Introduction to Finance

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  1. Given the capital structure find the appropriate discount rate of the firm using WACC

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  2. Compute the NPV of the project
  $$NPV = \sum_{t=0}^{T} \frac{CF_t}{(1+r_{WACC})^t}$$
  3. Make investment decision using the appropriate investment decision rule.

Today

- Introduce the notion of risk.
  - Central in finance and in economics in general
  - Has to do with the fundamental uncertainty of future.
  - Has to do with r.
- How can financial risk be managed?

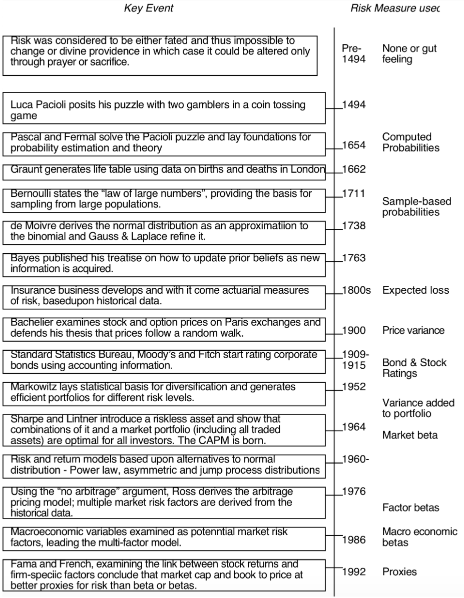
Risk
Definition

- Knight (1921) : Risk is uncertainty that you can quantify.
  - Risk is generally seen as negative.
  - In business, risk is dual as it can provide good and bad outcomes. A business that works is not a business that avoids risk but a business that weight risk in a good way.

Risk

- Risk in business has become more and more important with long-distance trade.
- You need to put contracts in place, insurances, invest a lot and might not see a return, etc.
  - But the investor does not suffer physically from the risk.
  - Finance separates economic risk from financial risk.

Risk



Key Event
Risk Measure usec
Risk was considered to be either fated and thus impossible to change or divine providence in which case it could be altered only through prayer or sacrifice.
Pre-1494
None or gut feeling
Luca Pacioli posits his puzzle with two gamblers in a coin tossing game
1494
Pascal and Fermal solve the Pacioli puzzle and lay foundations for probability estimation and theory
1654
Computed Probabilities
Graunt generates life table using data on births and deaths in London
1662
Bernoulli states the "law of large numbers", providing the basis for sampling from large populations.
1711
Sample-based probabilities
de Moivre derives the normal distribution as an approximatiion to the binomial and Gauss & Laplace refine it.
1738
Bayes published his treatise on how to update prior beliefs as new information is acquired.
1763
Insurance business develops and with it come actuarial measures of risk, basedupon historical data.
1800s
Expected loss
Bachelier examines stock and option prices on Paris exchanges and defends his thesis that prices follow a random walk.
1900
Price variance
Standard Statistics Bureau, Moody's and Fitch start rating corporate bonds using accounting information.
1909-1915
Bond & Stock Ratings
Markowitz lays statistical basis for diversification and generates efficient portfolios for different risk levels.
1952
Variance added to portfolio
Sharpe and Lintner introduce a riskless asset and show that combinations of it and a market portfolio (including all traded assets) are optimal for all investors. The CAPM is born.
1964
Market beta
Risk and return models based upon alternatives to normal distribution - Power law, asymmetric and jump process distributions
1960-
Using the "no arbitrage" argument, Ross derives the arbitrage pricing model; multiple market risk factors are derived from the historical data.
1976
Factor betas
Macroeconomic variables examined as potenntial market risk factors, leading the multi-factor model.
1986
Macro economic betas
Fama and French, examining the link between stock returns and firm-speciic factors conclude that market cap and book to price at better proxies for risk than beta or betas.
1992
Proxies

Risk and return

- Investors are generally seen as risk-averse: they seek the highest return for the lowest risk.
- But how risk and return linked?
- Let's compare three investments:
  - Treasury bills: U.S. government debt maturing in less than 1 year. Considered as zero-risk: no risk of default and prices are stable.
  - U.S. Long-term treasury bonds: risk of interest rate change (price fall when interest rate increase)
  - A portfolio of U.S. stocks: riskier, depends on the above risk and on the performance of companies.
- Look at the long-run performance of these investments

Risk and return

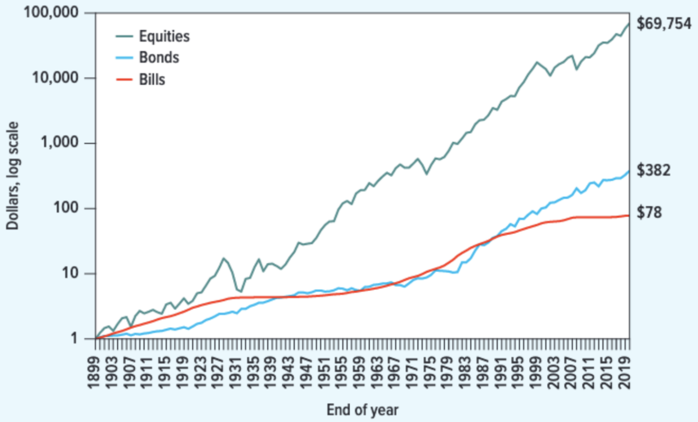


FIGURE 7.1

How an investment of $1 at the start of 1900 would have grown by the end of 2020, assuming reinvestment of all dividend and interest payments.

Source: E. Dimson, P. R. Marsh, and M. Staunton, *Triumph of the Optimists: 101 Years of Global Investment Returns* (Princeton, NJ: Princeton University Press, 2002), with updates provided by the authors.

Risk and return

FIGURE 7.2

How an investment of $1 at the start of 1900 would have grown *in real terms* by the end of 2020, assuming reinvestment of all dividend and interest payments. Compare this plot with Figure 7.1, and note how inflation has eroded the purchasing power of returns to investors.

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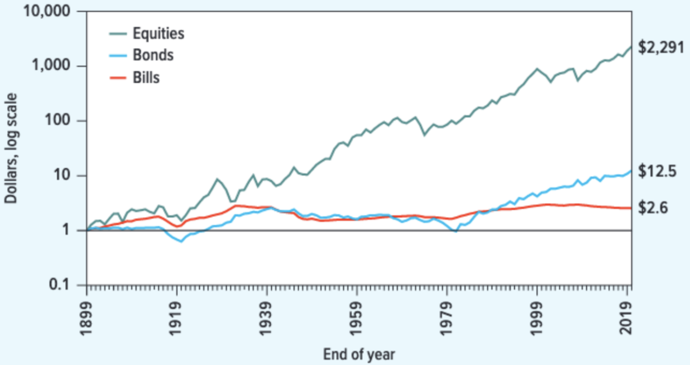

Risk and return

Average Annual Rate of Return			
	Nominal	Real	Average Risk Premium (Extra Return versus Treasury Bills)
Treasury bills	3.7%	0.9%	0%
Government bonds	5.4	2.6	1.7
Stocks	11.5	8.5	7.8

Risk and return

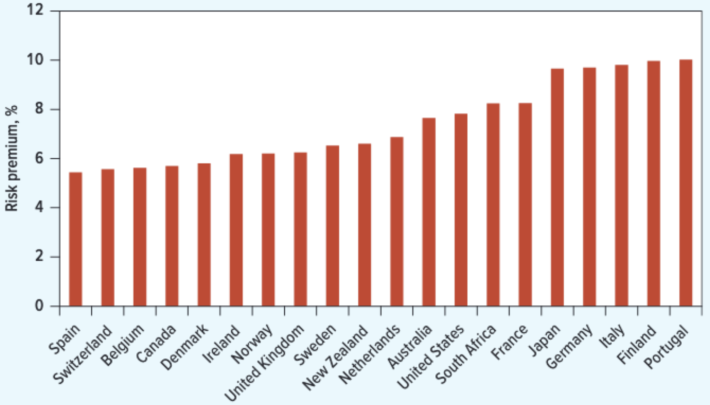

FIGURE 7.3

Average market risk premiums (nominal return on stocks minus nominal return on bills), 1900–2020.

Source: E. Dimson, P. R. Marsh, and M. Staunton, *Triumph of the Optimists: 101 Years of Global Investment Returns* (Princeton, NJ: Princeton University Press, 2002), with updates provided by the authors.

Risk and return

- Returns seems correlated with risk: low risk investments offer low returns.
- Take r_m, the expected return of the market (think about S&P500 or CAC40 in France).
- Past performance can help understand future performance but it is not a perfect predictor.
  - Return is the sum of the risk-free interest rate (r_f) and the risk premium.
  - Both are affected by changes in interest rate, macroeconomic conditions, policies, etc.
- Approximation: take today r_f and add the observed past risk premium (7.8%).
- Assuming $r_f = 2\%$, what is r_m?

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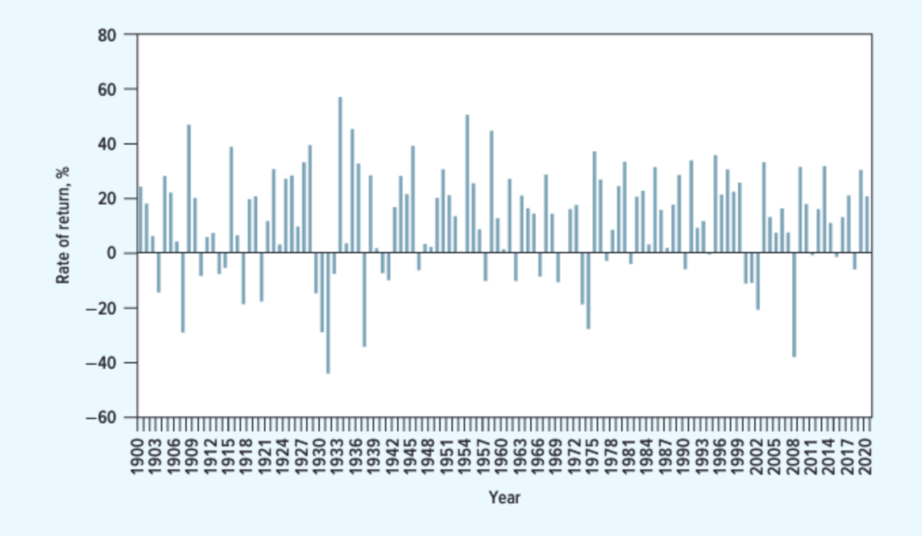
- Approximation: take today r_f and add the observed past risk premium (7.8%).
- Assuming $r_f = 2\%$, what is r_m? $r_m = 9.8\%$.
- Assumption that there is a stable risk premium on equity.
- Evaluating risk involves a lot of uncertainty and heterogeneity among actors.

Risk premium does not come for free



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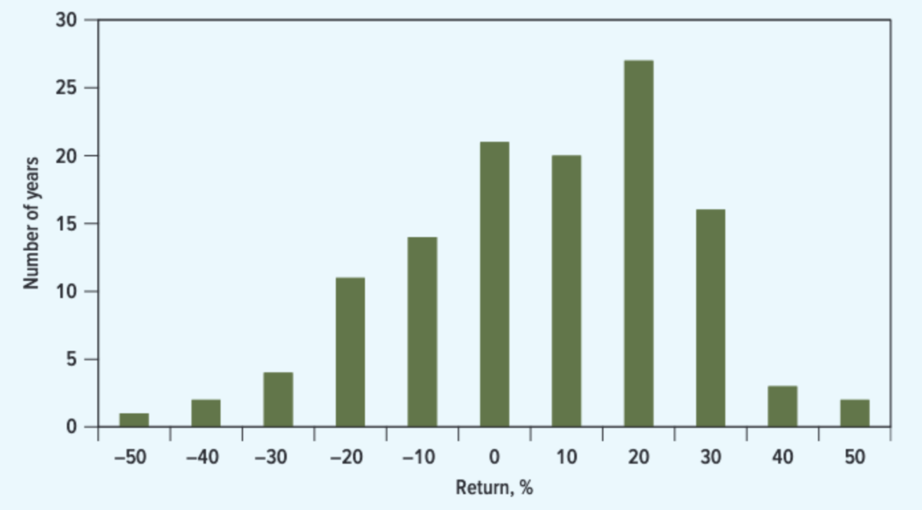
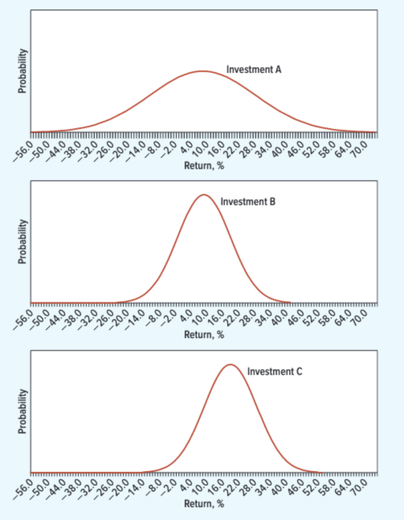


Measuring risk

- We want a metric to measure risk.
  - We used past performance to determine r_m but what about other types of investments?
- Remark that the distribution looks like a normal curve.
  - Nice property: normal curves are defined by only two parameters: mean and variance.
- Variance is the mean of squared deviations to the mean: $V(r_i) = \sigma_{r_i}^2 = \frac{1}{n}\sum_k (r_k - \bar{r}_i)^2$
- Standard deviation is the square root of variance: $\sigma_{r_i} = \sqrt{V(r_i)}$

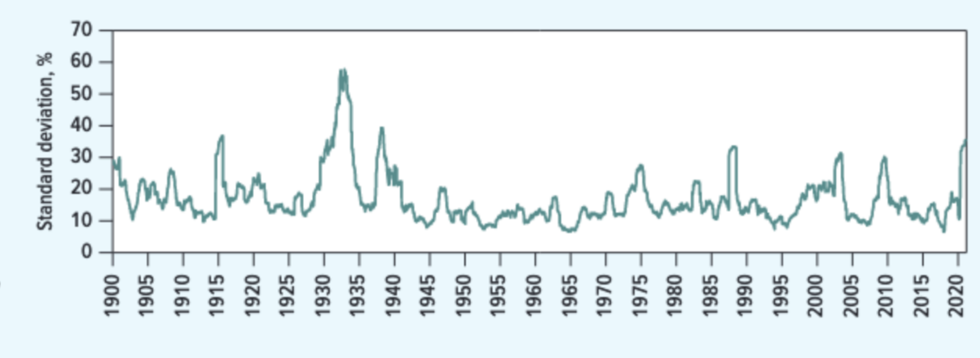
Measuring risk



Measuring risk

Portfolio	Standard Deviation (σ)	Variance (σ^2)
Treasury bills	2.8%	8.1
Government bonds	8.9	79.7
Stocks	19.5	381.8

Measuring risk



Risk and diversification

Standard Deviation (σ)					
	Stock	Market		Stock	Market
BHP Billiton (Australia)	26.2%	10.9%	Sanofi (France)	17.5%	14.0%
BP (U.K.)	22.8	11.3	Nestlé (Switzerland)	13.6	10.9
Siemens (Germany)	22.5	15.5	Sony (Japan)	27.6	16.4
Hyundai Heavy Industry (Korea)	40.7	12.5	Toronto-Dominion Bank (Canada)	12.0	9.1
Agricultural Bank (China)	25.5	18.5	Tata Motors (India)	45.3	15.0

Risk and diversification

- All individual stocks here appear more risky than the market. How come?

Risk and diversification

- All individual stocks here appear more risky than the market. How come?
- Diversification!
- Mathematical property: Standard deviation of a mean (*e.g.* a market) is not the mean of the standard deviations
- $V(X+Y) = V(X) + V(Y) + 2cov(X,Y)$
- For a portfolio with weights:
  $V(\omega_X X + \omega_Y Y) = \omega_X^2 V(X) + \omega_Y^2 V(Y) + 2\omega_X \omega_Y \rho_{XY} \sigma_X \sigma_Y$

Risk and diversification

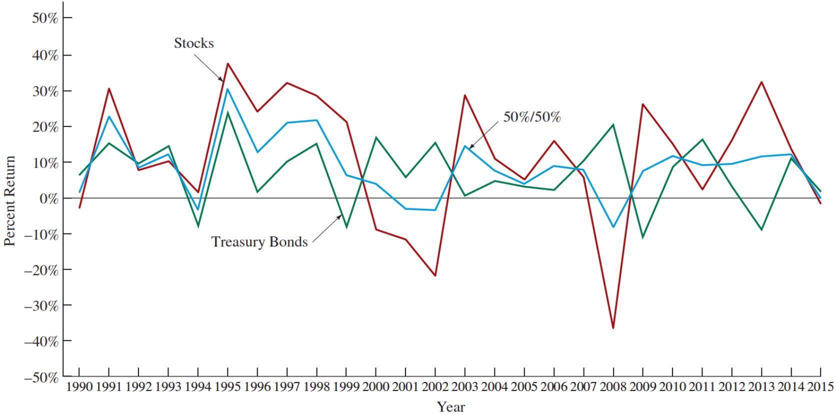
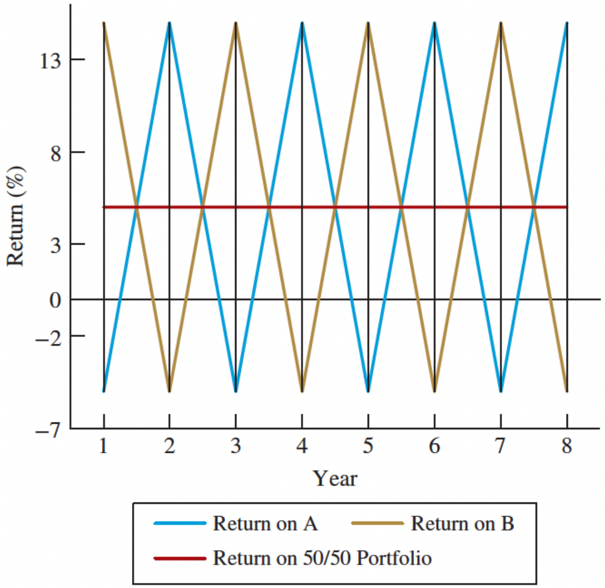


FIGURE 12.4b **Stocks, Treasury Bond Returns, and Returns on a 50/50 Stock/Bond Portfolio, 1990–2015**

Risk and diversification



Risk and diversification

	Stock 1	Stock 2
Monthly return	1.5%	2.5%
Standard deviation (σ)	10%	15%
Correlation Stock 1-Stock 2 (ρ_{12})	0.2	

- Compute the return and its standard deviation when you invest half on each stock.
- Assume $\rho_{12} = 1$
- Assume $\rho_{12} = -1$

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    $V(portfolio) = 0.5^2 * 0.1^2 + 0.5^2 * 0.15^2 + 2 * 0.5 * 0.5 * 0.1 * 0.15 * 0.2 = 0.009625$, so
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  - $V(portfolio) = 0.5^2 * 0.1^2 + 0.5^2 * 0.15^2 + 2 * 0.5 * 0.5 * 0.1 * 0.15 * (-1) = 0.000625$ so $\sigma = \sqrt{0.000625} = 0.025$

Where does risk come from?

- There are two types of risk: **specific risk** and **systematic risk**.
- **Specific risk** only affects one company, or a group of company, an industry, etc.
  - *e.g.* A shock on food price will affect food distributors but not the aeronautic industry.
  - This risk is diversifiable through a well-diversified portfolio.
- **Systematic or undiversifiable risk** are shared by most businesses. A stock market crisis, macro-economic shocks, etc.
- Total risk is the sum of both risks.

Where does risk come from?

Diversifiable Risk (also known as unsystematic risk or firm-specific risk, or micro risk)	Undiversifiable Risk (also known as systematic risk, market risk, or macro risk)
Business Risk	Market Risk
Financial Risk	Interest Rate Risk
Event Risk	Purchasing Power Risk
Tax Risk	Exchange Rate Risk
Liquidity Risk	

Where does risk come from?

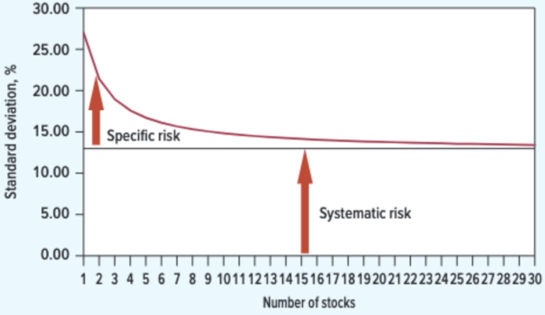


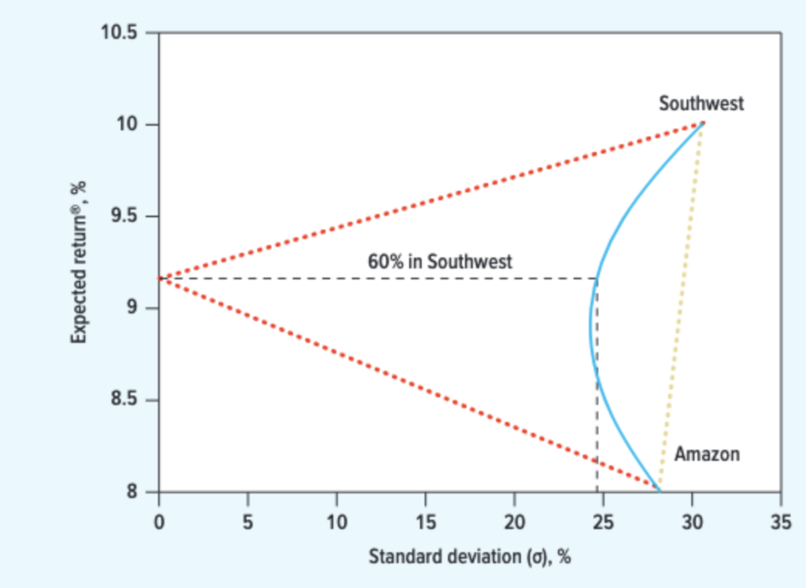
FIGURE 7.12

Average risk (standard deviation) of portfolios containing different numbers of stocks. The stocks were selected randomly from stocks traded on the New York Stock Exchange from 2010 through 2019. Notice that diversification reduces risk rapidly at first, then more slowly. This is because diversification can only eliminate *specific risk*. It cannot eliminate *systematic risk*.

Choosing a portfolio

- What's the best portfolio to hold ?
- That's exactly the question Harry Markowitz asked in 1952.
- The *investment opportunity set* represents all the available combinations of risk and return.
- **Efficient portfolios** is the set of the best portfolio you can achieve with a given investment strategy.
- The market portfolio is the one that aggregates all stocks.
- Its return and standard deviation is easy to compute.

Choosing a portfolio



Choosing a portfolio

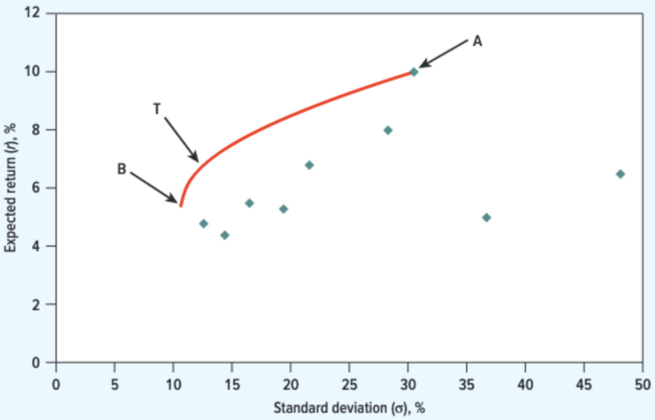


FIGURE 7.14

Each dot shows the expected return and standard deviation of stocks in Table 7.5. There are many possible combinations of expected return and standard deviation from investing in a mixture of these stocks. If you like high expected returns and dislike high standard deviations, you will prefer portfolios along the red line. These are *efficient* portfolios. We have marked the three efficient portfolios described in Table 7.5 (A, T, and B).

Choosing a portfolio

- How to chose between portfolios on the red line ?
- Remember the risk-free asset r_f? It's going to be important.
- Assume some of the wealth can be invested in this asset where $\sigma_f = 0$
- It is also possible to borrow at the market rate r_f.
- What's the return and standard deviation of such a portfolio?

Choosing a portfolio

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- What's the return and standard deviation of such a portfolio?
- $Return = (\omega_f r_f + \omega_p r_p), \sigma = \omega_p \sigma_p$ because $\sigma_f = 0$
- Possible to show that the range of opportunity can be written as a straight line.

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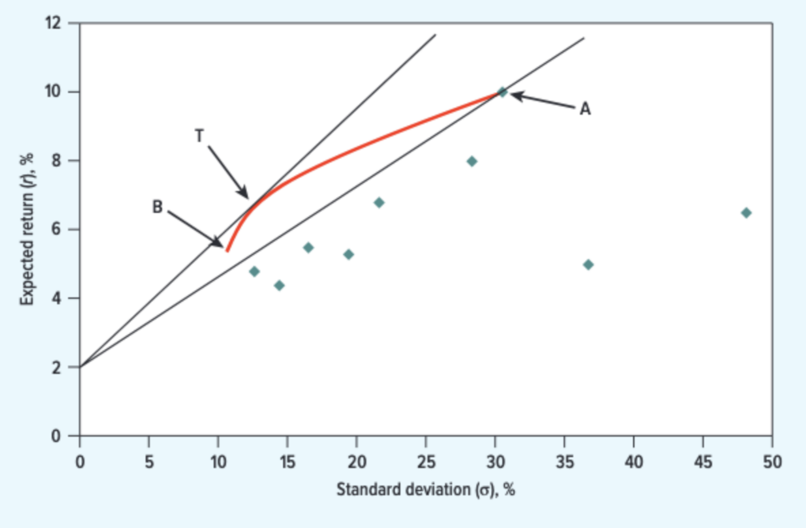
- Possible to show that the range of opportunity can be written as a straight line.
  - Hint: the return formula and the σ formula can be seen as a system of equation.
  - $\omega_f = 1 - \omega_p$

Choosing a portfolio

Lending and borrowing extend the range of opportunity



Choosing a portfolio

- The slope of the line is: $\frac{r_p - r_f}{\sigma_p}$.
- This is called the Sharpe ratio: how much expected return rises when σ increases.
- Lending and borrowing extend the range of opportunity with better alternatives.
- What's the best choice?
- It's the one with the highest Sharpe ratio possible that touches the investment set.
- Therefore, it's the one that is just tangent to point T.
- It means that investors will hold the same portfolio T and a different combination of borrowing and lending according to their risk profile.
- But... only true if all investors have the same information: expected returns, standard deviations and correlations.

Choosing a portfolio

- What does T - the best portfolio available - look like?
- It is the market portfolio *i.e.* the portfolio of all stocks in the economy, where the weights correspond to the fraction of the overall market that each stock represents.
- Thanks to this, all specific risk is diversified away. The risk that remains is market risk.
  - **The risk of a well-diversified portfolio depends on the market risk of the securities included in the portfolio.**
- The line is called the Capital Market Line. It shows the best trade-off between risk and return.
- Its Sharpe ratio is: $\frac{r_m - r_f}{\sigma_m}$

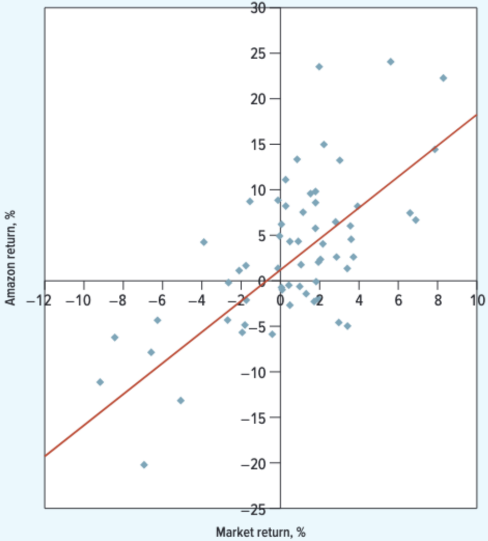
Market risk

- The risk that a stock contributes to a well-diversified portfolio is its **market risk**.
- How to compute market risk, the risk that a stock shares with the market?
  - How sensitive a stock is to market movements.
  - It's called β.
- $\beta_i = \frac{\sigma_{iM}}{\sigma_M^2}$
- with σ_{iM} the covariance between a stock return and the market return and σ_M^2 the variance of the market return.

Market risk

FIGURE 8.1

The return on Amazon stock changes on average by 1.55% for each additional 1% change in the market return. Beta is therefore 1.55.



Market risk

- Stocks with $\beta > 1$ move more than proportionally with the market.
    - *e.g.* Luxury companies
- Stocks with $0 < \beta < 1$ move less than proportionally with the market.
    - *e.g.* Necessity companies
- The β of a portfolio is simple the weighted average of individual β_i.
- Interpretation: A well-diversified portfolio with a beta of 1.5 will end up with 150% of the market's risk.
- When the market rises by 1%, the price of the stock will increase by 1.5%. When the market falls by 2%, its price will fall by 3%.

Market risk

Stock	Beta (β)	Stock	Beta (β)
Tata Motors (India)	1.83	Sony (Japan)	0.82
Hyundai Heavy Industry (Korea)	1.44	BHP Billiton (Australia)	0.80
BP (UK)	1.33	Agricultural Bank (China)	0.74
Siemens (Germany)	1.21	Sanofi (France)	0.55
Toronto Dominion Bank (Canada)	0.89	Nestlé (Switzerland)	0.11

The relationship between risk and return

- Crucial question: How much extra return should earn an investor that bear market risk?
- Capital Market Line: $r_p = r_f + \frac{r_M - r_f}{\sigma_M}\sigma_p \longrightarrow$ expected return for an efficient portfolio with borrowing and lending.
- It does not apply to individual stocks because they are not efficient (contrary to a portfolio).
- An investor should not be rewarded for diversifiable risk. Only for market risk.
- What's the market risk of a stock i?

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- What's the market risk of a stock *i*? It's $\beta_i \sigma_M$.
- $r_i = r_f + \frac{r_M - r_f}{\sigma_M}\beta_i \sigma_M = r_f + \beta_i (r_M - r_f)$
- Equivalently: $r_i - r_f = \beta_i (r_M - r_f)$

$\longrightarrow$ Expected premium on stock = $\beta \times$ expected market risk.

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- Equivalently: $r_i - r_f = \beta_i(r_M - r_f)$

$\longrightarrow$ Expected premium on stock = $\beta \times$ expected market risk.

The CAPM

- The CAPM defines a fundamental relationship between risk and return.
- In a competitive market, the expected risk premium on any security or portfolio, is its β multiplied by the market risk premium.
- *e.g.* the expected risk premium on an investment with a β of 0.5 is half the expected risk premium on the market.
- β is a very useful measure of risk.

- The security market line plots the relationship between β and return.
- Treasury bills have a $\beta = 0$ and a risk premium of zero.
- The market portfolio has $\beta = 1$ and a risk premium of $r_M - r_f$.

The CAPM

The Security Market Line

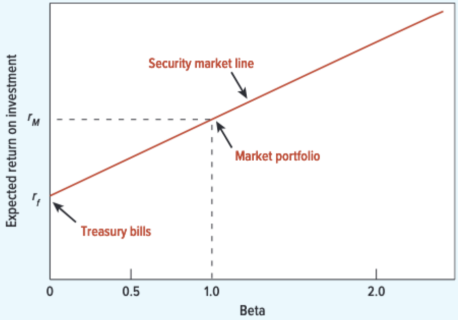

FIGURE 8.3

The capital asset pricing model states that the expected risk premium on each investment is proportional to its beta. This means that each investment should lie on the sloping security market line connecting Treasury bills and the market portfolio.

The CAPM

- The CAPM helps the estimate the cost of equity.
    - Opportunity cost of holding the equity of the firm.
    - Foregone return for investors of holding other firms' equity with similar risk.
- To compute it, we need:
    1. Which alternative projects should be used to compare the current firm to.
    2. Forecast the returns from investing in these alternative opportunities.
- When assets are risky, (risk-averse) investors need to be compensated for bearing the risk of that asset in excess of holding a risk-free asset.
- **CAPM:** $r_i - r_f = \beta_i(r_M - r_f)$
- The only stock-specific variable is the β:measure of how the stock's return move with the market.

The CAPM

- **CAPM:** $r_i = r_f + \beta_i(r_M - r_f)$

The CAPM

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  - How to get expected future returns? Take average past return (*e.g.* on NYSE, or Euronext) to forecast future returns. Need to define over which horizons.

The CAPM

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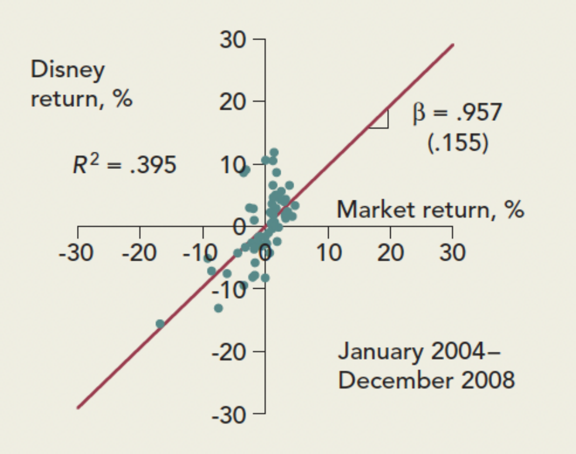
- r_f
  - In the U.S.: government bonds. Need to define the maturity (usually short, because the CAPM is a short-run model).
- β_i
  - Use past returns of projects/firms in the same industry.
  - Look at how the return of the stock move with the market return.
  - If returns are not available for the firm/project, find comparable public companies (a *pure play*) and take their average beta.

The CAPM

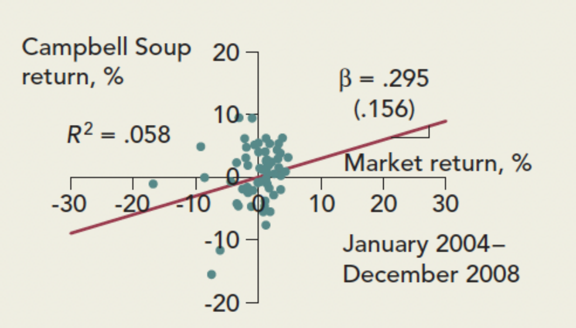
Amazon
return, %
R^2 = .297
β = 2.156
(.436)
Market return, %
January 2004–
December 2008
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-30
-20
-10
0
10
20
30

The CAPM



Disney return, %
$R^2 = .395$
$\beta = .957$ (.155)
Market return, %
January 2004–December 2008
30
20
10
0
-10
-20
-30
-30 -20 -10 0 10 20 30

The CAPM



Campbell Soup
return, %
20
10
0
-10
-20
R^2 = .058
β = .295
(.156)
Market return, %
-30
-20
-10
0
10
20
30
January 2004–
December 2008

The CAPM

- This method will give the equity beta of the *pure plays*.
- To get the asset's beta, we need to unlever the beta:

$$\beta_A = \frac{E}{E+D}\beta_E + \frac{D}{E+D}\beta_D$$

- β_D is the covariance between the pure play's return on its debt and the market return.
    - Hard to observe but for investment grade debt (above BBB), we can assume that β_D is zero. Otherwise it is likely to be small.

The CAPM

- General Conglomerates is evaluating an oil exploration project proposed by the manager of its aviation division

Company	Equity-to-assets ratio	Equity beta	Debt beta
General American Oil	0.85	1.81	0
Flight Airlines	0.5	2	0.25
Everything Conglo	0.95	1.1	0
Louisiana Oil	0.63	2.36	0.12
Mesa Petroleum	0.77	1.9	0.05

The CAPM

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- $\beta_{GAO} = 0.85 * 1.81 + 0.15 * 0 = 1.539$

The CAPM

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- $\beta_{GAO} = 0.85 * 1.81 + 0.15 * 0 = 1.539$

- $\beta_{LOO} = 0.63 * 2.36 + 0.37 * 0.12 = 1.531$

The CAPM

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- $\beta_{MP} = 0.77 * 1.9 + 0.23 * 0.05 = 1.475$

The CAPM

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- $\beta_{GAO} = 0.85 * 1.81 + 0.15 * 0 = 1.539$
- $\beta_{LOO} = 0.63 * 2.36 + 0.37 * 0.12 = 1.531$
- $\beta_{MP} = 0.77 * 1.9 + 0.23 * 0.05 = 1.475$
- Average is 1.515.

The CAPM

- The CAPM is a model and therefore simplifies the reality.
- But it is useful to understand the risk associated to a stock.
  - 73% of investors use it to compute the cost of capital (Graham and Harvey, 2001).
  - Alternative is to use the DCF formula to get $r_E = \frac{DIV_1}{P_0} + g$ (cf. last lecture) but it is less common.
- Does it hold in real life?

The CAPM

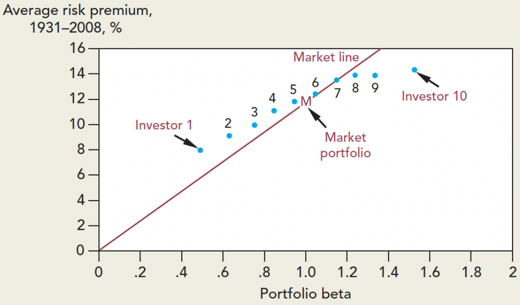

FIGURE 8.8

The capital asset pricing model states that the expected risk premium from any investment should lie on the security market line. The dots show the actual average risk premiums from portfolios with different betas. The high-beta portfolios generated higher average returns, just as predicted by the CAPM. But the high-beta portfolios plotted below the market line, and the low-beta portfolios plotted above. A line fitted to the 10 portfolio returns would be "flatter" than the market line.

Source: F. Black, "Beta and Return," *Journal of Portfolio Management* 20 (Fall 1993), pp. 8–18. © 1993 Institutional Investor. Used with permission. We are grateful to Adam Kolasinski for updating the calculations.

Note: Investor 1 invests in the stocks that have betas in the first decile, Investor 2 in those that have betas in the second decile, *etc.*

The CAPM

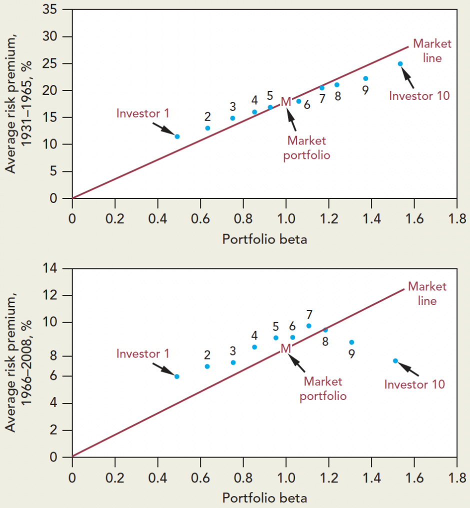

FIGURE 8.9

The relationship between beta and actual average return has been weaker since the mid-1960s. Stocks with the highest betas have provided poor returns.

Source: F. Black, "Beta and Return," *Journal of Portfolio Management* 20 (Fall 1993), pp. 8–18. © 1993 Institutional Investor. Used with permission. We are grateful to Adam Kolasinski for updating the calculations.

The CAPM

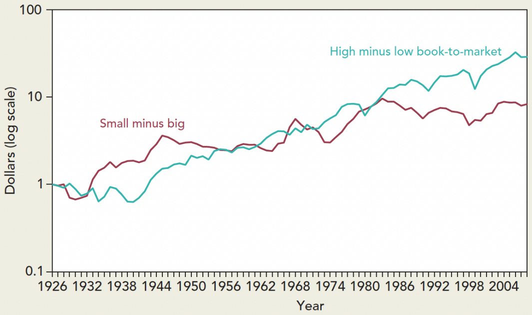

FIGURE 8.10

The red line shows the cumulative difference between the returns on small-firm and large-firm stocks. The green line shows the cumulative difference between the returns on high book-to-market-value stocks (i.e., value stocks) and low book-to-market-value stocks (i.e., growth stocks).

Source: Kenneth French's Web site, **mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html**. Used with permission.