CORPORATE FINANCE FOR LONG-TERM VALUE

Chapter 12: Risk-return analysis

Part 4: Risk, return and impact

Chapter 12: Risk-return analysis

The BIG Picture

- How to analyse risk and return profiles for all types of capital?

Methods

- Finance uses several tools (volatility, correlation, diversification) to calculate risk return of individual assets, asset classes and asset portfolios
- Key insight is to split between systematic risk (which is not diversifiable and priced) and idiosyncratic risk (which is firm-specific and is not priced)
- Social and environmental risk are increasingly seen as sources of systematic risk
- Most tools are backward-looking using historical data
- Forward-looking measures (scenario analysis, real options) are needed to include new risks, like climate risk

Historical financial risk and return

- Two key questions for investors:
  1. **Financial return:** what can you earn on investing in an asset?
  2. **Financial risk:** what can you lose on holding an asset?
- Investors are assumed to be risk averse, so they ask compensation for higher risk in the form of a risk premium on risky assets
- The average annual return $\bar{r}$ is the average realised return for years $n = 1$ to N:

$$\bar{r} = \frac{1}{N} \cdot (r_1 + r_2 + \cdots + r_N) = \frac{1}{N} \cdot \sum_{n=1}^{N} r_n$$

Real returns

- Because of wide differences in inflation across time and countries, it is helpful to compare returns in real terms
- The realised consumer price index (CPI) inflation rate in a given country i and year t:

$$i_{i,t} = \frac{(CPI_{i,t} - CPI_{i,t-1})}{CPI_{i,t-1}}$$

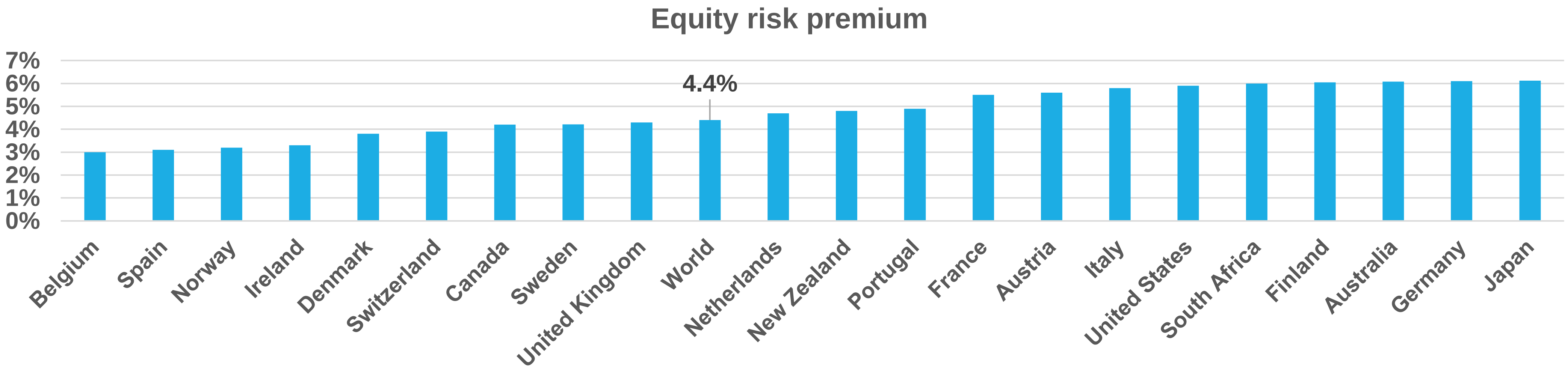
- Inflation-adjusted real returns r^r for an asset class is: $r^r = \frac{(1+r)-(1+i)}{1+i} = \frac{r-i}{1+i} \approx r - i$

Asset class	Average nominal returns	Average real returns	Decadal moving average real returns
Treasury bills	4.6%	1.0%	-5% to +6%
Government bonds	6.1%	2.5%	-7% to +8%
Equities	10.7%	6.9%	-4% to +15%
Risk premium (relative to bills)	6%	6%	0% to 13%
Risk premium (relative to bonds)	4.5%	4.5%	0% to 13%

Global average annual returns from 1870 to 2015 (in 16 countries). Source: Jorda, et al. (2019)

Equity risk premium

- The aggregate picture hides significant variation within and between asset classes due to differing risk profiles
- Dimson, Marsh and Staunton (2021) find significant variation in equity risk premiums over the 1900-2020 period



Equity risk premiums (relative to bills) from 1900 to 2020 (for 21 countries). Source: data from Dimson, Marsh and Staunton (2002 and 2021)

Equity returns

- The total annual return on a financial asset r can be divided into two components:
  - The capital gain from the change in the asset price P
  - A yield component y, that reflects the cash-flow return on an investment (e.g. dividend yield)

- Total return: $r_{t+1} = \frac{P_{t+1} - P_t}{P_t} + y_t$

	Equity		
Time period	Real capital gain	Dividend income	Real total return
Full sample	2.8%	4.1%	6.8%
Post-1950	4.7%	3.8%	8.4%

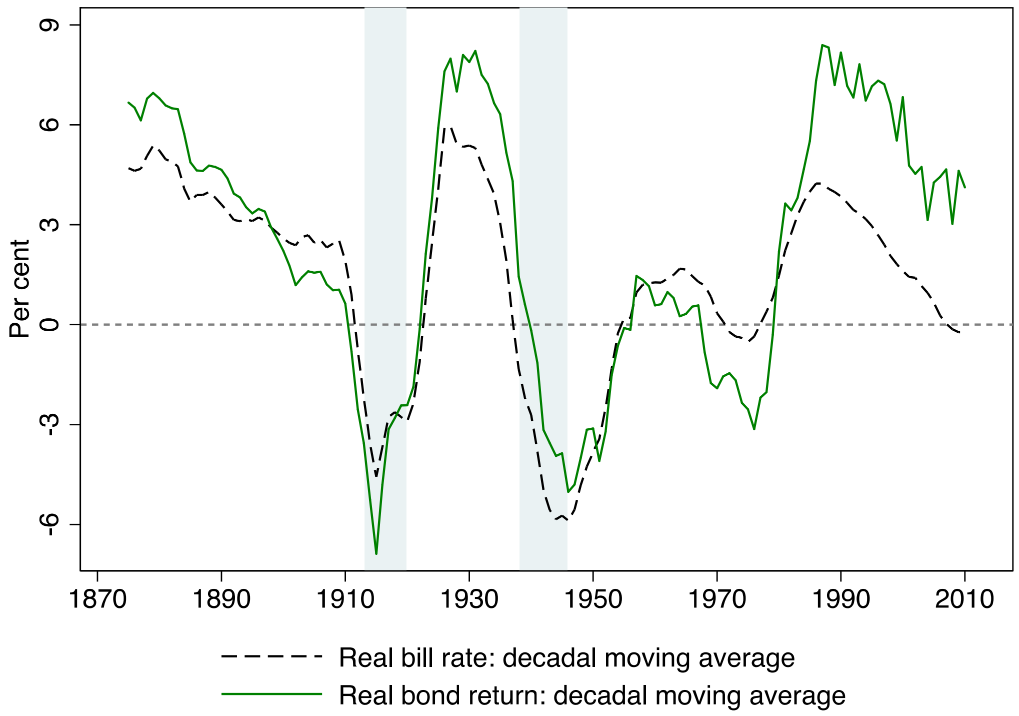
Equity returns from 1870 to 2015. Source: Jorda, et al. (2019)

Insights:

- For the total return of equities both the capital gain and dividend income are important
- More recent returns (from 1950 to 2015) are higher than over the full sample period (1870-2015)
- Real returns on equities and government bonds have been relatively high until the 1990s
- Only current returns in the low interest environment from 2015 to 2021 have been very low: 3% for equities and -0.5% for government bonds

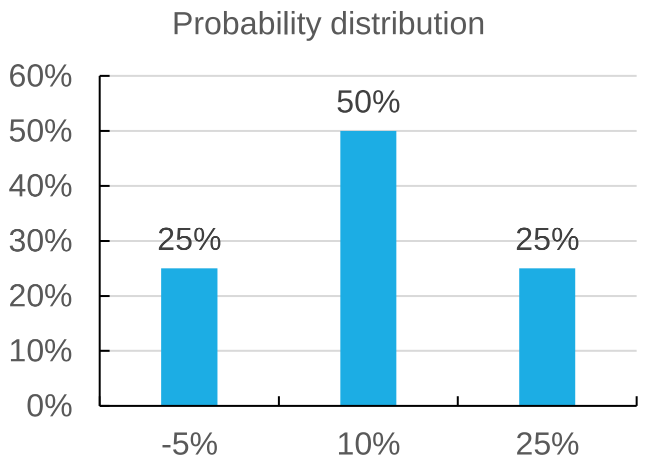
Bill rate (= short-term interest rate)

- Historical series show that returns can turn negative during wars and times of crisis
- The Treasury bill rate, which is a proxy for the risk-free rate, averages about 1%
  - -4% during WWI in the 1910s
  - +6% post WWI in the 1920s
  - -5% during WWII in the 1940s
  - +3% in the 1980s
  - 0% in 2015



Expected return

- The performance of assets or projects is typically measured as a return r: the percentage increase in the value of an investment per euro invested in the asset
- Risky assets have uncertain returns in the future.
- The probability distribution shows the distribution of returns, by assigning a probability or likelihood p_r to each possible return
- The expected or mean return $E[r]$ as a weighted average of possible returns, with the probabilities as weights:



$$E[r] = \sum_r p_r \cdot r$$

Probability x each possible return

Current stock price	Stock price in 1 year	Probability distribution	
		Return r	Probability p_r
	€95	-5%	25%
€100	€110	10%	50%
	€125	25%	25%

$$E[r] = 25\% \cdot -5\% + 50\% \cdot 10\% + 25\% \cdot 25\% = \mathbf{10\%}$$

Variance and standard deviation

- The standard statistical measures of the risk probability distribution are variance and standard deviation
  - The variance of the return distribution is the expected squared deviation from the mean return from previous equation

$$Var[r] = E[(r - E[r])^2] = \sum_r p_r \cdot (r - E[r])^2$$

  - The standard deviation is simply the square root of the variance

$$SD[r] = \sqrt{Var(r)}$$

- The standard deviation can predict future values with a certain confidence level (about 68% for 1 standard deviation)
- In finance, this standard deviation is also called the volatility of a stock

Calculating variance and volatility

Problem

Suppose stock X is equally likely to have a 20% return or a -10% return. What are the stock's expected return and volatility?

Solution

The expected return is calculated by taking the weighted average of possible returns:

$$E[r] = \sum_r p_r \cdot r = 50\% \cdot 0.20 + 50\% \cdot -0.10 = 5.0\%$$

The variance of stock X:

$$Var[r] = \sum_r p_r \cdot (r - E[r])^2 = 0.50 \cdot (0.20 - 0.05)^2 + 0.50 \cdot (-0.10 - 0.05)^2 = \mathbf{0.0225}$$

The volatility of stock X is the square root of the variance: $\sqrt{0.0225} = \mathbf{15\%}$

Historical returns and historical volatility

- As the future probability distribution of returns is not known, investors use historical returns to calculate the expected return and volatility of assets
- The underlying assumption is that the volatility of historical return patterns provides a good indicator or proxy of future risk
  - Structural changes at companies and in the wider economy, including sustainability trends, violate this assumption

Asset class	Average annual return	Standard deviation
Treasury bills	3.4%	3.1%
Corporate bonds	6.2%	6.4%
S&P 500	12.0%	19.8%
Small stocks	18.7%	39.2%

Average annual returns and volatility for the United States, from 1926 to 2017
Source: Berk and DeMarzo (2020)

S&P 500 covers large companies

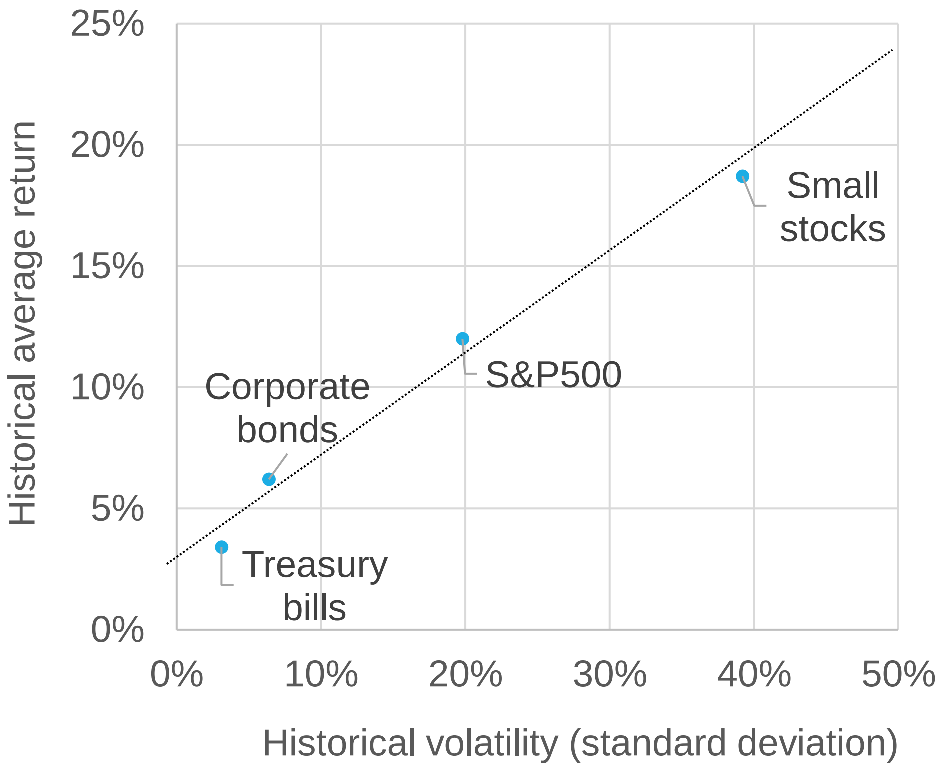
Small stocks are far riskier (higher volatility)

Historical returns and historical volatility

- The relationship between higher reward and higher risk is more or less linear
  - Bills are seen as a risk-free asset r_f
  - The expected return in excess of the bill rate is the risk premium RP that investors receive for holding a risky asset i

$$RP = E[r_i] - r_f$$

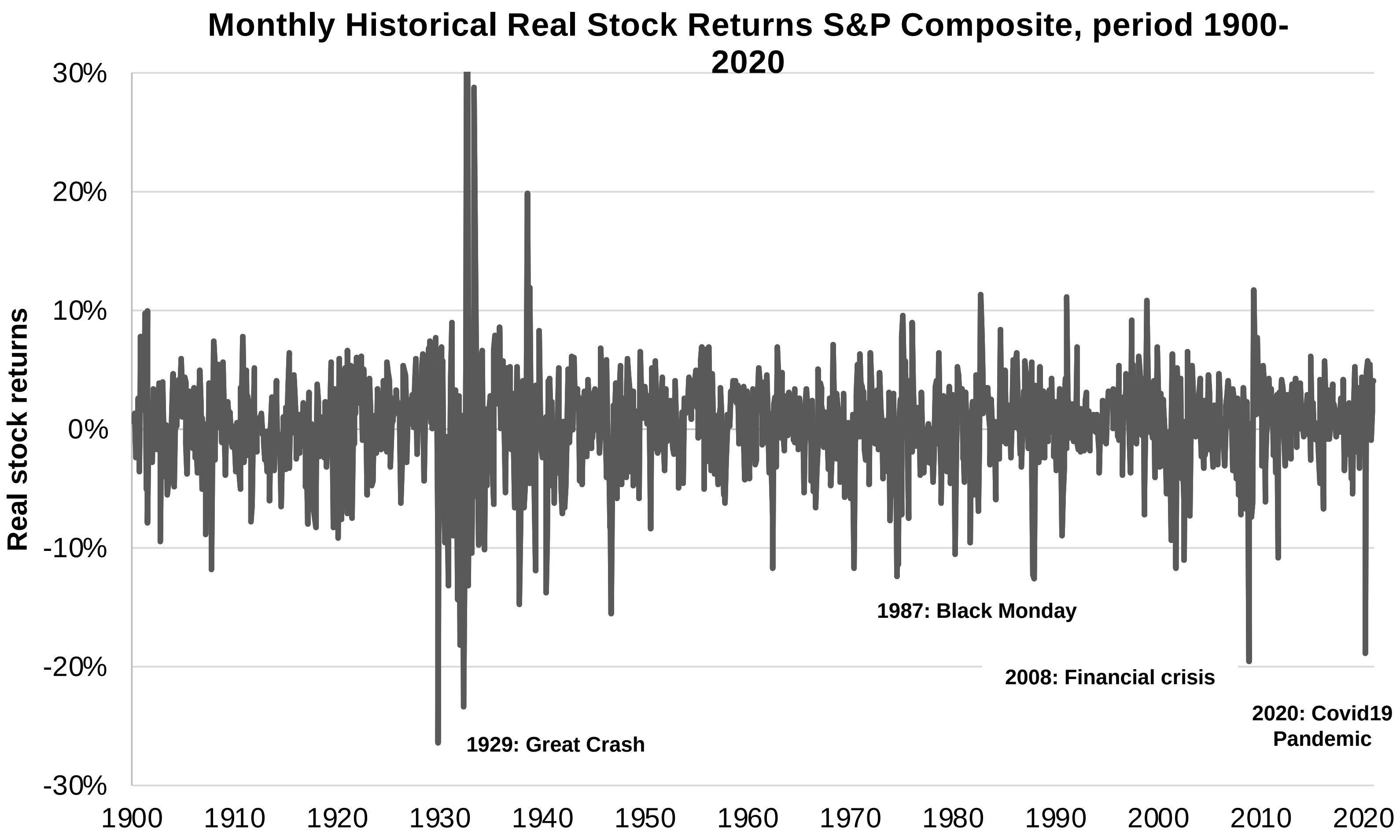
  - The risk premium for large companies (in the S&P500) is about 8% = 12% - 4%
  - Remember this high number of 8% is from the 1926-2017 period with high returns



Average annual returns and volatility for the United States, from 1926 to 2017
Source: Berk and DeMarzo (2020)

Stock performance vs. government bonds

- US stocks have outperformed US bonds in every 30-year period since 1850
- Neared zero in the Great Depression of the 1930s and the Global Financial Crisis of 2008-2009

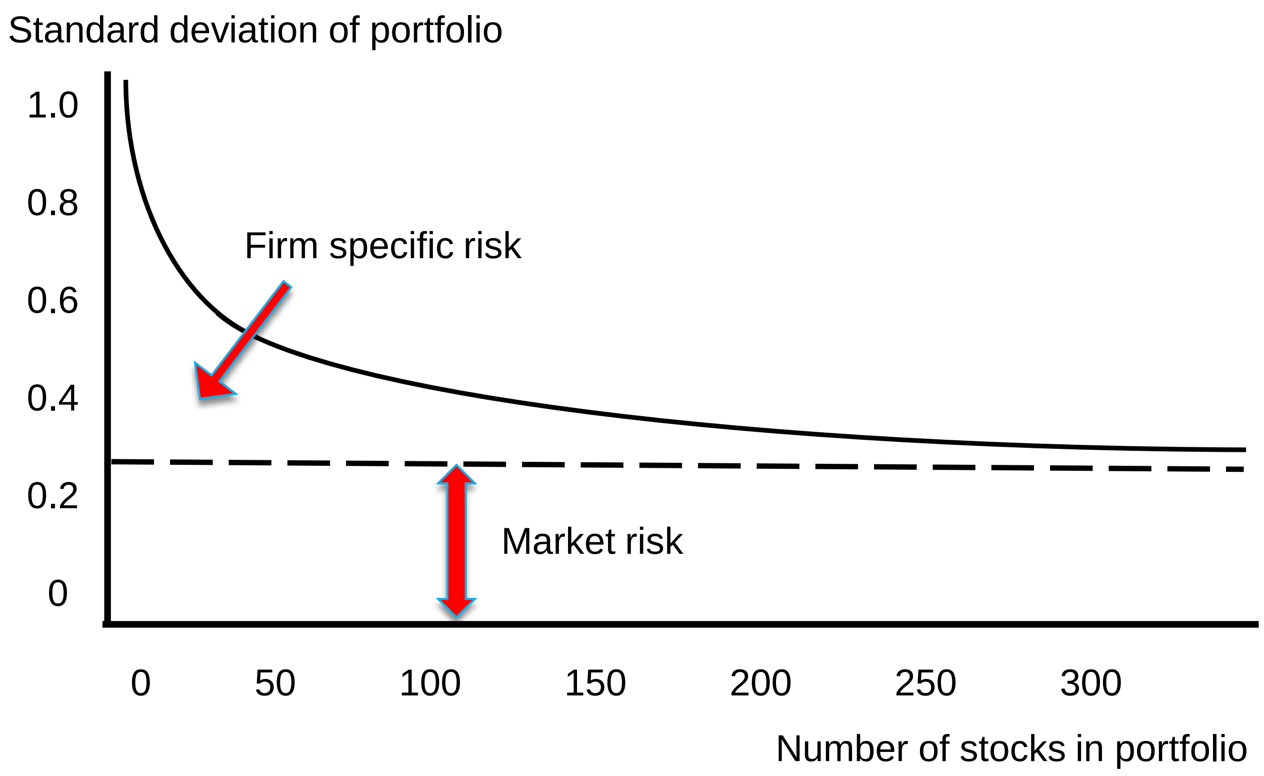


Diversification of financial risk

- To hedge against risk, an investor may want to diversify its stock holdings in an investment portfolio
  - Classical example: hold stock in an umbrella company and in an ice cream company
- The risk of fluctuating stock prices can be split into:
  - **Firm-specific risk** (idiosyncratic risk): unique to the company and can be diversified in a portfolio
  - **Market risk** (systematic risk): common to all companies and cannot be diversified
    - Example of the business cycle: in a downturn almost all companies will have lower returns
    - Only market risk is priced in financial markets, as systematic risk cannot be diversified away
- How many stocks do you need for a diversified portfolio?
  - Statman (2004) shows that a well-diversified stock portfolio needs to include just 50 to 100 stocks to eliminate firm-specific or idiosyncratic variance of stock returns

Diversification of financial risk

- There are smaller benefits of diversification beyond those 100 stocks, but they are exhausted when the number of stocks surpasses 300 stocks



Portfolio return

- The expected portfolio return r_p is a weighted combination of individual stock returns r_i, with weights x_i for each stock i:

$$E[r_p] = \sum_i x_i \cdot E[r_i]$$

- The derivation of portfolio risk is more difficult than for portfolio return
  - Only when stocks are fully correlated can we take the average of the individual standard deviations
- In practice, most stocks have a correlation of less than 1: $0 \leq \rho < 1$
- Stocks can even be negatively correlated: $-1 \leq \rho < 0$

Portfolio variance

- The portfolio variance is made up of the variance of the individual stocks and the covariance between the individual stocks
  - The covariance between two stocks σ_{12} is the product of the correlation coefficient ρ_{12} and the two standard deviations:

$$\sigma_{12} = \rho_{12} \cdot \sigma_1 \cdot \sigma_2$$

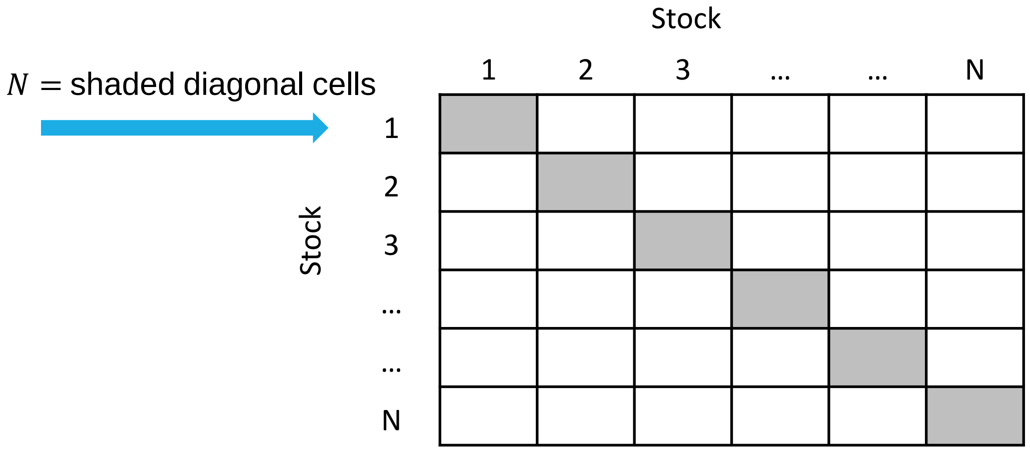
Portfolio variance: $Var[r_p] = x_1^2 \cdot \sigma_1^2 + x_2^2 \cdot \sigma_2^2 + 2 \cdot x_1 \cdot x_2 \cdot \rho_{12} \cdot \sigma_1 \cdot \sigma_2$

variance of two stocks + covariance between stocks

- The standard deviation of a portfolio is the square root of the portfolio's variance

Variance of large portfolios

- To derive the general formula for the variance of a portfolio with N stocks:
  - The weight of each stock is: $x_i = \frac{1}{N}$
  - We have N cells with the variance of each stock $x_i^2 \cdot \sigma_i^2$
  - The remaining $N^2 - N$ cells contain the covariances between stocks $x_i \cdot x_j \cdot \rho_{ij} \cdot \sigma_i \cdot \sigma_j$



Source: Adapted from Brealey, Myers, Allen and Edmans (2022)

$$Var[r_p] = N \cdot \left(\frac{1}{N}\right)^2 \cdot \sigma_i^2 + (N^2 - N) \cdot \left(\frac{1}{N}\right)^2 \cdot \rho_{ij} \cdot \sigma_i \cdot \sigma_j$$

$$= \frac{1}{N} \cdot \sigma_i^2 + \left(1 - \frac{1}{N}\right) \cdot \rho_{ij} \cdot \sigma_i \cdot \sigma_j$$

$$= \frac{1}{N} \text{ x average variance } + \left(1 - \frac{1}{N}\right) \text{ x average covariance}$$

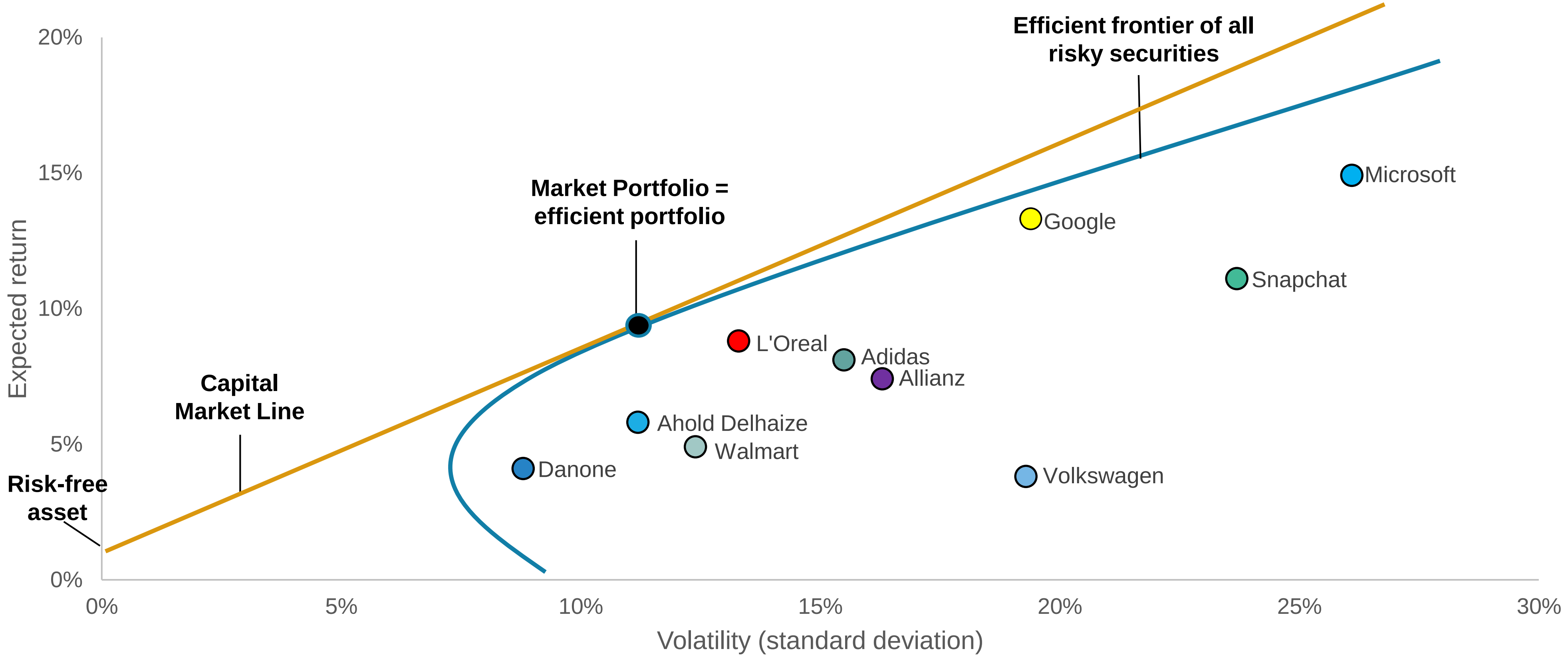
- As the number of stocks in the portfolio N increases, the portfolio variance becomes the average covariance of the stocks in the portfolio and **the correlation of each stock to the portfolio determines its contribution to overall portfolio risk** ← **core of portfolio diversification**

Capital Asset Pricing Model (CAPM)

- The risk-return measures and the principles of portfolio diversification provide the building blocks for the Capital Asset Pricing Model (CAPM)
- CAPM assumes that diversification through combining risky stocks in a portfolio eliminates the firm-specific risk of individual stocks
- An efficient portfolio is a stock portfolio whereby investors cannot increase return given the level of risk (volatility)

Efficient frontier

- The efficient frontier is the combination of highest return portfolios for each volatility level
- The capital market line shows the combinations of the efficient portfolio and the risk-free asset



Efficient frontier

- The tangent portfolio provides the highest possible return for a given level of volatility of any (efficient) portfolio available
- Assuming that investors have homogeneous expectations, all investors want to hold this tangent portfolio ← **it becomes the market portfolio**
- A key insight of the CAPM is that all investors hold a combination of the risk-free asset and the market portfolio in equilibrium

Capital Asset Pricing Model (CAPM)

- CAPM states that returns vary proportionally with market risk:

$$r_i = r_f + \beta_i \times [E(r_{MKT}) - r_f]$$

- Where r_i is the return of a stock *i*, $E(r_{MKT})$ the return on the market portfolio, r_f the risk-free rate and β_i the "CAPM beta"

- Beta: $\beta_i = \frac{\sigma_i \cdot \rho_{i,mp}}{\sigma_{mp}}$

  σ_i = variance of the stock

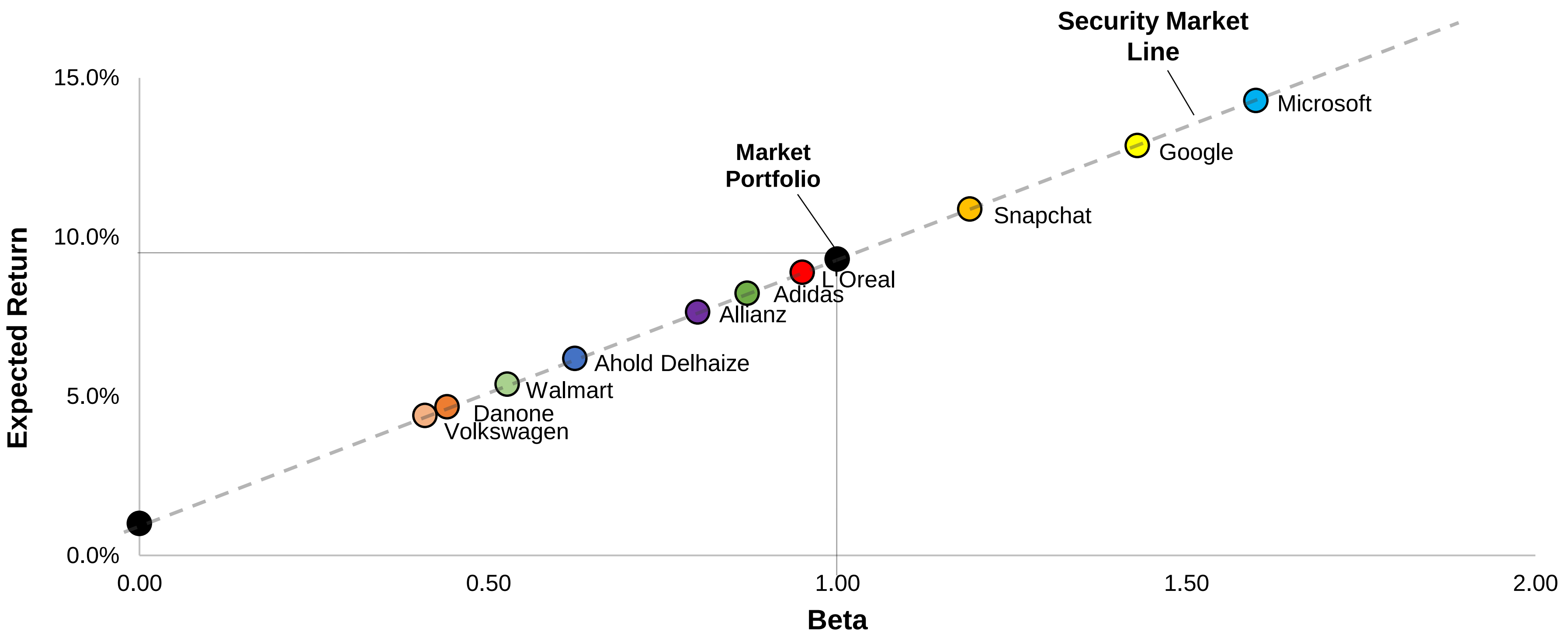
  σ_{mp} = variance of the market portfolio

  $\rho_{i,mp}$ = correlation coefficient between stock and market portfolio

- Market risk premium: $RP_{MKT} = E[r_{MKT}] - r_f$

Security market line (SML)

- The security market line (SML) shows the graphic representation of the risk-return relationship by plotting the expected return against the beta of each stock or portfolio
- The slope is the risk premium of the market portfolio



Limitations to measures of historical risk and return

- Using backward-looking statistics, the implicit assumption is that the risk-return relationships remain the same in the future
- Lucas (1976) basically argues that the structure of the historical relationships will change, when the nature of the assets changes due to policy changes
  - Government policies (or stakeholder pressure) to address sustainability challenges may turn the tables on the stock market
  - Profitable companies in the past may become stranded assets (oil & tobacco), while new companies providing solutions rise in value (e.g. Tesla with electric cars)

Limitations to measures of historical risk and return

- There are severe limitations to the benchmarks used by investors (passive investing)
  - Weightings of countries
    - In 1900, the United Kingdom accounted for 24% of global stock market value, followed by the United States (15%), Germany (13%), France (11%) and Russia (6%)
    - In 2021, the United States accounted for 56% of global stock market value, followed by Japan (7%), the United Kingdom (5%), China (4%) and France (3%)
  - Weightings of sectors
    - In 1900, rail made up over 60% of the US stock market, and almost 50% of the UK stock market
    - In 2021, large sectors were technology, industrials, health, retail, banking and oil & gas
- **Today's market index represents yesterday's industry:** old companies and industries are slowly fading out, while new companies and industries are added after much delay

Social and environmental risks

- Stock prices react primarily to news about financial risks as reported by companies
- There is less attention for other risk indicators, such as social and environmental risks
- Just like financial (F) risk, social (S) and environmental (E) risks can be split into:
  - Idiosyncratic risks: for example, water pollution by an individual company
  - Systematic (systemwide) risks: for example, increased global temperature as a result of climate change

Sources of systematic risk

Multifactor model

- The market risk premium captures a wide range of financial and macroeconomic risks in a single factor
- We expand this single-factor model to a multifactor model by adding social and environmental risk factors as sources of systematic risk
- In this multifactor model, a company's adjusted cost of equity capital r_i is:

$$r_i = r_f + \beta_i^{MKT} \cdot RP_{MKT} + \beta_i^{SF} \cdot RP_{SF} + \beta_i^{EF} \cdot RP_{EF}$$

Social risk premium: $RP_{SF} = E[r_{SF}] - r_f$ = expected return on social factor – risk-free rate

Environmental risk premium: $RP_{EF} = E[r_{EF}] - r_f$ = expected return on environmental factor – risk-free rate

Social and environmental factor portfolios

- How do we derive the social and environmental factor portfolios?
- We can devise trading strategies that capture social risk and environmental risk respectively, which is not captured by the market portfolio
- Based on the S(ocial) and E(nvironmental) pillar of companies' ESG rating
- ESG ratings summarise a company's performance on environmental, social and governance issues, as measured by an ESG rating agency

Social and environmental factor portfolios

- The environmental factor portfolio could be constructed with:
  - **A brown portfolio**, which takes the bottom third of the E rating of a large index (i.e. S&P 500)
  - **A green portfolio**, which takes the top third of the E rating of the same index
- A trading strategy that takes a long position in the brown portfolio, which it finances with a short position in the green portfolio, produces the environmental risk premium
- This portfolio which is long in brown stocks and short in green stocks is called the **brown-minus-green (BMG)** E portfolio
- Similarly, a **bad-minus-good (BMG)** S portfolio uses the top third and bottom third of the S rating to capture the social risk premium

Challenges of the multifactor model

- There are several challenges in the application of the multifactor model in practice:

1. Constructing the social and environmental factor portfolios based on ESG ratings is challenging due to low ESG data quality

2. Deriving social and environmental risk premiums from financial market data assumes the *efficient markets hypothesis (EMH)*, arguing that stock prices incorporate all relevant information (Fama, 1970)

    - EMH thus assumes that social and environmental risk is priced
    - Instead, the *adaptive markets hypothesis (AMH)* argues that the degree of market efficiency depends on an evolutionary model of individuals adapting to a changing environment (Lo, 2004, 2017)

Environmental and social risk premiums

- Summary of the findings on environmental and social risk premiums:

Type of risk premium	Annual risk premium	Period	Companies
Environmental risk premium			
*** broad environmental pillar**	1.2% - 1.9%	2012-2020	U.S.
*** carbon risk premium**	3.6% - 4.6%	2005-2018	global
Social risk premium			
*** broad social pillar**	N / A	N / A	N / A
*** sin risk premium**	2.5% 2.8%	1965-2006 1999-2019	U.S. U.S.

Sources: Pastor, Sambaugh and Taylor (2022), Bolton and Kacperczyk (2023), Hong and Kacperczyk (2009) and Zerbib (2022)

Factor betas

- The factor betas, β_i^{SF} and β_i^{EF}, measure the company's sensitivity to social risk and environmental risk

- Beta coefficients can be interpreted as follows:
  - $\beta_i^{SF}, \beta_i^{EF} > 1$ reflect relatively high exposure indicating that this company is not prepared for the sustainability transition
  - $0 < \beta_i^{SF}, \beta_i^{EF} < 1$ reflect relatively low exposure indicating this company is partly prepared for transition
  - $\beta_i^{SF}, \beta_i^{EF} < 0$ reflect that the company's activities will likely benefit financially from transitions

Social discount rate

- The next step for calculating the integrated risk-return is examining the social and environmental risk-return relationship
- The social discount rate is the appropriate discount rate for S and E factors:
  - Basic social discount rate: $\boldsymbol{r^s = \delta + \eta \cdot g}$
  - δ reflects the time preference between current and future generations, where equal treatment of current and future generations gives $\delta = 0$
  - The growth rate g is driven by growth in consumption
  - Given a diminishing marginal utility of consumption, the growth rate is multiplied by the elasticity of marginal utility of consumption η

Risk & social discount rate

- There are several sources of risk related to the growth factor g:
  - **Growth risk**: the macroeconomic risk that the growth rate of consumption fluctuates;
  - **Company risk**: the correlation between company risk and growth risk;
  - **Catastrophe risk**: the extreme element of macroeconomic risk of rare disasters or society collapse

- Fluctuations of the growth rate give rise to uncertainty about future growth of consumption

- The risk premiums for growth and company risk are very small (less than 0.1%) due to low variance of consumption growth

- The final source of risk is represented by the catastrophic risk parameter L, which is the likelihood that there will be a catastrophic event so devastating that social and environmental returns are eliminated

Estimating social discount rate

- Ord (2022) estimated the probability of a catastrophe occurring in the next 100 years as 1 in 6, which is 16.7%

- The 100-year survival rate of 83.3% (=100%-16.7%) can be transformed into an annual survival rate of 99.8% as $\sqrt[100]{0.833} = 0.998$ → catastrophic risk parameter L = 0.2%

- We expand the social discount rate r^s with a risk parameter L:

$$\boldsymbol{r^s = \delta + \eta \cdot g + L}$$

  - Dasgupta (2020) sets the time preference δ at 0% and growth g at 1.3%
  - Groom and Maddison (2019) find an elasticity η of 1.5

- Social discount rate: $r^s = \delta + \eta \cdot g + L = 0\% + 1.5 \cdot 1.3\% + 0.2\% =$ **2.2%**

Estimating cost of integrated capital

- Assuming full equity financing, the cost of equity is then the cost of financial capital

- The cost of integrated capital r_i^{IV} is the the weighted average of the cost of equity r_i and the costs of social and environmental capital r^s :

$$r_i^{IV} = \frac{FV}{IV} \cdot r_i + \frac{SV + EV}{IV} \cdot r^s$$

Where $\mathrm{I}V = FV + SV + EV$

- Given that $r_i > r^s$, companies with relatively more social and environmental value face a lower cost of integrated capital than companies with lower or negative social and environmental value

Estimating cost of integrated capital

Problem

See below the cost of financial, social and environmental capital (left) and value dimensions (right) for an oil company and a medtech company:

Cost of capital	Oil company	Medtech company
Financial	9.0%	6.0%
Social	2.2%	2.2%
Environmental	2.2%	2.2%

Value dimension	Oil company	Medtech company
Financial value	8	4
Social value	-1	3
Environmental value	-4	-1
Integrated value	3	6

What is the cost of integrated capital of the two companies?

Estimating cost of integrated capital

Solution

For the oil company, the cost of integrated capital is:

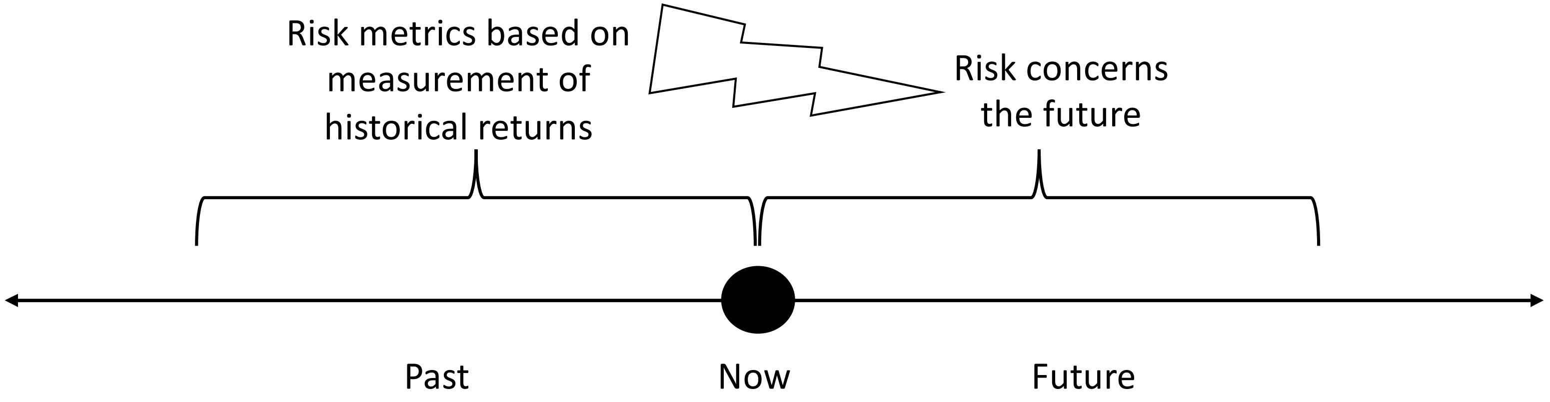
$$r_{oil}^{IV} = \frac{8}{3} \cdot 9\% + \frac{(-1-4)}{3} \cdot 2.2\% = \mathbf{20.3}\%$$

For the medtech company, the cost of integrated capital is:

$$r_{med}^{IV} = \frac{4}{6} \cdot 6\% + \frac{(3-1)}{6} \cdot 2.2\% = \mathbf{4.7}\%$$

Forward-looking risk

- Given the limitations of historical or backward-looking risk measures, it makes sense to develop forward-looking risk measures that takes transitions into account
- Forward-looking risk measures tend to be of a more qualitative nature
  - Methods: scenario analysis; options analysis; integrating forward-looking estimates



Scenario analysis

- Scenario analysis is a process of analysing possible future events by considering alternative possible outcomes (also known as ‘alternative worlds’)

- The scenario construction process requires choices on parameters:
  - **Time horizon**: sufficiently long;
  - **Number and diversity of scenarios**: 3 to 4 differing scenarios;
  - **Focal question**: critical question that company (or investor) wants to address;
  - **Drivers of change**: main clusters of risk;
  - **Impact on companies**: translate scenarios into impact on companies;
  - **Probabilities of scenarios**: assign probabilities to scenarios

Scenario matrix for climate risk

Physical risk

High

1) Hot house scenario

- Rising temperatures
- Rising sea level
- Little action to avert global warming

2) Too little, too late

- Rising temperatures
- Rising sea level
- Late disorderly transition

Low

High

Transition risk

3) Orderly

- Global warming limited
- Timely policy response to reduce emissions

4) Disorderly

- Global warming limited
- Sudden and unanticipated policy response

Low

Quantifying the scenario analysis

- Using expected values per transition scenario:

30% * $50 + 30% * $0 + 20% * $40 + 20% * $60 = $35

	No transition by 2030	Transition by 2030
Company does not change	$50 (30%)	$0 (30%)
Company does position for transition	$40 (20%)	$60 (20%)

- For Inditex case study:

24% * €31.9 + 16% * €10.4 + 36% * €22.5 + 24% * €28.4 = €24.2

Inditex	No transition by 2030	Transition by 2030
Company does not change	€31.9 (24%)	€10.4 (16%)
Company does position for transition	€22.5 (36%)	€28.4 (24%)

Strategy setting

- Scenario outcomes can be used as input for the strategy setting
- The company can increase its value by better preparing itself for transition, and thus avoid the costly collapse scenario
  - Good management would take strategic action on its own initiative
  - Investors can demand from the company that it prepares itself for transition in the process of engagement
- If the company is not prepared to take action, investors may divest from the company as it is overvalued on the basis of the climate risk scenario analysis

Transition pathways

- There are several investor-led initiatives, in particular in the area of climate transition preparedness, to make these company assessments

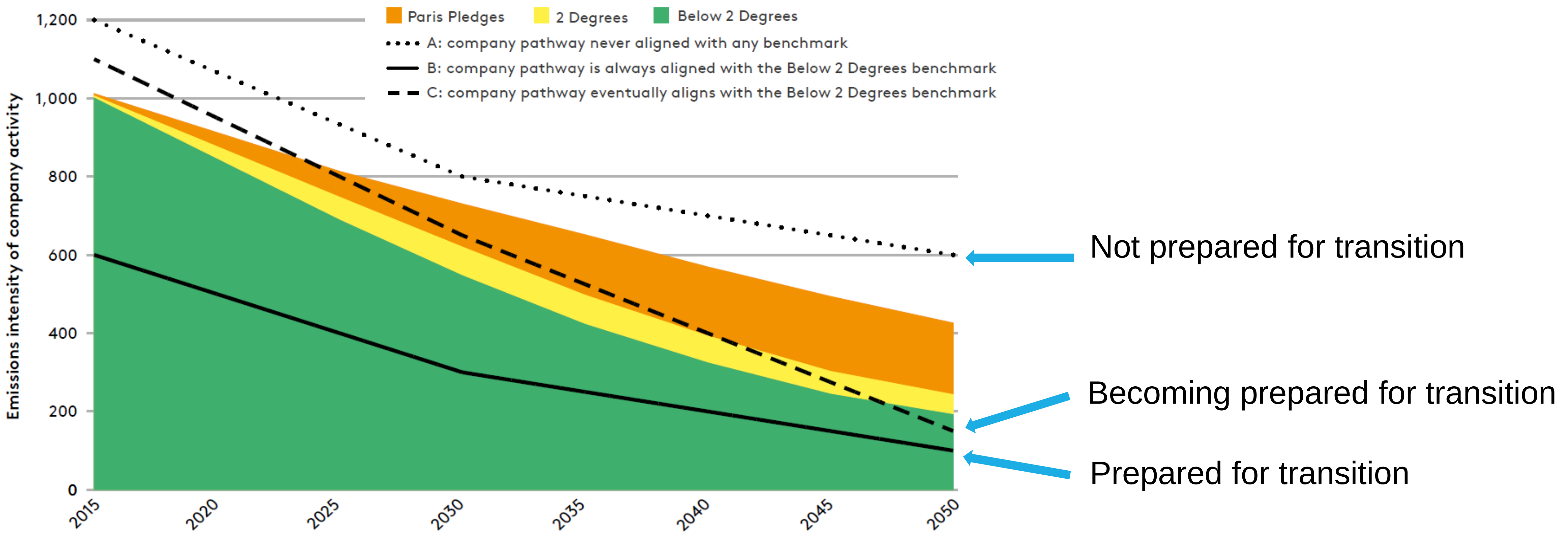
- Transition Pathway Initiative (TPI) that provides assessments of companies' preparedness for the transition to a low carbon economy:
  - The most stringent is the Paris 1.5º C global warming scenario
  - The medium benchmark is the 2º C global warming scenario
  - The least stringent is the Paris pledges (to reduce emissions) by national governments

- The global carbon reduction benchmarks are split into sectoral carbon benchmarks

- The assigned carbon budget for each sector (emissions) is divided by activity (e.g. tons of crude steel) to obtain sectoral carbon intensity *CI* benchmarks: $CI = \frac{carbon\ emissions}{activities}$

Transition pathways

- Plotting a company carbon reduction pathway against the benchmarks checks whether a company is Paris-aligned, and thus prepared for transition



Conclusions

- A company's risk can be split into systematic or market-wide risk; and idiosyncratic risk, which can be diversified away in a portfolio
- The Capital Asset Pricing Model (CAPM) states that in equilibrium, all investors hold a combination of the risk-free asset and the market portfolio
- Historical risk-return analysis has a limited capacity for assessing future financial risk
- We expand the single market model of the CAPM into a multifactor model by adding social and environmental factors (as sources of systematic risk)
- The cost of integrated capital gives corporate managers the tool to make an integrated risk-return assessment in their investment decisions