Finance

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Marinus van Reymerswale, *The Money Changer and his Wife*, 1539

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3. Make investment decision using the appropriate investment decision rule.

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  - Has to do with the fundamental uncertainty of the future.
  - Is directly related to r.
- Propose a general model for the expected return on a financial asset.
  - Go beyond the formula: $r = \frac{DIV_1}{P_0} + g$, which is less general.

Risk

Definition

- Knight (1921) : Risk is uncertainty that you can quantify.
  - Risk is generally seen as negative.
  - Risk is actually dual as it can provide good and bad outcomes.
    - A successful business does not avoid risk; it weighs risk appropriately.

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Risk and return

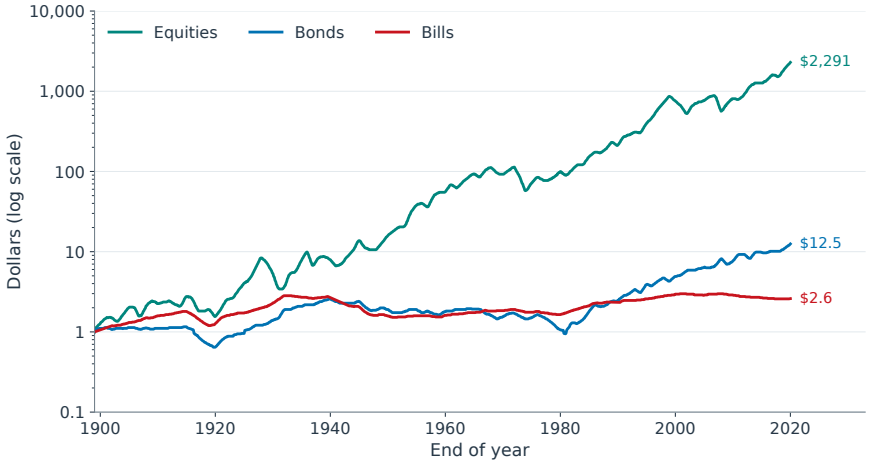
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  - U.S. long-term Treasury bonds: risk of interest-rate changes (prices fall when interest rates increase).
  - A portfolio of U.S. stocks: riskier, depends on the above risk and on the performance of companies.

Risk and return

Real returns in the 20th century



Risk and return

Investment	**Nominal return** (%)	**Real return** (%)	**Risk premium vs. bills** (%)
Treasury bills	3.7	0.9	0.0
Government bonds	5.4	2.6	1.7
Stocks	11.5	8.5	7.8

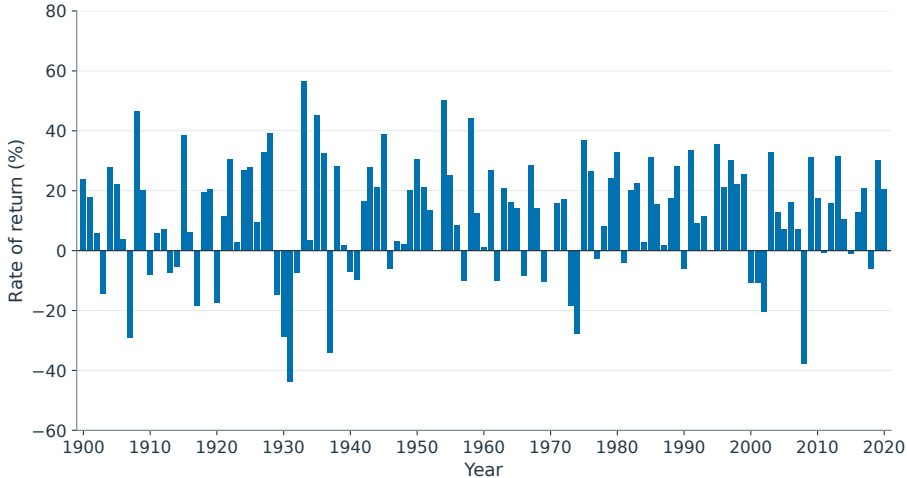
Risk and return

- Returns seem 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 rates, 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?

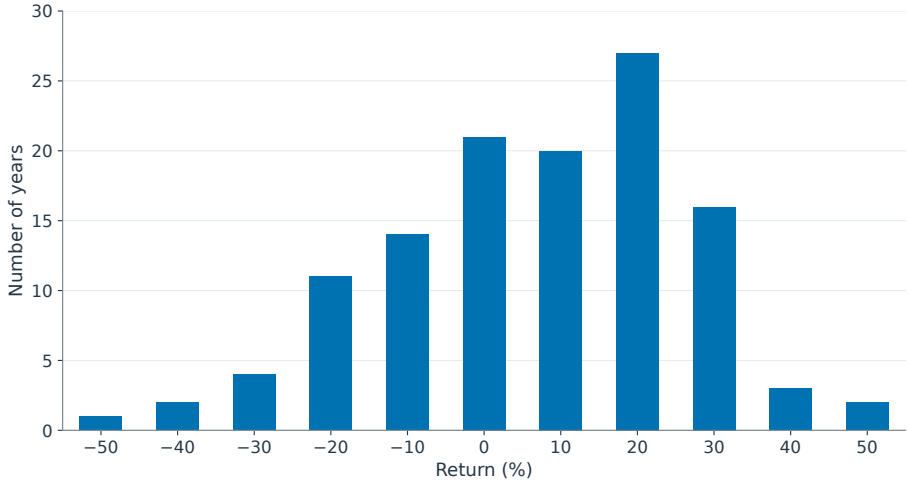
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- Approximation: take today r_f and add the observed past risk premium (7.8%).
- Assuming $r_f = 2\%$, what is r_m? $r_m = 9.8\%$.
- Assumption that there is a stable risk premium on equity.
- Evaluating risk involves a lot of uncertainty and heterogeneity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

Risk premium does not come for free



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Measuring risk

- We want a metric to measure risk. Any idea?

Measuring risk

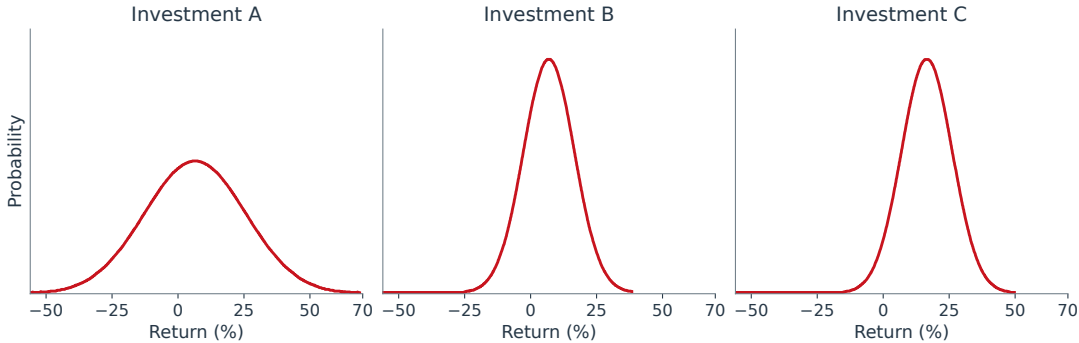
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Measuring risk

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- Note that the distribution of returns 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 from 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: $\sigma_{r_i} = \sqrt{V(r_i)}$

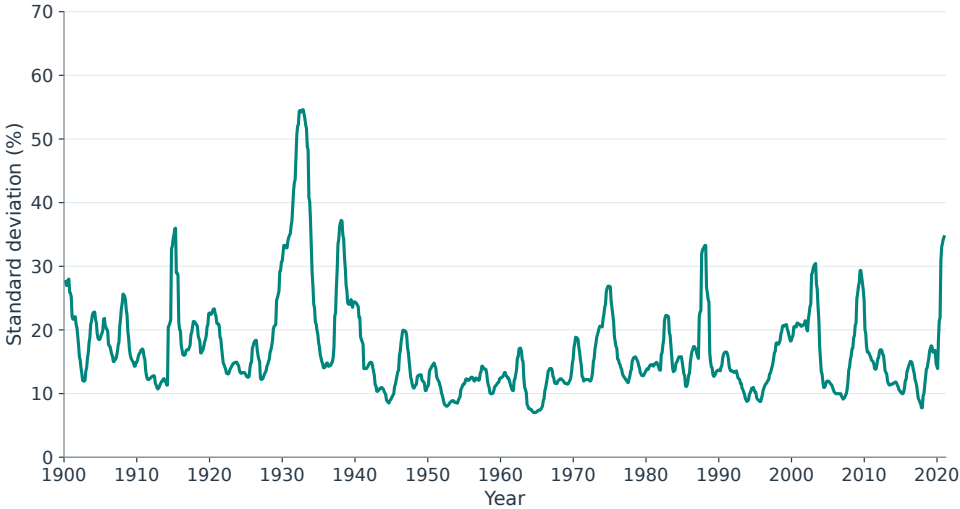
Measuring risk



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

Company	Stock σ (%)	Market σ (%)	Company	Stock σ (%)	Market σ (%)
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

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- $V(X+Y) = V(X) + V(Y) + 2\,\mathrm{Cov}(X,Y)$
- For a portfolio with weights ω: $V(\omega_X X + \omega_Y Y) = \omega_X^2 V(X) + \omega_Y^2 V(Y) + 2\omega_X\omega_Y\rho_{XY}\sigma_X\sigma_Y$ with ρ_{XY} the correlation between X and Y

Risk and diversification

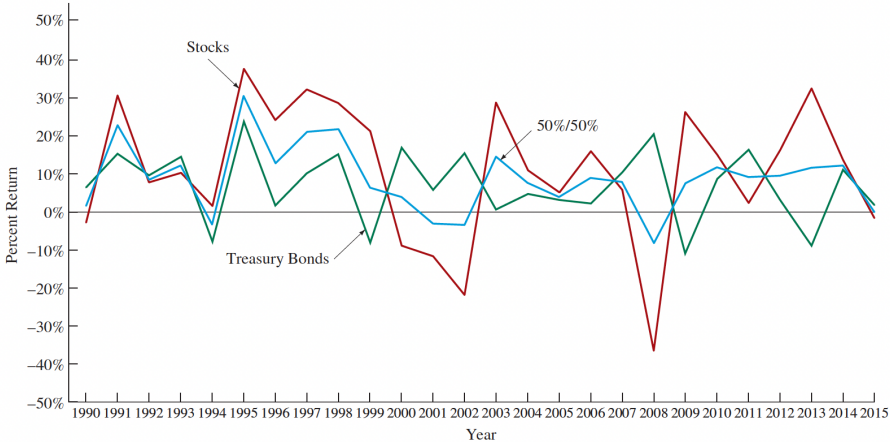
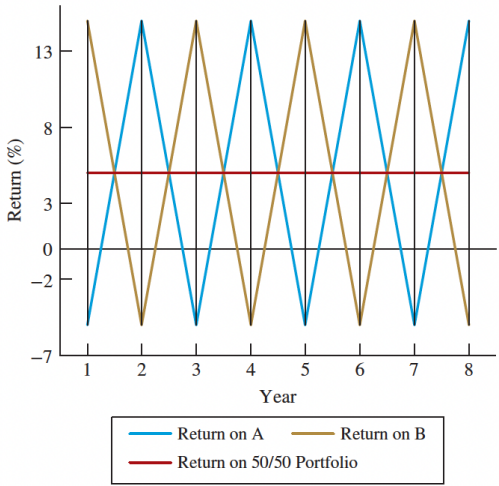


FIGURE 12.4b **Stocks, Treasury Bond Returns, and Returns on a 50/50 Stock/Bond Portfolio, 1990–2015**

Risk and diversification



Risk and diversification

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

Compute the return and standard deviation when you invest half in each stock.

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  $V_p = 0.25(0.1^2 + 0.15^2) + 0.5(0.1)(0.15)(0.2) = 0.009625, \quad \sigma_p \approx 0.0981.$
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- $\rho_{12} = -1$:
  $V_p = 0.25(0.1^2 + 0.15^2) - 0.5(0.1)(0.15) = 0.000625, \quad \sigma_p = 0.025.$

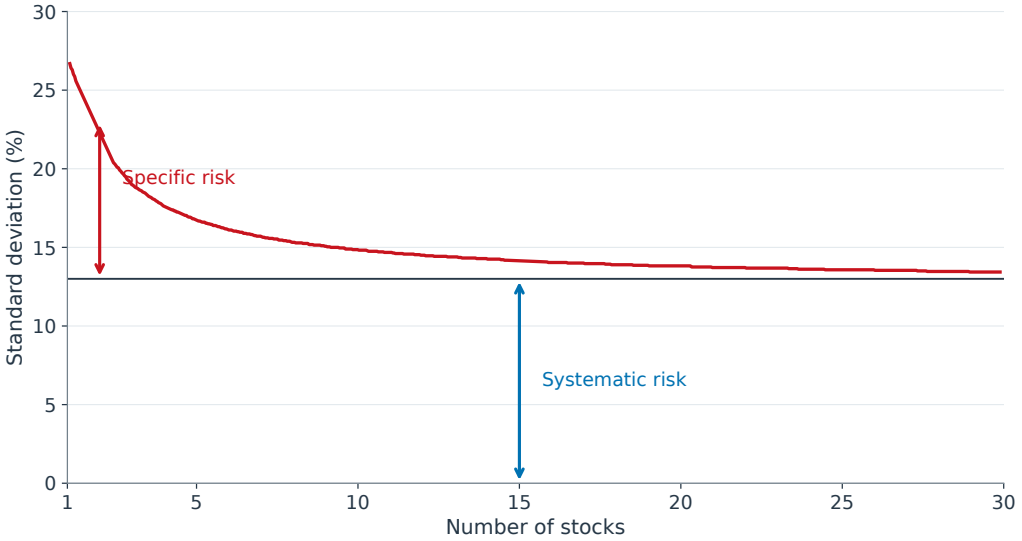
Where does risk come from?

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

Where does risk come from?

Diversifiable risk Unsystematic, firm-specific, or micro risk	**Undiversifiable risk** Systematic, market, or macro risk
Business risk	Market risk
Financial risk	Interest rate risk
Event risk	Purchasing power risk
Tax risk	Exchange rate risk
Liquidity risk	

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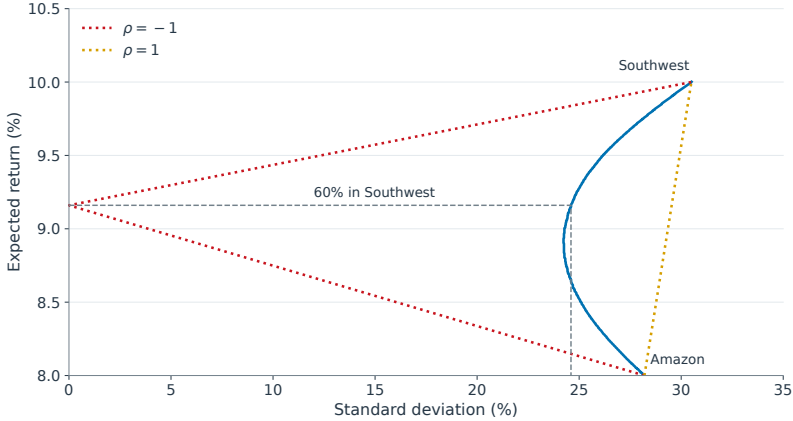
Choosing a portfolio

- What's the best portfolio to hold?

Choosing a portfolio

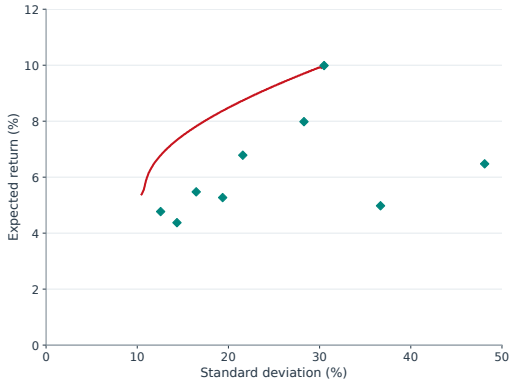
- What's the best portfolio to hold?
- That's exactly the question Harry Markowitz asked in 1952.
- The *investment opportunity set* represents all the available combinations of risk and return.
- **Efficient portfolios** are the set of the best portfolios you can achieve with a given investment strategy.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

Choosing a portfolio



Choosing a portfolio

- Each dot represents a stock.
- Many combinations of them are possible.
- The red line shows **efficient portfolios**, those that offer the best return-to-risk ratios.



Choosing a portfolio

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- 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.
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- $\textit{Return} = (\omega_f r_f + \omega_p r_p)$, $\sigma = \omega_p \sigma_p$ because $\sigma_f = 0$

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- The return formula and the σ formula can be seen as a system of equations.

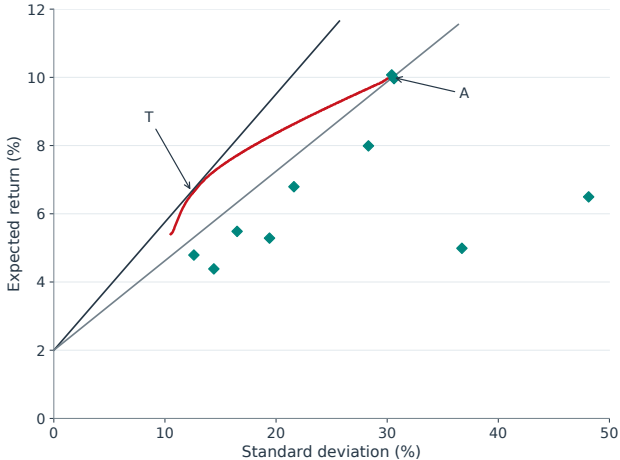
$$\begin{cases} r = \omega_f r_f + \omega_p r_p \\ \sigma = \omega_p \sigma_p \end{cases}$$

- Using $\omega_p = \frac{\sigma}{\sigma_p}$ and $\omega_f = 1 - \omega_p$:

$$\boxed{r = r_f + \frac{r_p - r_f}{\sigma_p}\sigma}$$

Choosing a portfolio

Lending and borrowing extend the range of opportunity



Choosing a portfolio

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- What's the best choice?
- Choose the line with the highest Sharpe ratio (efficiency) that touches the investment set (constraint) $\longrightarrow$ tangent at point T.
- 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 $\longrightarrow$ efficient markets.

Choosing a portfolio

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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: $\frac{r_m - r_f}{\sigma_m}$

$\longrightarrow$ All investors should hold the same portfolio, which is the market portfolio.

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  - This is the **market risk** of a stock, which cannot be diversified away.
- How can we measure this exposure to market risk?

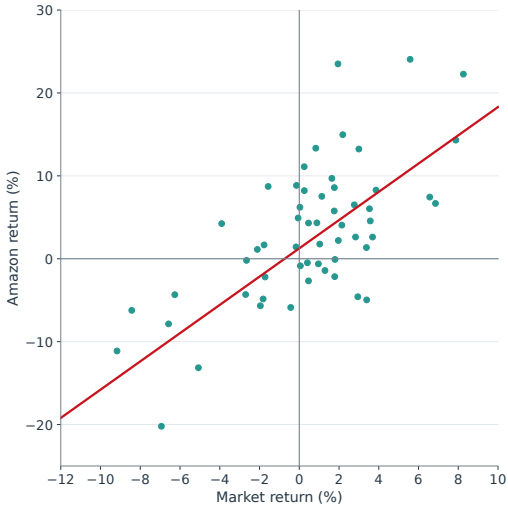
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- How can we measure this exposure to market risk?
- By measuring how sensitive the stock's return is to market movements: its **beta** (β).

$$\boxed{\beta_i = \frac{\mathsf{Cov}(r_i, r_M)}{\mathsf{Var}(r_M)}}$$

Choosing a portfolio

- It simply corresponds to the line of best linear fit (or OLS) between r_i and r_m.
- The return on Amazon increases on average by 1.55% when the market return increases by 1%.
- Its beta is 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 simply 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

Company	**Beta (β)**	**Company**	**Beta (β)**
Tata Motors (India)	1.83	Sony (Japan)	0.82
Hyundai Heavy Industry (Korea)	1.44	BHP Billiton (Australia)	0.80
BP (U.K.)	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

- How much extra return should an investor who bears market risk earn?
- 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.
- An investor should not be rewarded for diversifiable risk. Only for market risk.
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- $r_i = r_f + \frac{r_M - r_f}{\sigma_M}\beta_i \sigma_M = r_f + \beta_i (r_M - r_f)$
- Equivalently: $r_i - r_f = \beta_i (r_M - r_f)$

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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.

$\longrightarrow$ One of the most famous equations in finance: the equation of the **Capital Asset Pricing Model** (CAPM).

The Capital Asset Pricing Model (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 (and simple) measure of risk.
- Assumptions behind the CAPM: all investors are mean-variance optimizers, they can borrow/lend at the risk-free rate, and they face the same information and beliefs.

The Capital Asset Pricing Model (CAPM)

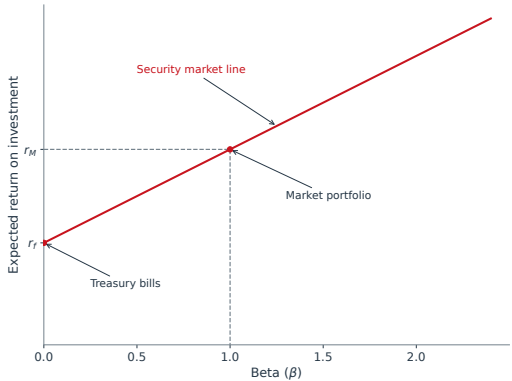
The Security Market Line

- 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 Capital Asset Pricing Model (CAPM)

The Security Market Line

- The CAPM states that the expected risk premium on each investment is proportional to its beta.
- Each investment should lie on the SML, connecting Treasury bills and the market portfolio.



The Capital Asset Pricing Model (CAPM)

- The CAPM helps to 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 with the current firm.
  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 β: a measure of how the stock's return moves with the market.

The Capital Asset Pricing Model (CAPM)

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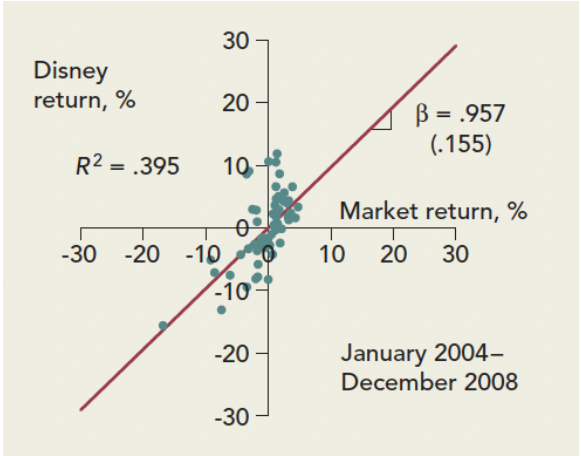
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- β_i
  - Use past returns of projects/firms in the same industry.
  - Look at how the return of the stock moves with the market return.
  - If returns are not available for the firm/project, find comparable public companies (a *pure play*) and take their average beta.

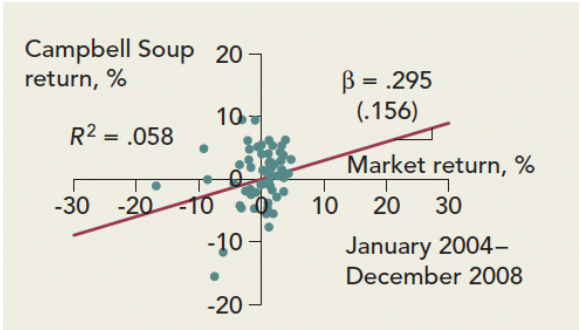
The Capital Asset Pricing Model (CAPM)



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The Capital Asset Pricing Model (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 Capital Asset Pricing Model (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	0.00
Flight Airlines	0.50	2.00	0.25
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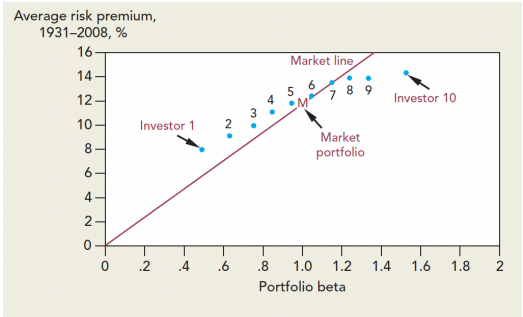
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- Average is 1.515.

The Capital Asset Pricing Model (CAPM)

- The CAPM is a model and therefore simplifies reality.
- But it is useful for understanding the risk associated with a stock.
  - 73% of investors use it to compute the cost of capital (Graham and Harvey, 2001).
  - An 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 and less general.
- Does it hold in real life?

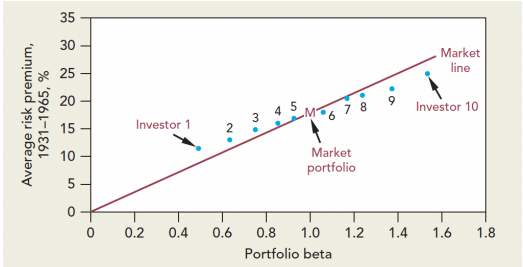
The Capital Asset Pricing Model (CAPM)

- Investor 1 invests in the stocks that have betas in the first decile; Investor 2 invests in those that have betas in the second decile.
- In the CAPM, any investment should lie on the SML.
- The positive and linear relationship between beta and risk holds.
- But with a smaller slope.



The Capital Asset Pricing Model (CAPM)

- The relationship has been less sharp in recent years.



The Capital Asset Pricing Model (CAPM)

- Lines correspond to the cumulative difference in returns for two different types of stocks.
- In the CAPM, the only reason for different returns is the beta.
- This is invalidated by the figure, which shows other determinants of returns.

