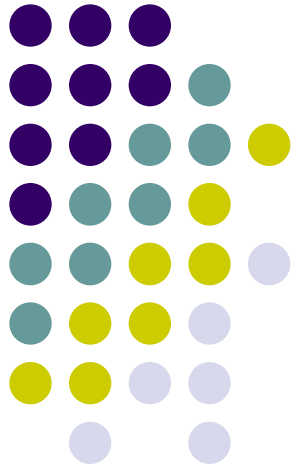
Lecture 7: CAPM

Risk and Return

Yuan Shi ©

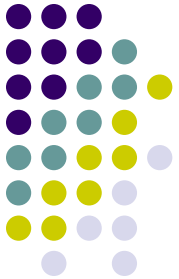
HSBC Business School

Peking University



PHBS 北京大学汇丰商学院

Housekeeping



- Presentation on Jan 9
- Midterm exam result is available

Where we are

NPV is the right **capital budgeting** technique

- Tells us if a particular project is a good investment
- But you must make sure you are using it correctly by **identifying the right cash flows** and using the **correct discount rate**

Cost of capital

Start from Now!

$$WACC = \frac{E}{V}\,\boldsymbol{E}(\boldsymbol{R_E}) + \frac{D}{V}\,\boldsymbol{E}(\boldsymbol{R_D})(1-\tau)$$

Estimation of E(R)

- We can infer investors' required return from the market prices of financial securities
  - Bond: YTM inferred from bond price
  - Stock: $r = \frac{D_1}{P} + g$ (under Dividend Discount Model)
- However, market price might be affected by noises
  - Uninformed trades for liquidity reason, institutional frictions, behavioral biases, etc.
  - Share price might not reflect the "fair" cost of capital
- So we need a bit more **theory** for E(R)

Estimation of E(R)

Recall

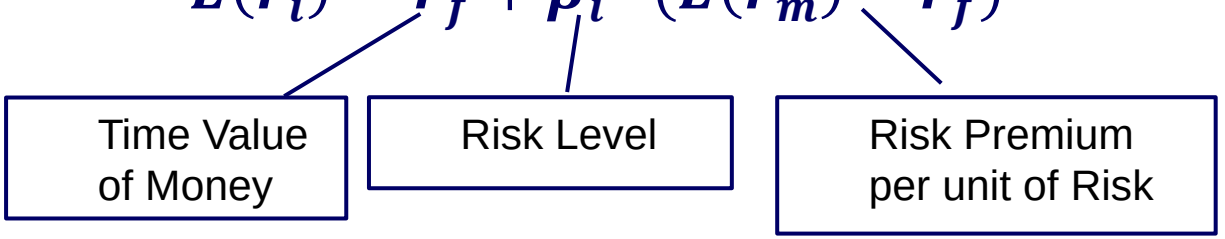
Required rate of return	=	Compensation for the time value of money	+	Compensation for risk

- Compensation for time value of money: risk-free rate
  - Short maturity government bond, such as a 90-day treasury bill
- Compensation for risk: **risk premium**
  - For bond: risk premium is called *credit spread*
  - How to measure *risk* and *risk premium* for stocks?

CAPM

- Capital Asset Pricing Model
- The risk premium is equal to the multiplication of
  - the level of risk $\boldsymbol{\beta_i}$
  - the required return that is charged by the investor for each level of risk $(\boldsymbol{E(r_m) - r_f})$

$$\boldsymbol{E(r_i) = r_f + \beta_i \cdot (E(r_m) - r_f)}$$



Outline

- Diversification and Portfolio Theory (Markowitz)
- Investors' preference and holding decision (Sharpe)
- Market equilibrium (Capital Market Line)
- Only systemic risk should be priced → CAPM

How to measure risk?

- Single Stock A: *standard deviation* of the *return* $\sigma(r_A)$;
- Portfolio (a collection of assets):
  - The portfolio return is a weighted average of the returns of each individual assets

$$r_P = (\frac{W_A}{W})r_A + (\frac{W_B}{W})r_B$$

  - However, interestingly,

$$s(r_p) < \left(\frac{W_A}{W}\right) s(r_A) + \left(\frac{W_B}{W}\right) s(r_B)$$

  - Why?

Diversification

Principal of Diversification

- Recall the Variance formula
- $Var(aX + bY) = a^2Var(X) + b^2Var(Y) + 2abCov(X, Y)$
- The returns of individual assets in a portfolio do not always move in the same direction, they *cancel each other* and *reduce variability* of the portfolio.

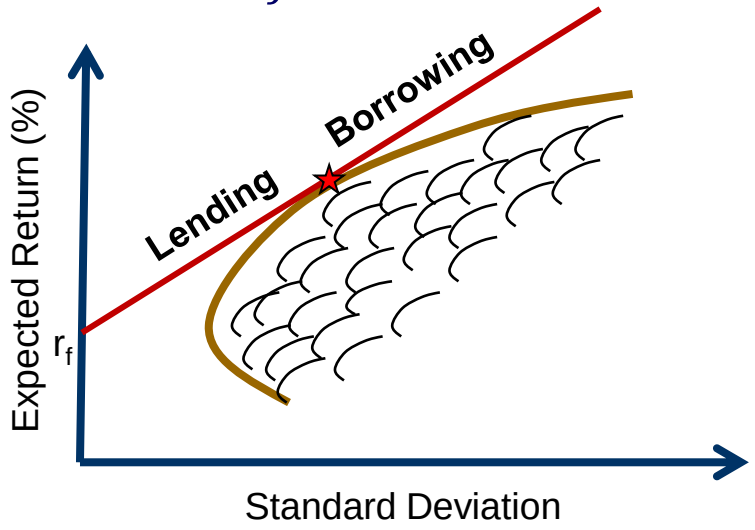
$$s^2(r_p) = s^2(ar_A + br_B) = a^2s^2(r_A) + b^2s^2(r_B) + 2abr_{AB}s(r_A)s(r_B)$$

where $a = \frac{W_A}{W}, b = \frac{W_B}{W}$

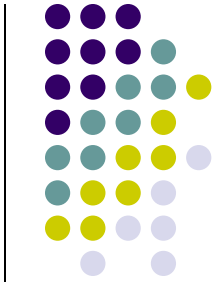
Capital Market Line

Any point on this line gives the same *Sharpe Ratio*, which is the highest possible Sharpe Ratio one can achieve in this capital market. (Thus we call it the *Capital Market Line*)

- In terms of risky assets, only invest into the **tangent portfolio**
- Vary the preferred level of risk by investing x% into *tangent portfolio* and the rest in *risk free asset*.



Risk and Diversification

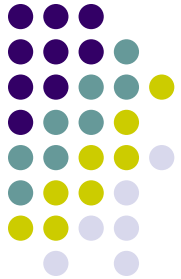


- Risk can be classified into two groups: diversifiable (unsystematic) and non-diversifiable (systematic).
- Diversifiable risk: risks that can be mitigated through investing in other financial assets/companies/countries, etc.
- Diversifiable risk is not compensated.
- Why? Imagine company A is selling its stocks. Company A has operational risk that its business might be stolen by company B.
  - Investor 1 says they're requesting a higher return to compensate for this risk.
  - Investor 2 says since I also own company B, I don't care about company A's operational risk.
  - Investor 2 will win the investment opportunity. Investor 1 will exit the market by not optimally holding the diversifying portfolio

Risk and Diversification

- "*Undiversifiable*" or "*systematic*" risk: risk that cannot be eliminated through diversification.
- What risk cannot be diversified away? "*market*" *risk*
  - As an example, consider the risk associated with an economic recession.
  - In an economic recession, almost all stocks will experience an unexpected negative return.
  - Since almost all stocks will respond in the same way, these returns cannot cancel each other out even in a large portfolio.
  - Investors are compensated for bearing systematic risk through risk premium

Note: discount rate = required return



Here in CAPM, we show that securities with undesirable features (high market risk) have a higher return

The return is requested for compensating for the undesirable features

Securities with desirable features have a lower return

Measuring the undiversifiable risk: beta

- A measure of firm's **systematic risk**: its sensitivity to market portfolio returns
- Beta essentially is the regression coefficient of the assets' return on the market return

$$\beta_i = \frac{Cov(r_i, r_m)}{\sigma_m^2}$$

Covariance with the market

Variance of the market

- β can be positive, negative, larger than 1…

Beta

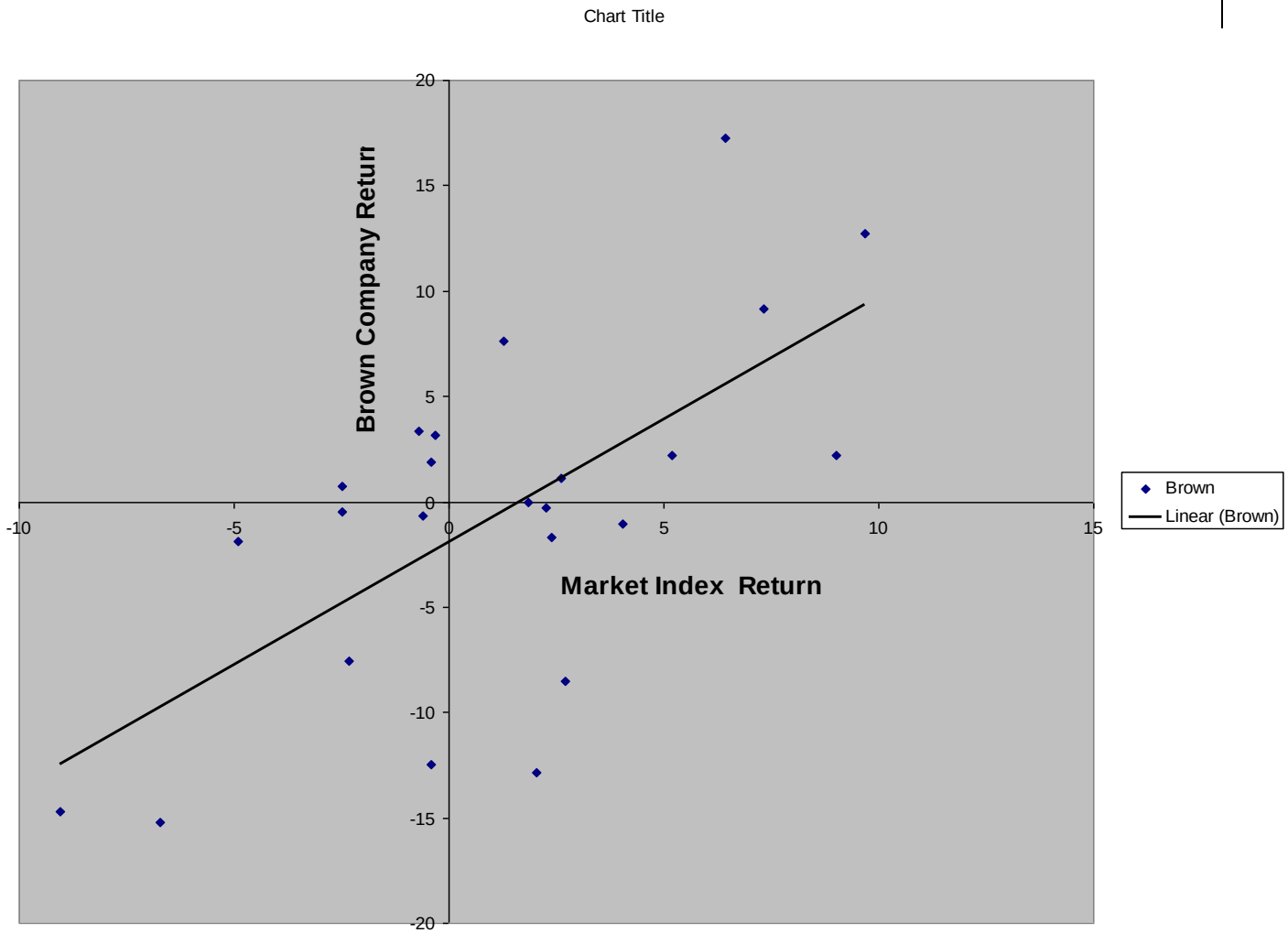


Chart Title
Brown Company Return
Market Index Return
20
15
10
5
0
-5
-10
-15
-20
-10
-5
0
5
10
15
Brown
Linear (Brown)

Beta is the regression coefficient of

- The Beta coefficient for Brown Company stock is the *slope* of the "best-fit line".
- The best-fit line has a slope of 1.16, implying that if the *Market Index return* changes by 1%, Brown Company return changes on average by 1.16%.
- Brown is 16% more risky than the *market index*.
- The Beta of Brown is 1.16.

CAPM

- By *systematic risk principal*, an asset's risk premium is the compensation for systematic risk.
- Suppose stock i's risk premium is $k \cdot \beta_i$.
- Consider the market portfolio (beta equals 1):

$$E(r_m) - r_f = k \cdot 1$$

- Therefore, the risk premium for stock i is:

$$E(r_i) - r_f = k \cdot \beta_i = (E(r_m) - r_f) \cdot \beta_i$$

CAPM

- This gives us the CAPM:

$$\boldsymbol{E(r_i) = r_f + \beta_i \cdot (E(r_m) - r_f)}$$

- Required return = compensation for time value of money + compensation for baring systematic risk
- Time value of money is compensated by the risk-free rate.
- β_i reflects asset i's quantity of systematic risk, i.e., the sensitivity of return to market return.
- $E(r_m) - r_f$ is also called *Market risk premium*: the required return for bearing one unit of market risk

Example

What is the expected return on the stock according to CAPM?

- Expected returns on the market portfolio is 10%
- Risk-free rate is 5%
- The annualized standard deviation of the market portfolio is 20% and that of a stock is 60%
- The correlation of stock and market returns is 0.4

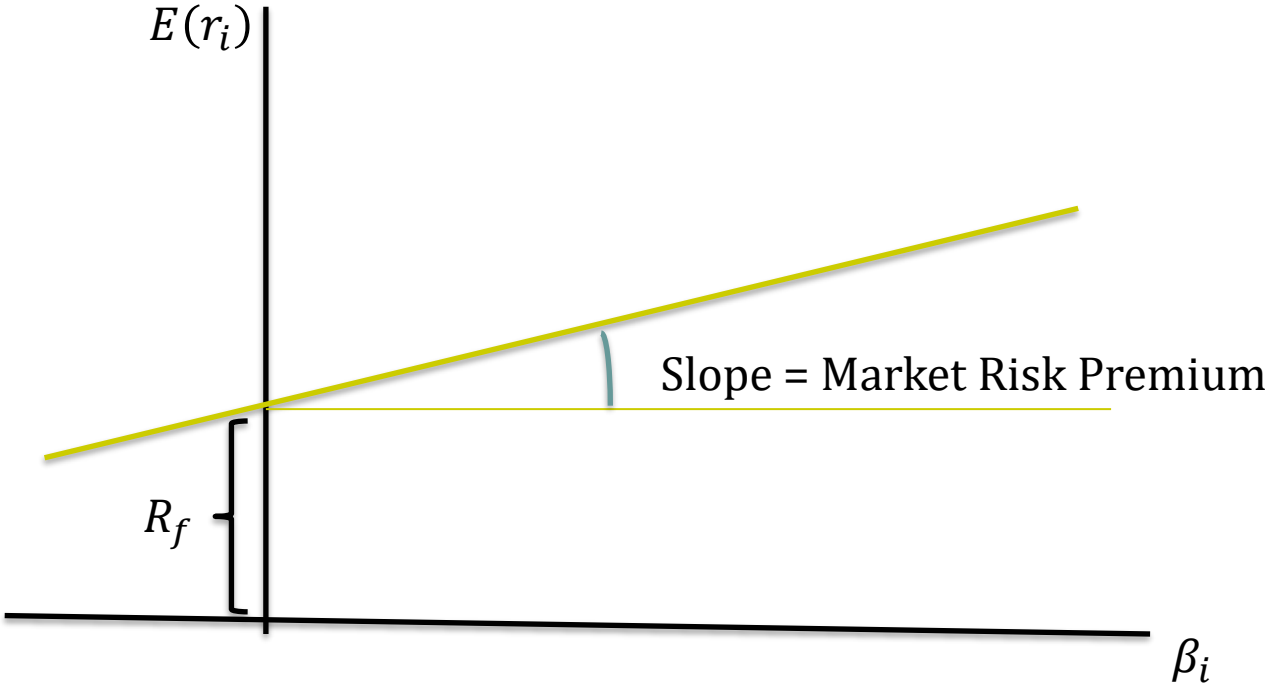
Beta = (0.4 x 0.2 x 0.6)/0.2^2 = 1.2

E(R) = 5%+1.2 x (10%-5%) = 11%

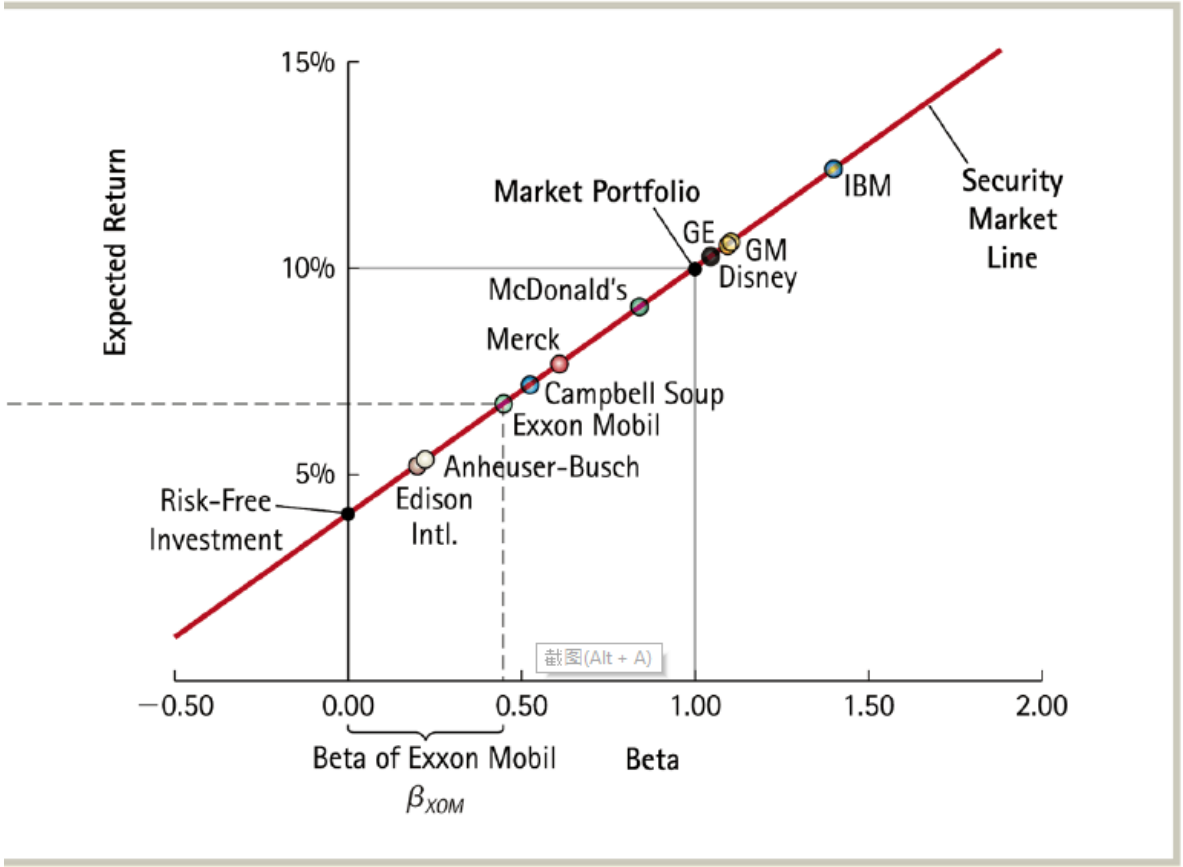
Security Market Line

SML depicts the relation between $E(r_i)$ and β_i.

- CAPM: $E(r_i) = r_f + \beta_i \cdot (E(r_m) - r_f)$

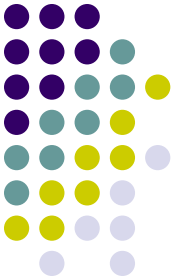


Security Market Line



(b) The SML shows the required return for each security as a function of its beta with the market. According to the CAPM, the market portfolio is efficient, which is equivalent to the required return equaling the expected return for every security. According to the CAPM, all stocks and portfolios should lie on the SML.

Security Market Line



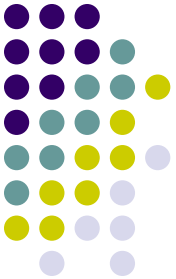
- Any investment with “risk” and “return” on the SML is giving the *correctly “risk-adjusted” return* (or, the *fair return*).
- In other words, investor has no reason to prefer one point on the SML over another.
- Investor can always combine investment in *risk-free asset* with a given point in the SML to go to another point on the SML.

Example 1

- Example: Suppose investment 1 has beta of 1.2 and investment 2 has beta of 1.6.
- Suppose risk-free rate is 3% and market risk premium is 10%.
- Expected return on investment 1 = 3%+(1.2)*(10%)=15%.
- Expected return on investment 2 = 3%+(1.6)*(10%)=19%.

- Suppose an investor has $100 to invest.
- If he invests $75 in investment 2 and $25 in risk-free asset, his *portfolio beta* is (75/100)*(1.6)+(25/100)*(0)=1.2
- The expected return on the portfolio is (75/100)*(19%)+(25/100)*(3%)=15%.
- Thus, his beta and expected return on the portfolio are the same as if he invested $100 in investment 1.

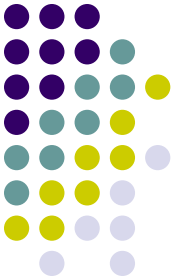
Example 2



- Example: Suppose investment 1 has beta of 1.2 and investment 2 has beta of 1.6.
- Suppose risk-free rate is 3% and market risk premium is 10%.
- Expected return on investment 1 = 3%+(1.2)*(10%)=15%.
- Expected return on investment 2 = 3%+(1.6)*(10%)=19%.

- Suppose now that the investor desires a beta of 1.6 and expected return of 19%.
- But she can only invest in investment 1 and the risk-free asset.
- How can he move up the SML and attain the desired risk and return?

Example 2



- Suppose he invests a fraction f of his wealth in investment 1, and $(1 - f)$ in the risk-free asset. f must be such that

$$f \cdot 15\% + (1 - f) \cdot 3\% = 19\%$$

- Solving, we get $f = 16\%/12\% = 4/3$.
- In other words, if the investor has \$100 to invest, he must *borrow \$33.33 at 3%* and *invest \$133.33 on investment 1*.
- Check that the beta of his portfolio is

$$(4/3)(1.2) + (-1/3) * 0 = 1.6$$

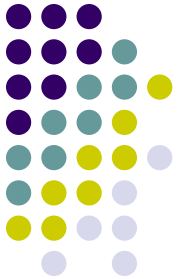
- That is, the beta of investment 2.

Security Market Line

- The above examples show that borrowing (lending) can increase (decrease) the risk exposure of an investor and increase (decrease) the beta of his portfolio.

- As we shall see, this continues to hold when the *investor buys equity in a company* and the **company** borrows (lends) money.

Example 3



- Suppose risk-free rate is 3% and market risk premium is 10%.
- A **real** asset has a beta of 1.8 and is offering a return of 24%. Is this a good investment?
- With a beta of 1.8, the expected return on an investment according to the SML should be

$$3\% + (1.8)(10\%) = 21\%.$$

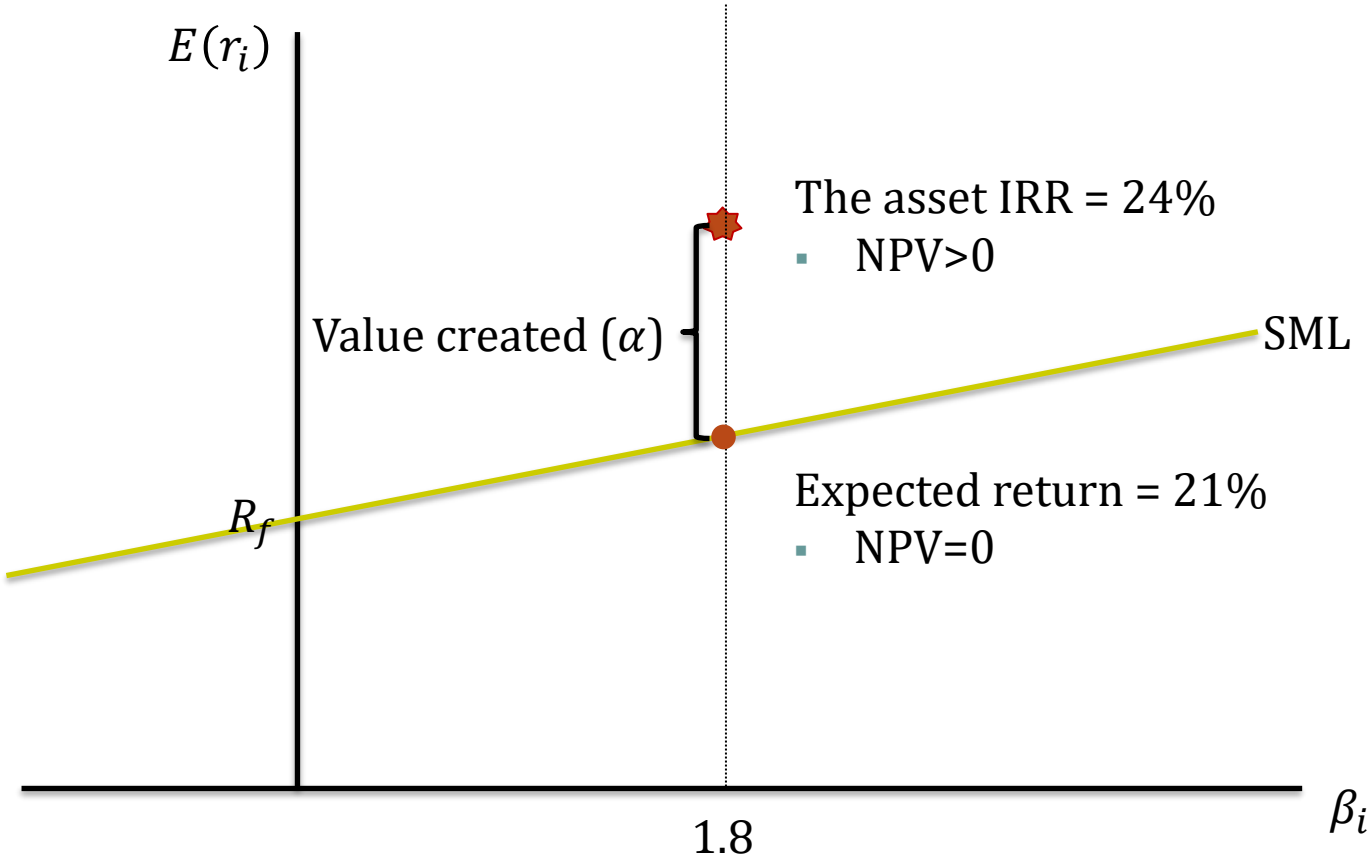
- Therefore, this investment is offering a return higher than what is required according to the SML (the "fair" return).
- So, it is a good investment.

IRR Revisited

Note that this is exactly the logic of the *IRR criterion* for project choice.

- If *IRR of a project* > *required return*, project is accepted.
- If *IRR of a project* < *required return*, project is rejected.

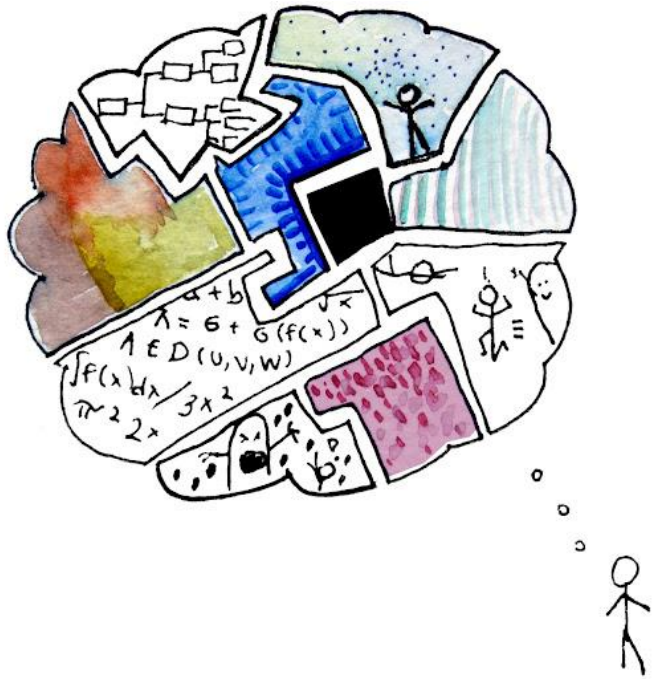
IRR Revisited



In Practice

How to estimate:

- Risk free rate
- Market risk premium
- Beta



Risk Free Rate

Use the current yield on the long term government bonds:

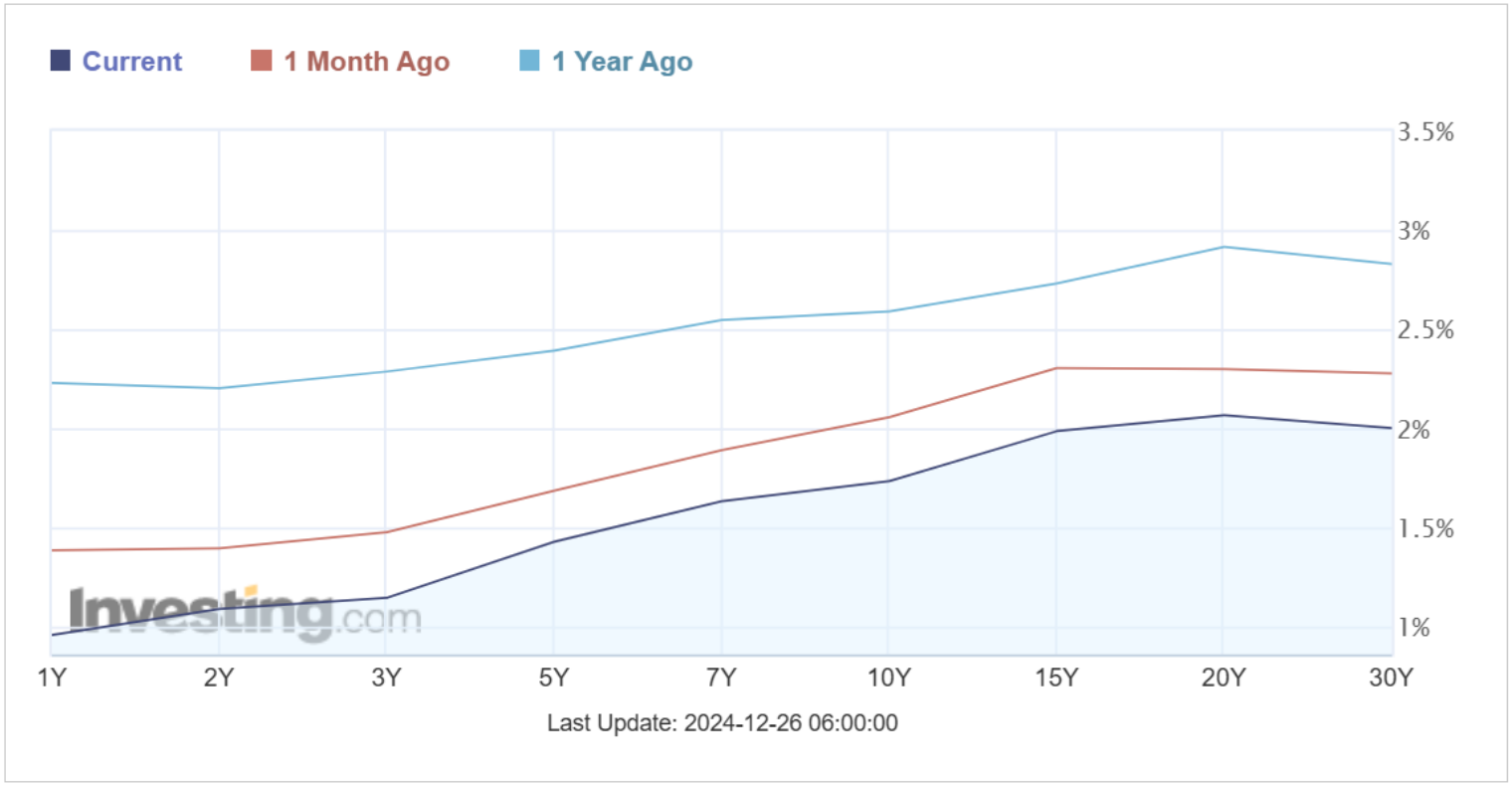
https://asianbondsonline.adb.org/economy/?economy=CN

https://finance.yahoo.com/bonds

Yield Curve

China »

Yield Curve



Source: Investing.com

HTTPS://WWW.INVESTING.COM/RATES-BONDS/CHINA-GOVERNMENT-BONDS?MATURITY_FROM=90&MATURITY_TO=290

Yield Curve

United States »

Yield Curve

BONDS?MATURITY_FROM=40&MATURITY_TO=290

Which term to use?

A professor at IESE did a survey and found on Feb 20, the average Rf used in China is 3.1%

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3560869

CGB Yield Curve and Others

Yield Curve Name: All | From: 2020-02-01 | To: 2020-02-29 | Maturity: All | Search | Download

Yield Curve Name	Date	3M	6M	1Y	3Y	5Y	7Y	10Y	30Y
ChinaBond Government Bond Yield Curve	2020-02-28	1.7865	1.8894	1.9291	2.3831	2.5266	2.7477	2.7376	3.3726
ChinaBond Financial Bond of Commercial Bank Yield Curve (AAA)	2020-02-28	2.3454	2.4830	2.6025	2.8808	3.1732	3.3673	3.6336	4.1911
ChinaBond CP&Note Yield Curve (AAA)	2020-02-28	2.5076	2.5787	2.6624	3.0154	3.3028	3.4851	3.7465	
ChinaBond Government Bond Yield Curve	2020-02-27	1.7510	1.8922	1.9051	2.3821	2.5953	2.8044	2.7702	3.4040
ChinaBond Financial Bond of Commercial Bank Yield Curve (AAA)	2020-02-27	2.3508	2.4742	2.6256	2.9176	3.2024	3.3873	3.6531	4.2103
ChinaBond CP&Note Yield Curve (AAA)	2020-02-27	2.5076	2.5963	2.6732	3.0131	3.3217	3.5051	3.7660	
ChinaBond Government Bond Yield Curve	2020-02-26	1.7556	1.8488	1.8863	2.3835	2.6283	2.8196	2.7973	3.4271
ChinaBond Financial Bond of Commercial Bank Yield Curve (AAA)	2020-02-26	2.3514	2.5171	2.6756	2.9131	3.2317	3.4021	3.6680	4.2252
ChinaBond CP&Note Yield Curve (AAA)	2020-02-26	2.5545	2.6469	2.6943	3.0231	3.3614	3.5200	3.7808	
ChinaBond Government Bond Yield Curve	2020-02-25	1.7715	1.8401	1.8951	2.3835	2.6384	2.8200	2.8220	3.4421

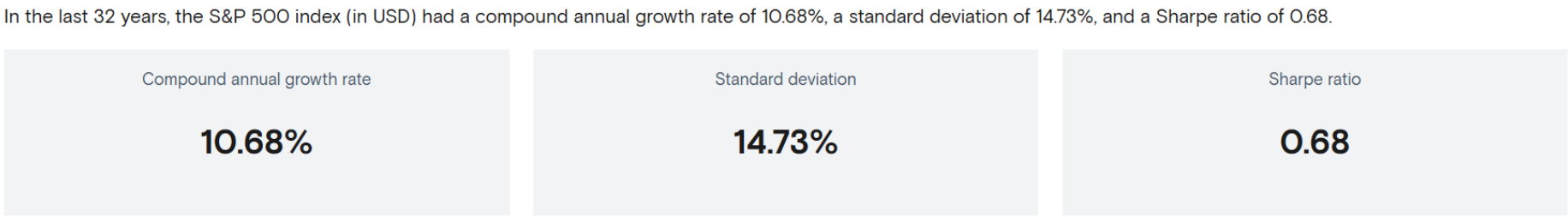
Table 3. Risk Free Rate (RF) used for 81 countries in 2020

RF	Number of Answers	Average	St. Dev.	Median	MAX	min
USA	2156	1,9%	0,8%	1,8%	5,2%	-0,2%
Spain 2020	521	1,3%	1,2%	1,0%	5,2%	-0,8%
Argentina	31	12,3%	7,5%	11,0%	29,2%	0,2%
Australia	37	2,4%	0,8%	2,4%	4,2%	0,8%
Austria	117	0,9%	0,9%	0,8%	2,7%	-0,7%
Belgium	119	0,9%	0,8%	0,9%	2,7%	-0,2%
Bolivia	17	3,1%	1,1%	3,0%	5,2%	0,2%
Bosnia	9	9,2%	1,4%	9,5%	11,2%	6,8%
Brazil	51	4,8%	2,4%	5,2%	9,2%	0,2%
Bulgaria	16	2,3%	1,3%	2,8%	3,9%	-0,1%
Canada	49	1,8%	0,9%	1,8%	4,2%	0,2%
Chile	30	3,6%	1,1%	3,7%	5,4%	0,8%
China	57	3,1%	1,5%	3,3%	6,0%	0,2%
Colombia	31	6,3%	0,9%	6,3%	8,2%	4,8%
Costa Rica	6	4,3%	1,5%	4,5%	6,7%	1,8%
Croatia	8	0,9%	0,8%	1,0%	2,2%	-0,5%
Czech Republic	21	1,8%	1,0%	2,1%	3,3%	-0,2%
Denmark	73	0,9%	1,0%	0,8%	3,7%	-0,4%
Dominican Rep.	7	5,3%	2,3%	5,9%	9,0%	0,2%
Ecuador	13	5,9%	3,8%	4,7%	16,5%	3,2%
Egypt	15	9,7%	3,9%	10,0%	15,2%	0,2%
Estonia	19	1,7%	1,2%	1,8%	3,7%	-0,3%
Finland	34	1,0%	0,8%	0,9%	2,7%	-0,2%

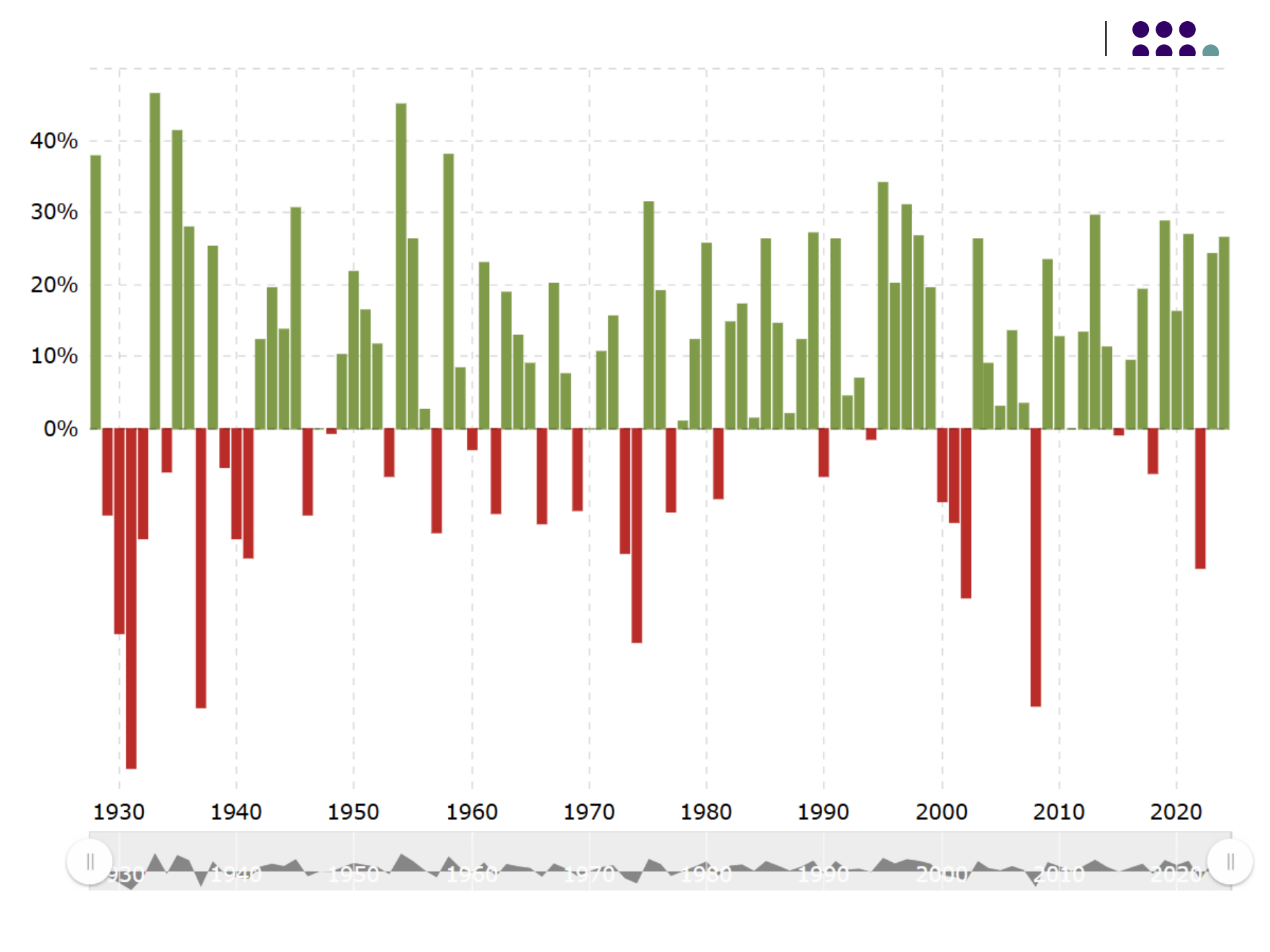
Market Risk Premium

What is *market portfolio*?

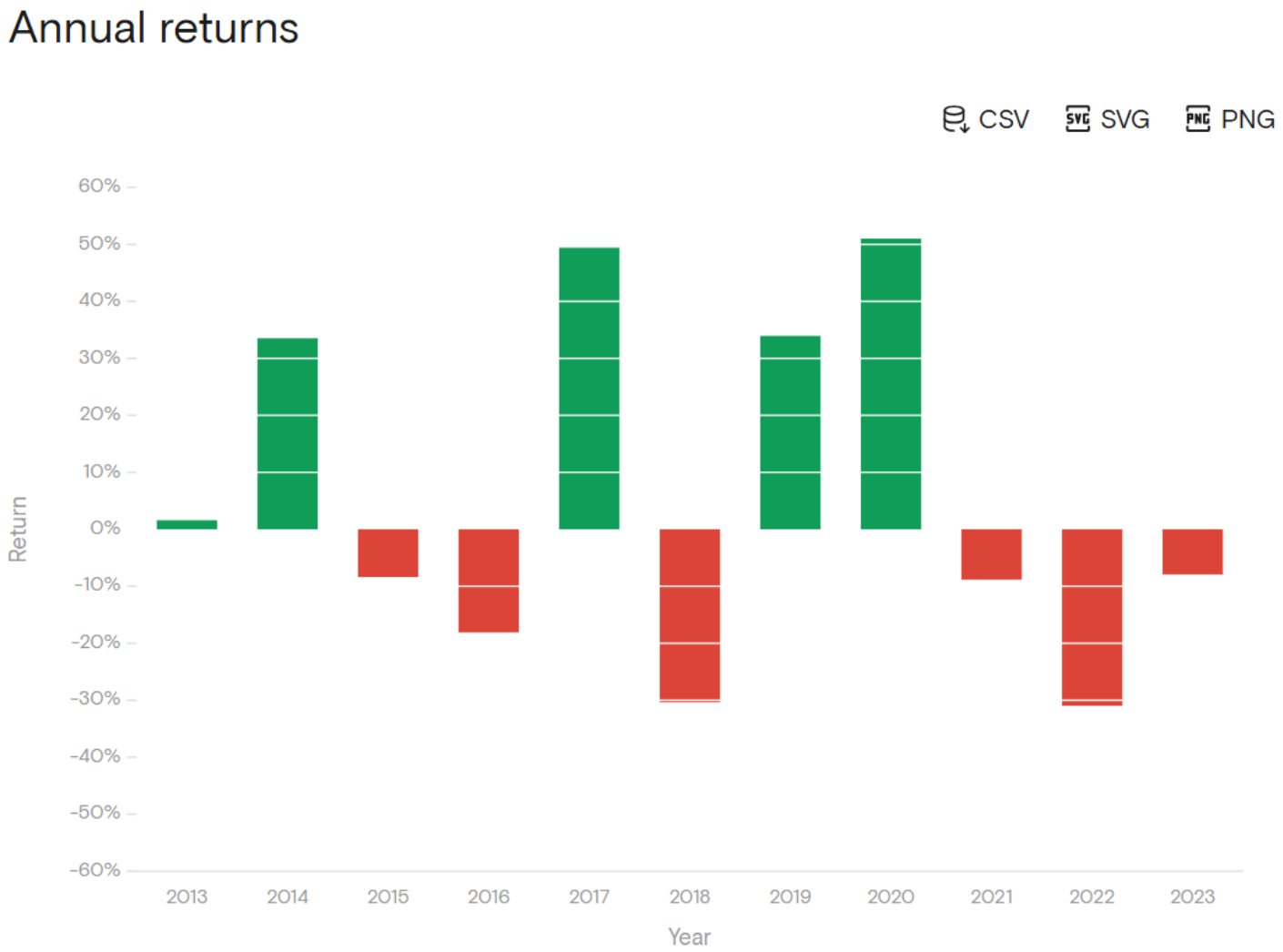
- Portfolio of **all risky assets** (stocks, bonds, etc.) traded in capital markets
- Common options
  - Stock indices: e.g. S&P 500, annual return around 10.68% (1992 – 2024)



  - China: CSI 300 index, annual return 9.6%/21.9%/3.34% (2023/2014/2012)


40%
30%
20%
10%
0%
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

China: 沪深300 (CSI 300)

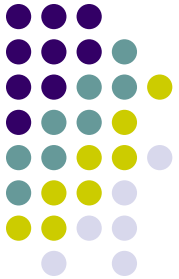


China:上证指数

Shanghai Composite Index - Historical Annual Data

Year	Average Closing Price	Year Open	Year High	Year Low	Year Close	Annual % Change
2018	3,185.96	3,348.33	3,559.47	2,733.88	2,827.63	-14.50%
2017	3,249.69	3,135.92	3,447.84	3,052.79	3,307.17	6.56%
2016	3,005.24	3,296.26	3,361.84	2,655.66	3,103.64	-12.31%
2015	3,739.79	3,350.52	5,166.35	2,927.29	3,539.18	9.41%
2014	2,238.22	2,109.39	3,234.68	1,991.25	3,234.68	52.87%
2013	2,191.70	2,276.99	2,434.48	1,950.01	2,115.98	-6.75%
2012	2,219.14	2,169.39	2,460.69	1,959.77	2,269.13	3.17%
2011	2,670.11	2,808.08	3,057.33	2,166.21	2,199.42	-21.68%
2010	2,827.52	3,243.76	3,282.18	2,363.95	2,808.08	-14.31%

Market Risk Premium



What do textbooks use?

	Suggestion
Copeland, Koller, and Murrin	4-6%
Berk and DeMarzo	5-6%
Brealey and Myers	7.4%
Stewart	6.0%
Ross, Westerfield, and Jaffe	7.5%

What do academics say?

- Fama and French (2002): ex ante risk premium is 2.55-4.32% for 1951-2000
- Ibbotson and Chen (2001): long-term risk premium is 4-6%

Market Risk Premium

What about different countries? Results from surveys

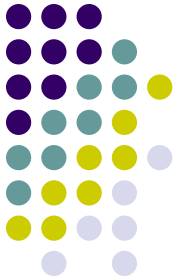
Finance and economics professors, analysts and managers of companies

MRP	N. Ans.	Average	St. Dev.	Median	MAX	min
USA	2156	**5.60%**	1.40%	5.40%	13.40%	2.00%
China	57	**6.70%**	1.50%	6.80%	11.10%	3.30%
Hong Kong	11	**6.20%**	0.80%	6.10%	8.00%	5.20%
Australia	37	7.90%	4.80%	6.20%	20.40%	2.80%
Japan	43	6.20%	1.50%	6.00%	10.40%	3.70%
Korea, (South)	12	6.10%	0.70%	6.00%	7.60%	4.80%
Spain	521	6.30%	1.60%	6.40%	13.30%	2.80%
France	133	6.20%	1.30%	6.00%	10.40%	3.80%
Germany	305	5.80%	1.60%	5.70%	10.40%	2.00%
Italy	97	6.20%	1.10%	6.10%	8.90%	3.80%
United Kingdom	95	5.80%	1.60%	5.80%	11.40%	1.60%

Source: P. Fernandez, J. Aguirreamalloa and L. Corres, 2020, Market Risk Premium and Risk-Free Rate used for 81 countries in 2020

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3560869

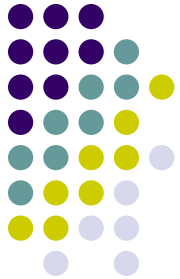
Market Risk Premium



Conclusion:

- Hard to tell.
- Anything between 3% and 8% could be justified
- May vary across countries
  - Investors may not be able to diversity globally
- Keep in mind the uncertainty regarding the estimates

Betas



- Get it from somewhere like Bloomberg/ Reuters/ Yahoo Finance
- Compute yourself using past stock returns and market returns
  - Analysts typically use a 5-year time horizon, and monthly returns to compute the betas
  - Subject to statistical error
- Use an "**industry beta**"

Betas

Which one has a higher beta, Walmart or Apple?

Wal-Mart Stores, Inc. (WMT)
NYSE - NYSE Delayed Price. Currency in USD
Add to watchlist

66.40 -0.10 (-0.15%)
At close: 4:00PM EST

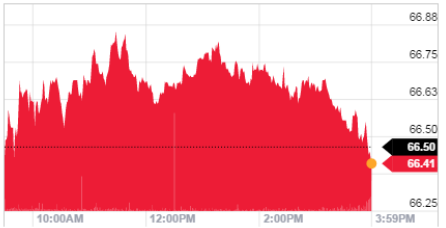
66.40 0.00 (0.00%)
After hours: 7:47PM EST

Summary | Conversations | Statistics | Profile | Financials | Options | Holders | Historical Data | Analysts

Previous Close	66.50	Market Cap	[illegible]
Open	66.37	Beta	-0.03
Bid	0.00 x	PE Ratio (TTM)	14.40
Ask	0.00 x	EPS (TTM)	4.61
Day's Range	66.37 - 66.86	Earnings Date	Feb 21, 2017
52 Week Range	62.35 - 75.19	Dividend & Yield	2.00 (3.01%)
Volume	9,097,238	Ex-Dividend Date	N/A
Avg. Volume	9,013,534	1y Target Est	74.05

Trade prices are not sourced from all markets

1D 5D 1M 6M YTD 1Y 2Y 5Y 10Y MAX Interactive chart



Apple Inc. (AAPL)
NasdaqGS - NasdaqGS Real Time Price. Currency in USD
Add to watchlist

130.29 +1.21 (+0.94%)
At close: 4:00PM EST

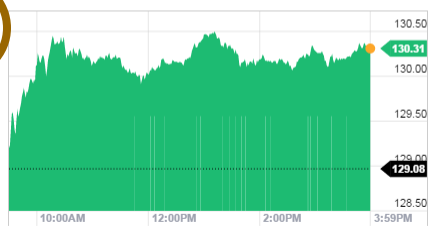
130.27 -0.02 (-0.02%)
After hours: 7:59PM EST

Summary | Conversations | Statistics | Profile | Financials | Options | Holders | Historical Data | A[illegible]

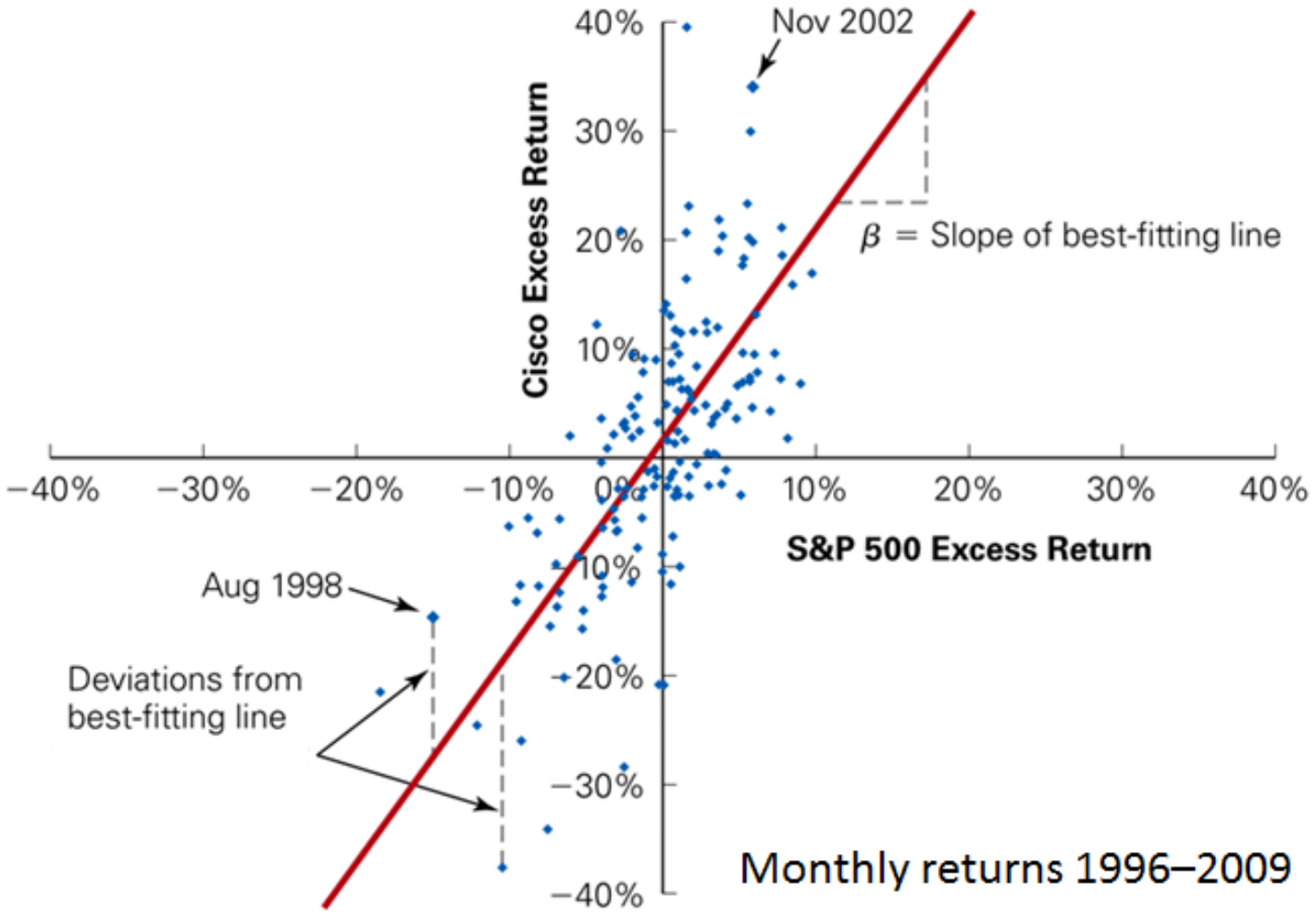
Previous Close	129.08	Market Cap	[illegible]
Open	128.95	Beta	1.36
Bid	130.25 x 500	PE Ratio (TTM)	15.68
Ask	130.34 x 2000	EPS (TTM)	8.31
Day's Range	128.92 - 130.50	Earnings Date	Jan 24, 2017 - Jan 30, 2017
52 Week Range	89.47 - 130.50	Dividend & Yield	2.28 (1.77%)
Volume	26,637,741	Ex-Dividend Date	N/A
Avg. Volume	31,694,267	1y Target Est	138.79

Trade prices are not sourced from all markets

1D 5D 1M 6M YTD 1Y 2Y 5Y 10Y MAX Interactive chart



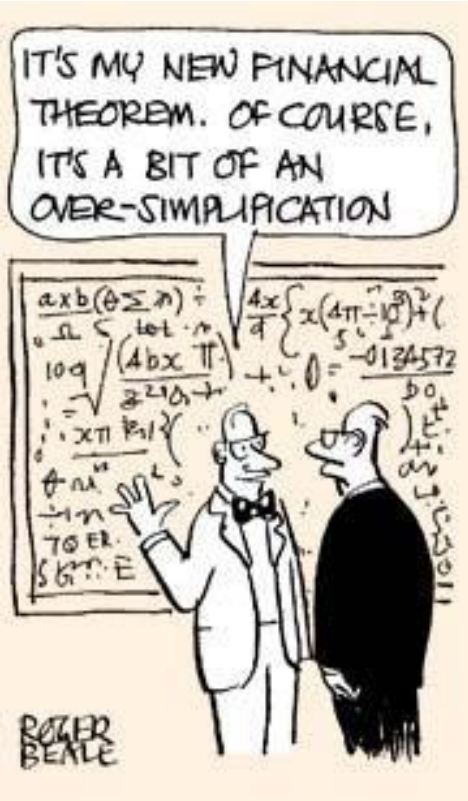
Estimating Betas



Caveat

CAPM relies on *strong simplifying* assumptions, e.g.:

- Diversified investors
- Observability of market portfolio
- Constant beta
- No arbitrage condition

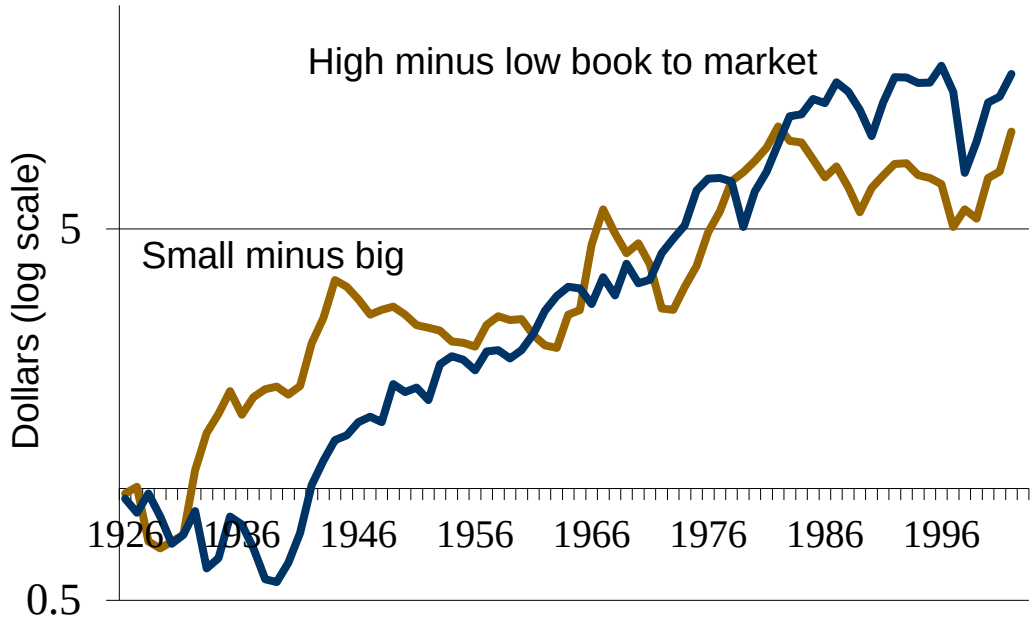


Source: Financial Times

Caveat

Fama and French (1992):

- Adjusted for beta, small stocks outperform big stocks
- Adjusted for beta, high BTM stocks outperform low BM stocks



Source: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Multi-factor model

Idea: risk-factors other than market risk can also be non-diversifiable and thus are priced

Example: SMH, HML(BM), Momentum

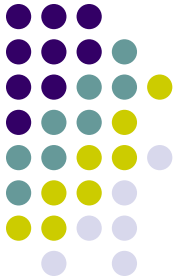
Factors are incorporated into a regression-based or risk model framework. A common form is the **linear multi-factor model**:

$$R_i = \alpha_i + \beta_{i1}F_1 + \beta_{i2}F_2 + \cdots + \beta_{ik}F_k + \epsilon_i$$

Where:

- R_i: Return of asset i
- α_i: Intercept (alpha)
- β_{ik}: Sensitivity of the asset to factor k
- F_k: Value of factor k
- ϵ_i: Idiosyncratic (unsystematic) return.

Multi-factor model



Risk calculation:

- Similar to CAPM, look at the covariance between stock performance and some portfolio's performances

Portfolio construction:

- Long-short portfolio of the companies sorted according to the metrics (SMB, HML, etc)
- Long companies with high metrics
- Short companies with low metrics