PRINCIPLES OF FINANCE

WEEK 3

Elise Gourier

(elise.gourier@essec.edu)

Last lecture

Do you remember

- What are the different rules that can be used to decide whether to undertake a project?
- What are their strengths and weaknesses?
- What are the challenges behind the computation of the NPV?

Video: How to predict Free Cash Flows (FCF)?

Real-life application: Apple’s FCF

Remaining question

- Where does the discount rate come from when the project is risky?

Some elements of answer

- The discount rate on a risky project should be the rate of return that is expected on an alternative investment whose cash flows carry a similar level of risk
- This discount rate should be higher when future cash flows carry more risks that investors worry about

→ How should we assess the risks of an investment? (this session)

→ Is there a precise way to link investments’ risk level to the return that is expected from them by investors? (later)

Outline of today’s lecture

In class: Risk-return trade-off

- Univariate and multivariate case
- Covariance, correlation

Video: Introduction to utility theory

- Utility function
- Risk aversion
- Certainty equivalent

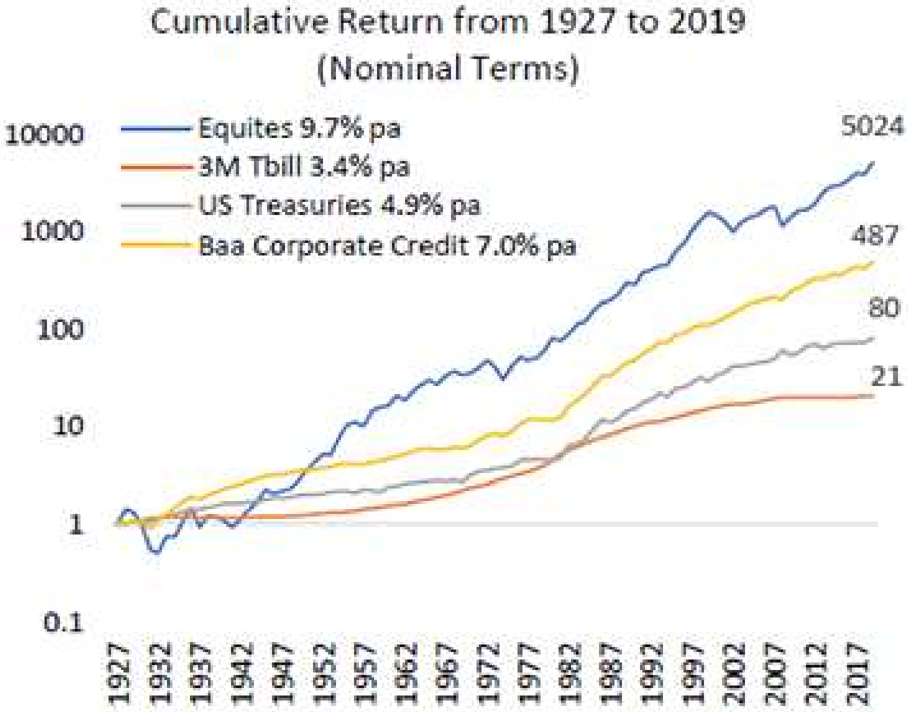
Returns

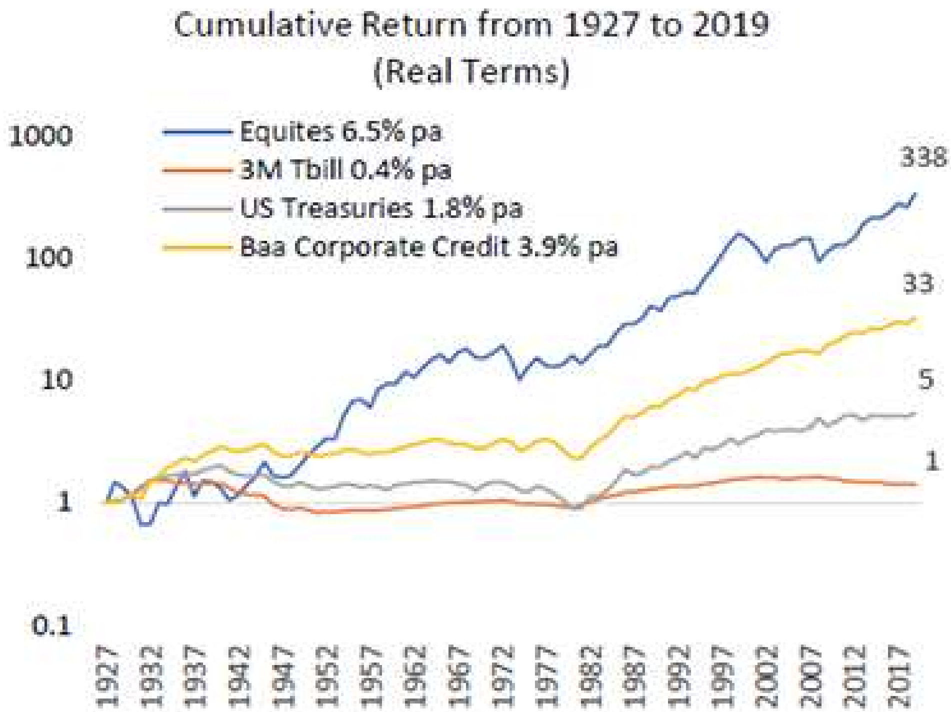
Investments over time

How did different types of investments perform over a long time period?

- **Portfolio:** combination of several assets put together with specific value weights.
  - Example: a 50/50 Apple/Microsoft portfolio has 50% of its value invested in Apple stocks and 50% of its value invested in Microsoft stocks
- **Stock Market Portfolio**: The combination of all the shares available on the stock market.
  - Note: Because shares from small companies do not represent a significant proportion of this portfolio (in terms of value), the stock market portfolio is often approximated by a basket of the shares from the biggest traded stocks (S&P 500 in the US, CAC 40 or SBF 120 in France)
- **Treasury Bills:** An investment in 3-month Treasury bills.

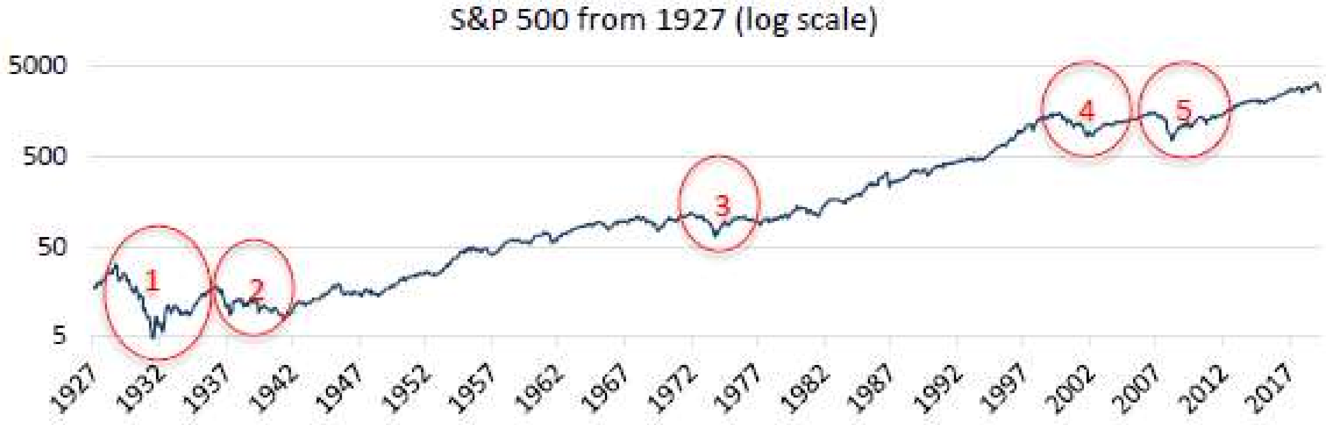
Value of 1$ invested on January 1st, 1927





Data source: Aswath Damodaran, NYU

Investing in the S&P 500

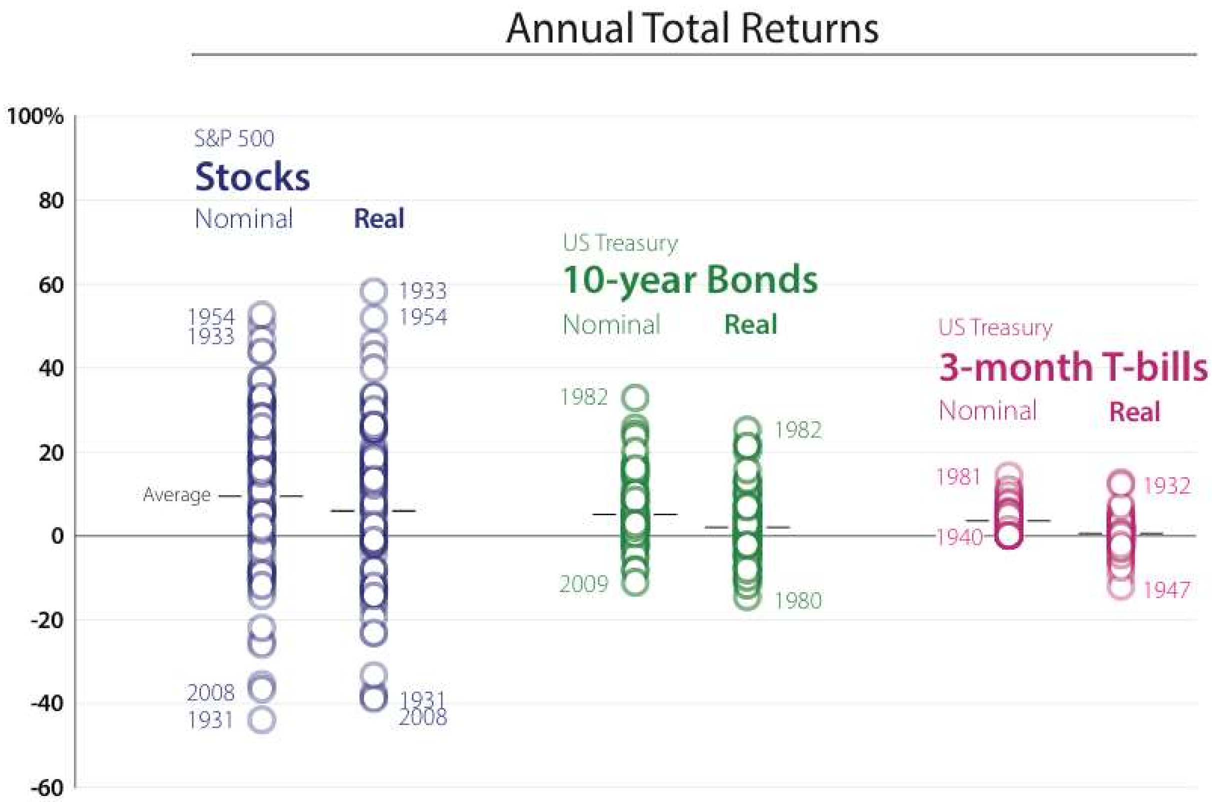


	Bear Market	Market Peak	Peak to Trough Drawdown	Duration (m)	Subsequent Bull Market	Bull Market Return	Duration (m)
1	1929 Wall Street Crash	Sep-29	-85%	32	Mar-35	129%	23
2	1937 Fed Tightening	Mar-37	-43%	61	Apr-42	158%	49
3	1973 Stagflation	Jan-73	-48%	20	Mar-78	62%	32
4	2000 Dotcom bubble	Mar-00	-49%	30	Oct-02	101%	60
5	2007 Great Financial Crisis	Oct-07	-57%	17	Mar-09	398%	130

Data source: Bloomberg

Historical annual returns

1928-2012 Stock, Bond, and T-bill Returns Since 1928

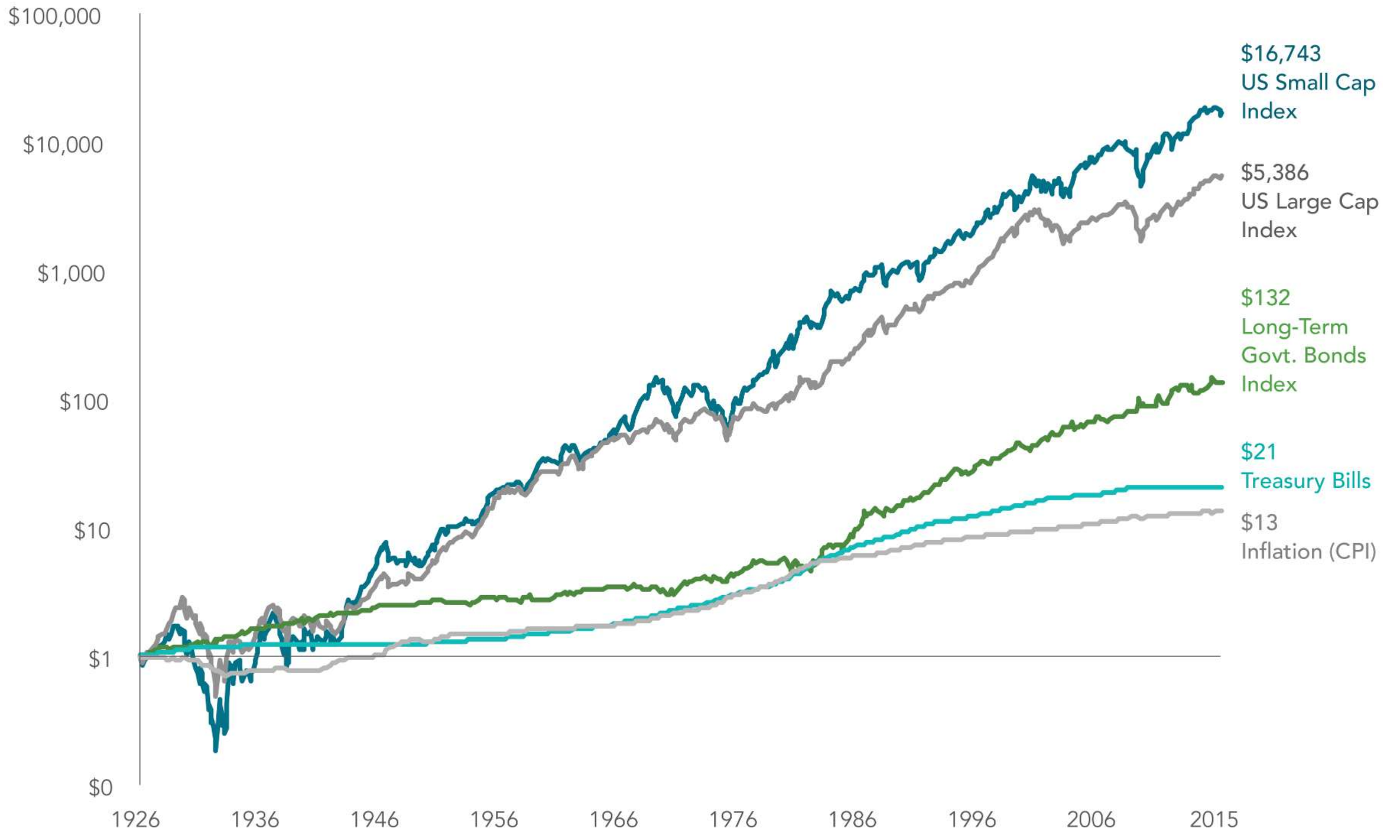


Source: Aswath Damodaran. "The Data Page." Damodaran Online. May 2013. http://people.stern.nyu.edu/adamodar/. • Lawrence H. Officer and Samuel H. Williamson. "The Annual Consumer Price Index for the United States, 1774-2012," MeasuringWorth, 2013. http://www.measuringworth.com/uscpi/.

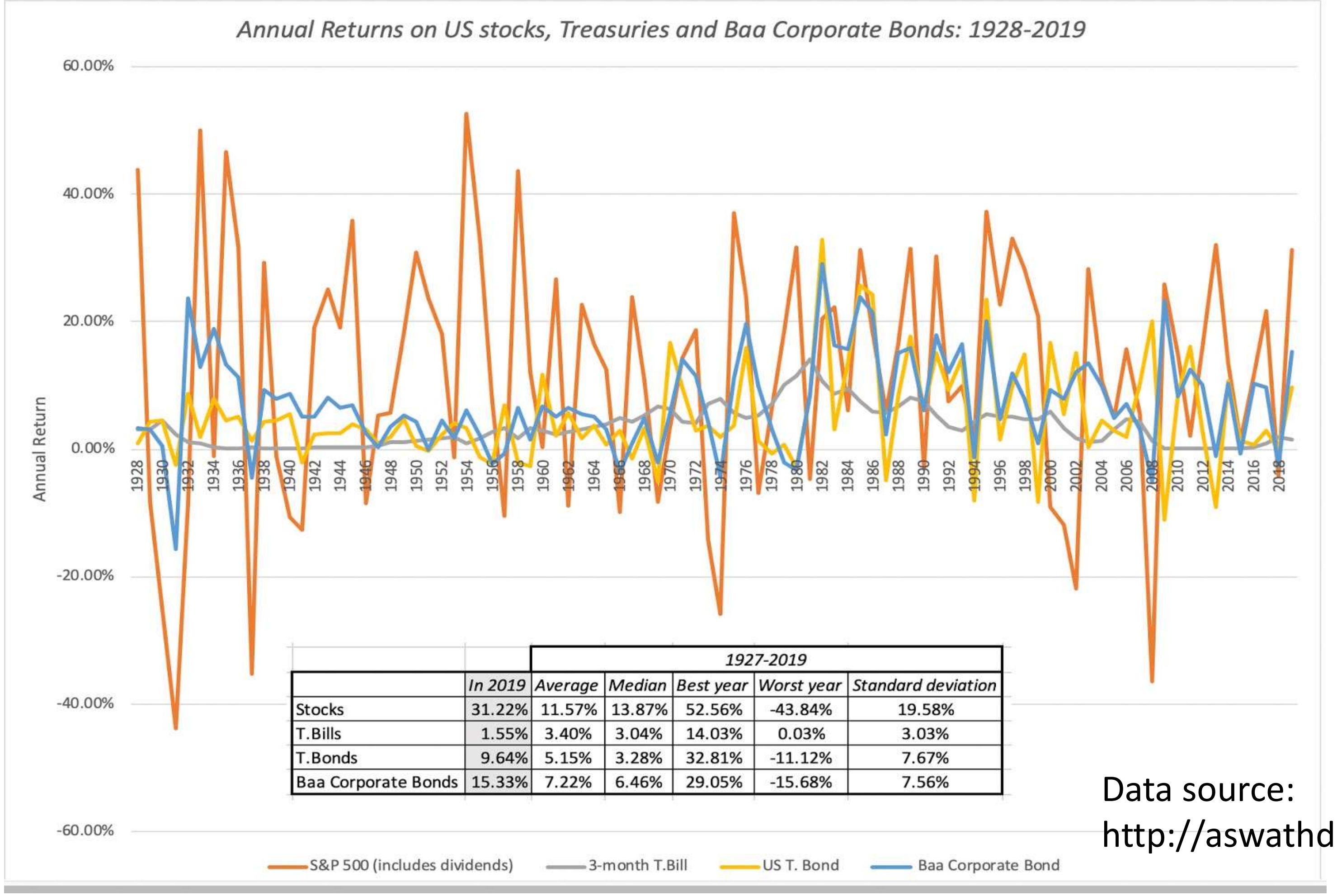
VisualizingEconomics.com

Data source: visualizingeconomics.com

Small versus large stocks



Returns



		1927-2019				
	In 2019	*Average*	*Median*	*Best year*	*Worst year*	*Standard deviation*
Stocks	31.22%	11.57%	13.87%	52.56%	-43.84%	19.58%
T.Bills	1.55%	3.40%	3.04%	14.03%	0.03%	3.03%
T.Bonds	9.64%	5.15%	3.28%	32.81%	-11.12%	7.67%
Baa Corporate Bonds	15.33%	7.22%	6.46%	29.05%	-15.68%	7.56%

Data source:
http://aswathdamodaran.blogspot.com/

Calculating returns

Keyword: Realized returns

- Realized (historical) returns
  - Return = percentage increase in value of an investment per $ initially invested in an asset
  - "Realized" because it is the return that actually occurred over a certain time period
  - E.g., for a stock:

$$R_{t+1} = \frac{Div_{t+1} + P_{t+1}}{P_t} - 1 = \frac{Div_{t+1}}{P_t} + \frac{P_{t+1} - P_t}{P_t} =$$
$$= \text{Dividend Yield} + \text{Capital Gains Rate}$$

  - So, R_{t+1} is the total return we earn from dividends and capital gains, expressed as a % of the initial stock price

Future returns are uncertain…

- When looking back, an asset has a unique (realized) return

- Unfortunately, when considering an investment, we are interested in its return in the future…

- … and before a return is realized, it could take on several plausible values, each occurring with a certain probability. The return in the future is a random variable.

  In the returns formula on the previous slide, at time *t* we do not know the exact values of P_{t+1} and Div_{t+1} *(except in the case of riskless investments)*

… But uncertainty can be quantified

Keyword: Probability distribution

- However, we may be able to assign certain **probabilities** to certain future possible returns occurring

- A *probability distribution* assigns a probability (P_R) that each possible return (*R*) can occur

		Probability Distribution	
Current Stock Price ($)	Stock Price in One Year ($)	Return, R	Probability, P_R
	140	0.40	25%
100	110	0.10	50%
	80	−0.20	25%

Return statistics

Statistics and returns

- Statistics summarize the information contained in data on the probability distribution of the data.

- As investors, we want to quantify **risk** and **return** of stocks, which requires no more and no less than the following from Stats 101:

  - How to calculate the **expected return** on a stock.
  - How to calculate the **variance** of stock returns.
  - How to apply the above to a portfolio of stocks:
    - How to calculate the **expected return on a portfolio**.
    - How to calculate the **covariance** between the return on two stocks.
    - How to calculate the **variance of a portfolio**.

Expected returns

Keyword:
Expected returns

Current Stock Price ($)	Stock Price in One Year ($)	Probability Distribution	
		Return, R	Probability, P_R
	140	0.40	25%
100	110	0.10	50%
	80	−0.20	25%

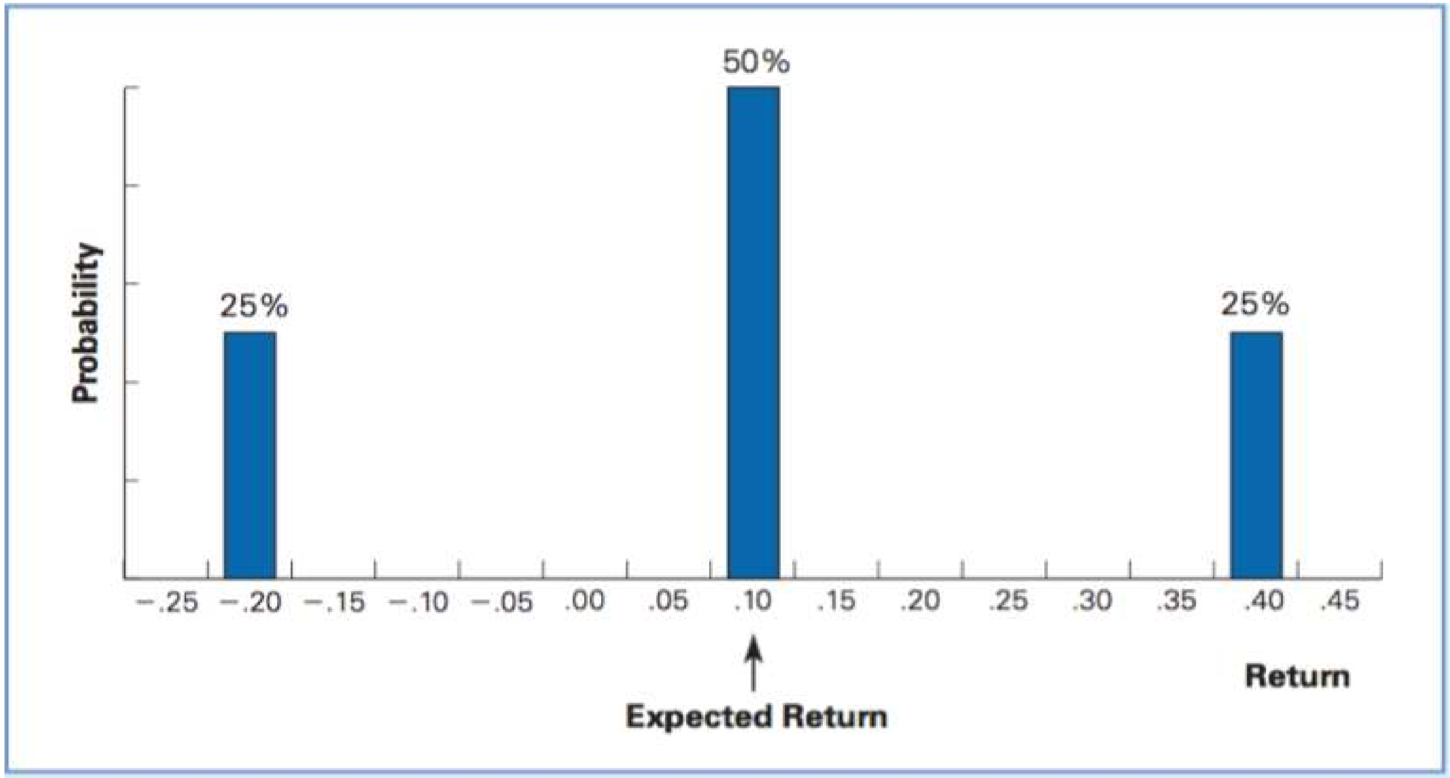
- Calculated as a weighted average of the possible returns, where the weights correspond to the probabilities

$$Expected\ Return = E[R] = \sum_R P_R . R$$

$$E\left[R_{example}\right] = 25\% \times 0.40 + 50\% \times 0.10 + 25\% \times (-0.20) = 10\%$$

Histogram of returns

- We can also represent the probability distribution with a histogram.



Measures of Variability: Variance and Standard Deviation

- Variance
  - The expected squared deviation from the mean

$$Var(R) = E\left[\left(R - E[R]\right)^2\right] = \sum_R P_R \times \left(R - E[R]\right)^2$$

- Standard Deviation (in Finance: "Volatility")
  - The square root of the variance $SD(R) = \sqrt{Var(R)}$
  - The advantage of using standard deviation over variance is that standard deviation is expressed in same unit (scale) as the underlying variable
    - E.g.: Returns in % → SD also in %

How to measure risk

- The higher the variance, the more “spread out” returns are around their expected value
  - If the return is risk-free and never deviates from its mean, the variance is zero.

- This is how investors measure the risk involved in their investments

Example

Current Stock Price ($)	Stock Price in One Year ($)	Probability Distribution	
		Return, R	Probability, P_R
	140	0.40	25%
100	110	0.10	50%
	80	−0.20	25%

$$Var(R_{example}) = 25\% \times (0.40 - 0.10)^2 + 50\% \times (0.10 - 0.10)^2$$
$$+25\% \times (-0.20 - 0.10)^2 = 0.045 = 4.5\%$$

$$Vol(R_{example}) = SD(R_{example}) = \sqrt{Var(R_{example})} = \sqrt{0.045} = 21.2\%$$

Exercise

Problem

Suppose AMC stock is equally likely to have a 45% return or a −25% return. What are its expected return and volatility?

Solution

First, we calculate the expected return by taking the probability-weighted average of the possible returns:

$$E[R] = \sum_R p_R \times R = 50\% \times 0.45 + 50\% \times (-0.25) = 10.0\%$$

To compute the volatility, we first determine the variance:

$$\begin{aligned} Var(R) &= \sum_R p_R \times (R - E[R])^2 = 50\% \times (0.45 - 0.10)^2 + 50\% \times (-0.25 - 0.10)^2 \\ &= 0.1225 \end{aligned}$$

Then, the volatility or standard deviation is the square root of the variance:

$$SD(R) = \sqrt{Var(R)} = \sqrt{0.1225} = 35\%$$

Exercise 2

TXU stock has the following probability distribution:

Probability	Return
.25	8%
.55	10%
.20	12%

What are its expected return and standard deviation?

Special case of the Normal distribution

- In the general case, the variance and the mean of a distribution are not always enough to compute:
  - The probability that a return goes below -20%, -30%, above 70%...
  - … which is likely something you understand better than a standard deviation

- However, when the distribution of returns follows a **Normal** distribution (a bell curve), the variance and the mean are enough to compute the probability of any given return scenario in the future
  - … and it turns out that the distribution of annual stock returns is approximately Normal
  - This is a third reason to focus on the variance/std. dev. of returns

Multivariate case

N different assets (securities), S possible future states of the economy

State of nature		1	2	…	s	…	S
Probabilities		π_1	π_2	…	π_s	…	π_S
	1	$R_{1,1}$	$R_{1,2}$	…	$R_{1,s}$	…	$R_{1,S}$
	2	$R_{2,1}$	$R_{2,2}$				
	…						
Securities	i				$R_{i,s}$		
	…						
	N	$R_{N,1}$					$R_{N,S}$

Probabilities are assigned to each state

$$\pi_s \geq 0 \qquad \sum_s \pi_s = 1$$

Multivariate case

Keywords:
Covariance
Correlation

Population statistics:

- **Mean** or **expected return**:

$$E(\tilde{R}_i) = \sum_s \pi_s R_{i,s} = \mu_i$$

Where $\widetilde{R_i}$ is the random variable representing future returns

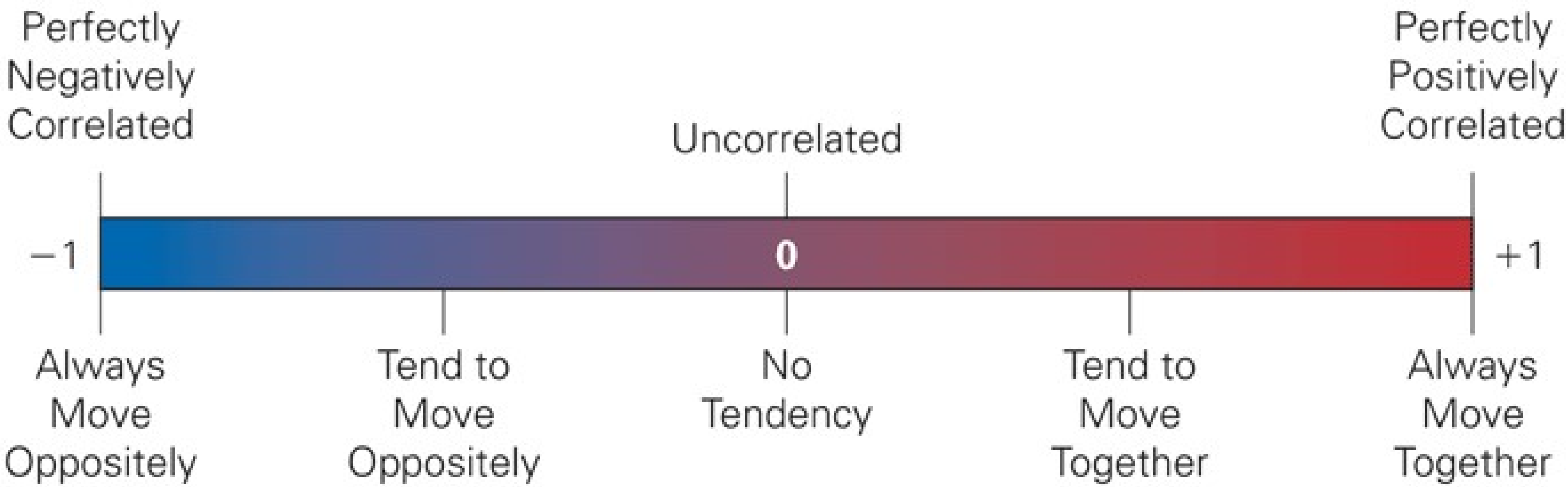
- **Variance:** $$V(\tilde{R}_i) = \sum_s \pi_s \cdot (R_{i,s} - \mu_i)^2 = \sigma_i^2$$
- **Standard deviation:** $$\sigma_i = \sqrt{\sigma_i^2}$$
- **Covariance:** $$Cov(\tilde{R}_i, \tilde{R}_j) = \sum_s \pi_s \cdot (R_{i,s} - \mu_i) \cdot (R_{j,s} - \mu_j)$$
- **Correlation** $$Corr(\tilde{R}_i, \tilde{R}_j) = \frac{Cov(\tilde{R}_i, \tilde{R}_j)}{\sigma_i \sigma_j} = \rho_{i,j}$$

Covariance

- Covariance measures the mutual dependence of two random variables
- A zero covariance implies no relationship.
- A positive covariance implies that when stock i has an exceptionally high return, so (usually) does stock j.
- A negative covariance implies that when the return on stock i is <u>unusually</u> high, the return on stock j tends to be <u>unusually</u> low.

Correlation

- Covariance can be normalized into the correlation coefficient



Exercise

State of Nature	Recession	Normal	Boom
Probability	0.25	0.55	0.2
Return of Stock A	-0.5	0	1.5
Return of Stock B	0	0	0.1

- What are the expected returns and variances of the returns of stocks A and B?
- What is the covariance of the returns of stocks A and B? their correlation?

Exercise

State of Nature	Recession	Normal	Boom
Probability	0.25	0.55	0.2
Return of Stock A	-0.5	0	1.5
Return of Stock B	0	0	0.1

- $E[R_A] = 0.25 * (\text{-}0.5) + 0.2 * 1.5 = 17.5\%; E[R_B] = 2\%$
- $Var(R_A) = 0.25 * (-0.5 - 0.175)^2 + 0.55 * (0 - 0.175)^2 + 0.2 * (1.5 - 0.175)^2 = 48.19\%;\ \ Var(R_B) = 0.16\%$
- $Cov(R_A, R_B) = 0.25 * (-0.5 - 0.175) * (-0.02) + 0.55 * (-0.175) * (-0.02) + 0.2 * (1.5 - 0.175) * (0.1 - 0.02)$=2.65%
- $Corr(R_A, R_B) = \frac{2.65\%}{\sqrt{48.19\% * 0.16\%}} = 95.43\%$

Properties of expected values and variances

Let R_1, R_2 and R_3 be random variables and w a constant.

- Mean or expected return:

$$E(R_1 + R_2) = E(R_1) + E(R_2)$$

$$E(wR_1) = wE(R_1)$$

- Variance:

$$Var(R_1 + R_2) = Var(R_1) + Var(R_2) + 2Cov(R_1, R_2)$$

$$Var(wR_1) = w^2 Var(R_1)$$

- Covariance:

$$Cov(R_1 + R_2, R_3) = Cov(R_1, R_3) + Cov(R_2, R_3)$$

$$Cov(wR_1, R_3) = wCov(R_1, R_3)$$

The risk-return trade-off

Historical versus future returns

- As investors, we are interested in the expected return and its volatility <u>in the future</u>
- **Problem:** where can we obtain such an information?
- **Answer:** most investors compute statistics on <u>historical returns</u> to guess what the expectation of the return on an investment and its variance will be in the future

Historical returns of stocks and bonds

- Computing historical returns
  - To calculate historical returns, we must specify how we invest any dividends we receive in the interim.
  - It is usually assumed that *all dividends are immediately reinvested and used to purchase additional shares of the same stock or security*.
  - If a stock pays dividends at the end of each quarter, with realized returns R_{Q1}, . . . ,R_{Q4} each quarter, then its annual realized return, R_{annual}, is computed as:

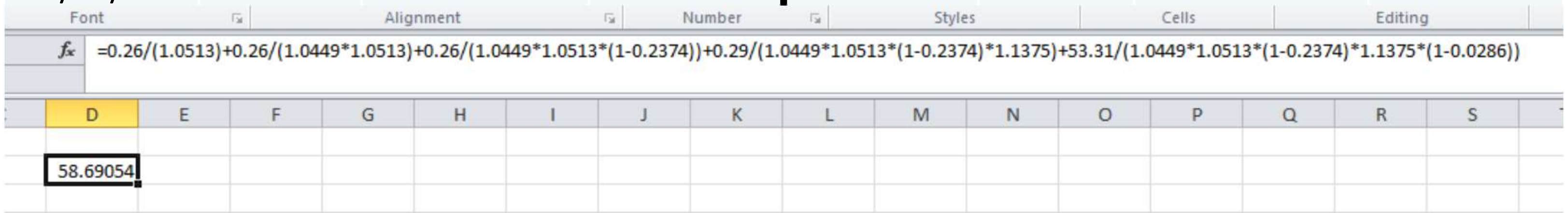
$$1 + R_{\text{annual}} = (1 + R_{Q1})(1 + R_{Q2})(1 + R_{Q3})(1 + R_{Q4})$$

Example

What were the realized annual returns for Ford stock in 1999 and in 2008?

- We look up stock price data for Ford at the start and end of the year, as well as dividend dates:

Date	Price ($)	Dividend ($)	Return	Date	Price ($)	Dividend ($)	Return
12/31/1998	58.69			12/31/2007	6.73	0	
1/31/1999	61.44	0.26	5.13%	3/31/2008	5.72	0	-15.01%
4/30/1999	63.94	0.26	4.49%	6/30/2008	4.81	0	-15.91%
7/31/1999	48.5	0.26	-23.74%	9/30/2008	5.2	0	8.11%
10/31/1999	54.88	0.29	13.75%	12/21/2008	2.29	0	-55.96%
12/31/1999	53.31		-2.86%				



Example: Computing historical returns

- To obtain annual returns, we first calculate returns between dividend dates
  - For example, the return from December 31, 1998 to January 31, 1999 is:

$$\frac{61.44+0.26}{58.69}-1=5.13\%$$

- We then determine annual returns as follows:

$$R_{1999}=(1.0513)(1.0449)(0.7626)(1.1375)(0.9714)-1=-7.43\%$$
$$R_{2008}=(0.8499)(0.8409)(1.0811)(0.440)-1=-66.0\%$$

Example: Computing historical returns

- Note that, since Ford did not pay dividends during 2008, the return can also be computed as:

$$\frac{2.29}{6.73} - 1 = -66.0\%$$

- In years where dividends are paid, we need to proceed as we did for year 1999 by first calculating individual returns between dividend dates

Using historical returns to measure risk & return

- Using historical returns data, we can get a sense of the past riskiness (volatility) of a stock's returns…
- … as well as the average historical return it produced

- Under some conditions, one can make the equivalence:
  - Past volatility of returns = Future volatility
  - Average historical return = Expected return in the future

Average annual return and return volatility

- Average annual return (=estimate for expected return)

$$\overline{R} = \frac{1}{T}\left(R_1 + R_2 + \cdots + R_T\right) = \frac{1}{T}\sum_{t=1}^{T} R_t$$

where R_t is the realized return of a security in year t, for the years 1 through T

- Historical variance (=estimate of the expected variance of the return)

$$Var(R) = \frac{1}{T-1}\sum_{t=1}^{T}\left(R_t - \overline{R}\right)^2$$

When are past returns informative about future returns?

The conditions for the equivalence between statistics on past returns and the distribution of future returns are:

1. **Stationarity**: i.e., the distribution of returns will be the same in the future as it was in the past
   - At the level of a single stock, this will be true for anything but the expected return
   - For ex., the standard deviation of Apple's stock from 1987 to 2017 will correctly predict future volatility, but its average return over that same period won't predict its future expected return
   - For large portfolios of stocks such as the S&P 500, even the expected return in the future is likely to reflect past average returns

When are past returns informative about future returns?

2. **Long historical data**: the more returns we are able to observe in the past, the more precise is our assessment of the underlying distribution of returns

- The data requirement is especially strong when you need to recover the expected return on an investment using past performance
- For ex., the expected return on holding the S&P 500 index is usually computed using average performance over at least the last 50 years

Example

Calculate average annual returns and volatility for GM stock returns from 1998 to 2008

Year End	S&P 500 Index	Dividends Paid*	S&P 500 Realized Return	GM Realized Return	3-Month T-Bill Return
1998	1229.23				
1999	1469.25	18.10	21.0%	25.1%	4.8%
2000	1320.28	15.70	–9.1%	–27.8%	6.0%
2001	1148.08	15.20	–11.9%	–1.0%	3.3%
2002	879.82	14.53	–22.1%	–20.8%	1.6%
2003	1111.92	20.80	28.7%	52.9%	1.0%
2004	1211.92	20.98	10.9%	–21.5%	1.4%
2005	1248.29	23.15	4.9%	–57.0%	3.3%
2006	1418.30	27.16	15.8%	58.0%	5.0%
2007	1468.36	27.86	5.5%	–10.1%	4.5%
2008	903.25	21.85	–37.0%	–86.9%	1.2%

*Total dividends paid by the 500 stocks in the portfolio, based on the number of shares of each stock in the index, adjusted until the end of the year, assuming they were reinvested when paid.

Source: Standard & Poor's, GM, and U.S. Treasury Data

Example

- First, we need to calculate the average return for GM over that time period:

$$\overline{R} = \frac{1}{10}(0.251 - 0.278 - 0.01 - 0.208 + 0.529 - 0.215$$
$$-0.570 + 0.580 - 0.101 - 0.869)$$
$$= -8.9\%$$

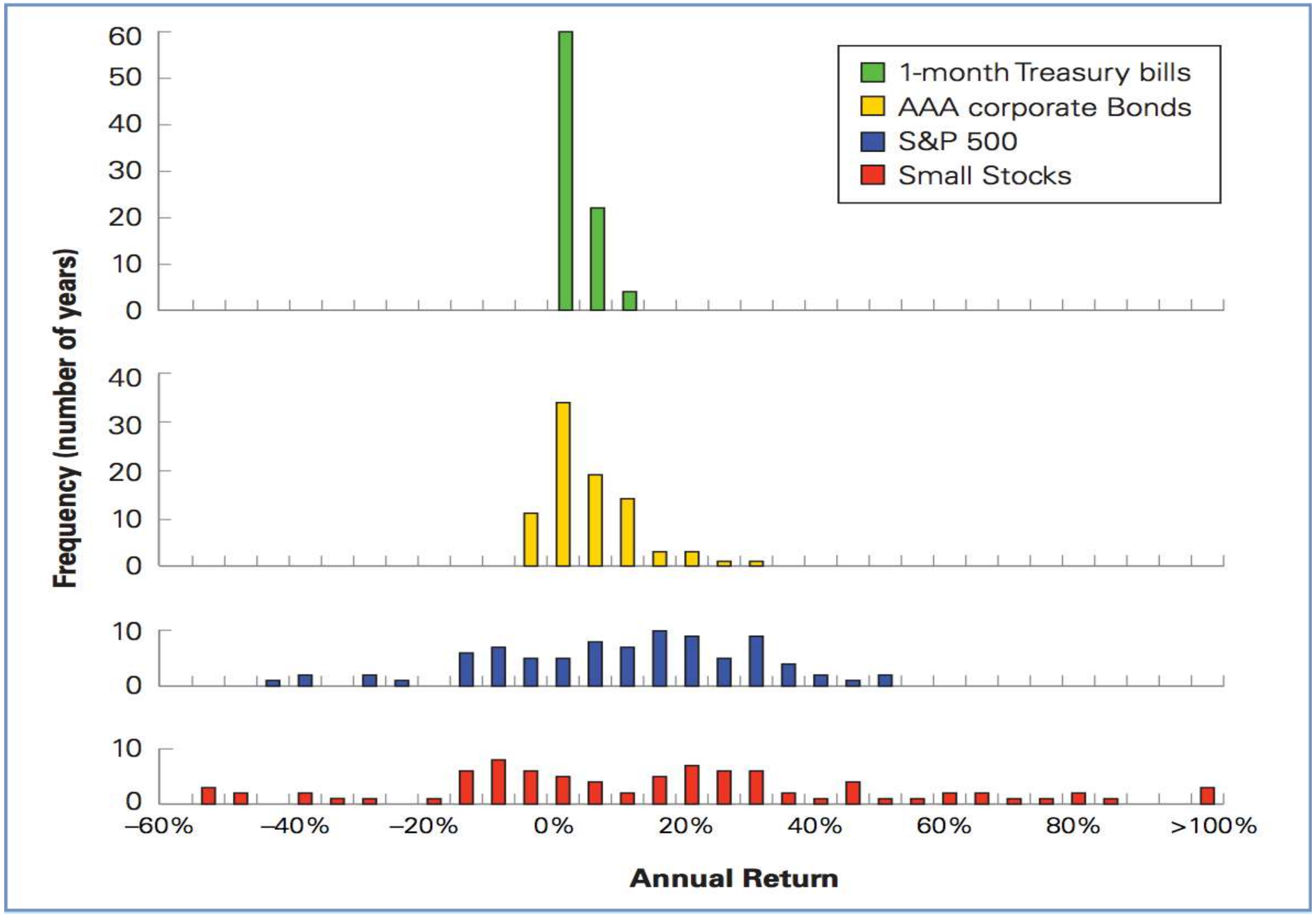
- Next, we calculate the historical return variance:

$$Var(R) = \frac{1}{T-1}\sum_t (R_t \text{-} \overline{R})^2$$
$$= \frac{1}{10-1}\left[(0.251 - (-0.089))^2 + (-0.278 - (-0.089))^2 + \ldots + (-0.869 - (-0.089))^2\right]$$
$$= 0.2063$$

- The volatility is therefore $SD(R) = \sqrt{Var(R)} = \sqrt{0.2063} = 45.4\%$

Historical annual returns

Historical Annual Returns for portfolios of U.S. Large Stocks (S&P 500), Small Stocks, Corporate Bonds, and Treasury Bills, 1926–2011

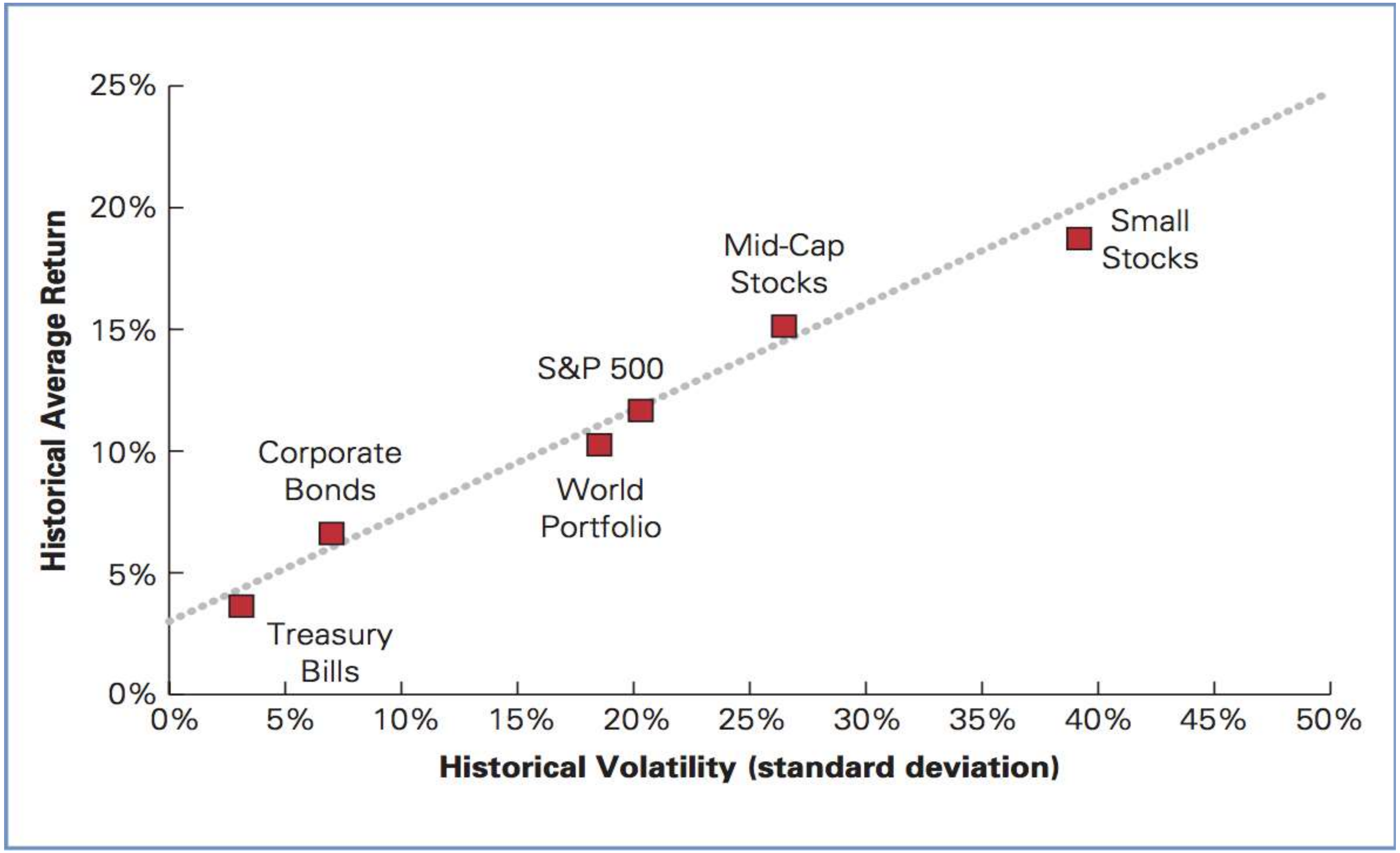


Historical average returns and volatility for U.S. portfolios of large stocks (S&P 500), small stocks, corporate bonds, and Treasury bills, 1926–2011

Investment	Average Annual Return
Small stocks	18.7%
S&P 500	11.7%
Corporate bonds	6.6%
Treasury bills	3.6%

Investment	Return Volatility (Standard Deviation)
Small stocks	39.2%
S&P 500	20.3%
Corporate bonds	7.0%
Treasury bills	3.1%

The historical tradeoff between risk and return in large portfolios, 1926–2011

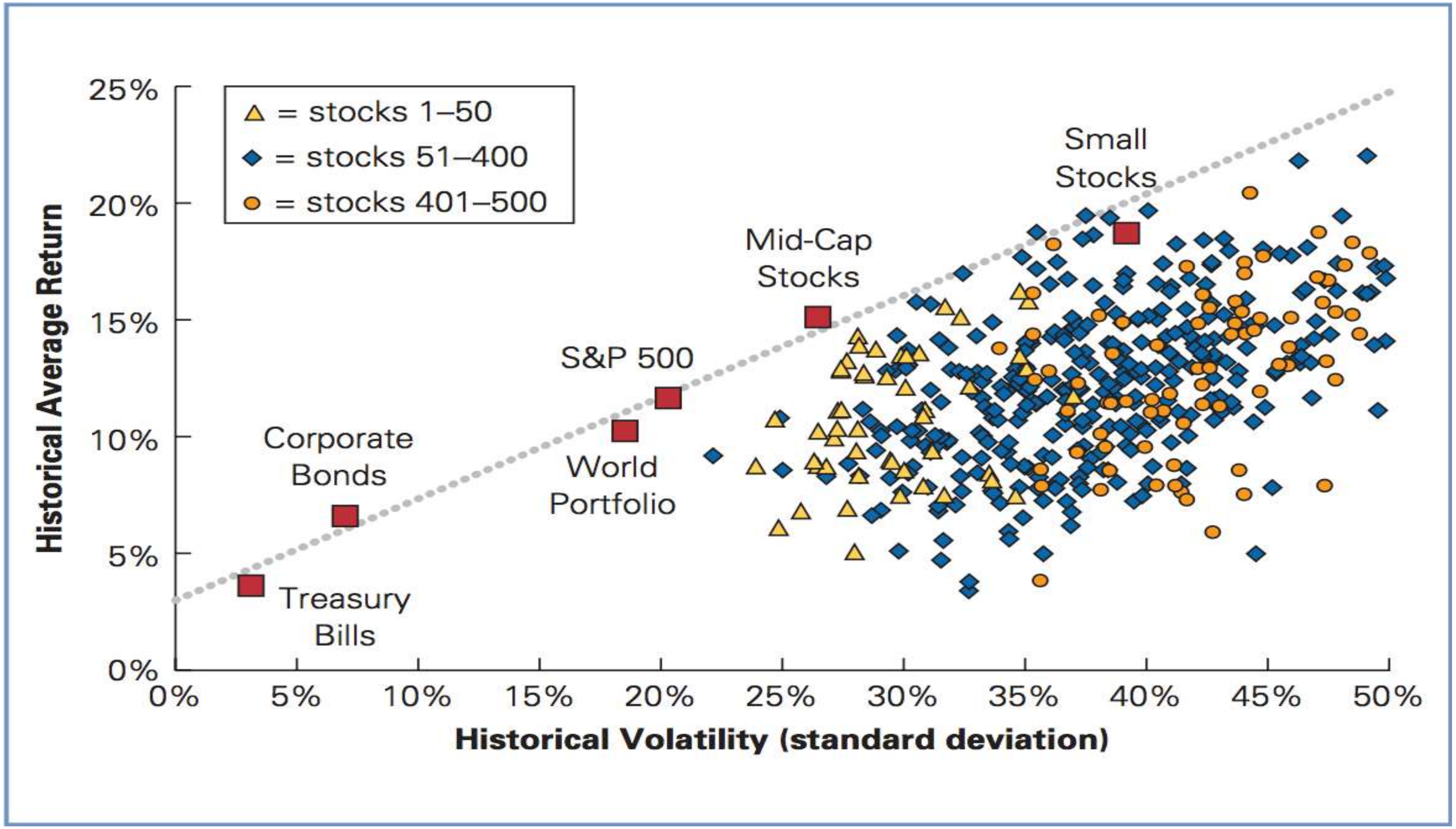


Risk & return

- On the previous slide, note that there is a linear, positive relationship between volatility & return of **large portfolios**

- Is there also a positive relationship between volatility & return for **individual stocks**?

Historical volatility and return for 500 individual stocks, 1926–2011



Risk & return: individual stocks vs. portfolios

- Larger stocks tend to have lower volatility than smaller (small-cap) stocks.
- Individual stocks tend to have higher volatility than the corresponding portfolios of stocks.
  - Many not only have higher volatility, but also lower returns than the portfolio
- So, while volatility seems to be a reasonable measure of compensated risk for portfolios of stocks (in the sense: more risk → higher returns)…
- … this does not seem to be the case for individual stocks

Risk & return

- In the case of individual stocks, there is no clear positive relationship between volatility and returns
  - Why don't we necessarily get a higher return for individual stocks with higher volatility?
    - Maybe volatility is not the right measure of risk for individual stocks!
  - Why does a portfolio of stocks tend to have lower volatility than its individual component stocks?

A portfolio of two assets

- Asset 3A's return over the past 6 months was 1.5%, its volatility was 11.54%; Asset 3B's return over the past 6 months was 1.5%, its volatility was 16.61%
- If you put half of your money on 3A and half on 3B, what is the return on your portfolio? How about the volatility?
- To answer this, you need to use the concepts of covariance and correlation

month	3A	3B	50%A+50%B
1	12.0%	5.0%	8.5%
2	5.0%	27.0%	16.0%
3	-15.0%	-2.0%	-8.5%
4	4.0%	-25.0%	-10.5%
5	-10.0%	3.0%	-3.5%
6	13.0%	1.0%	7.0%
E(r_i)	1.50%	1.50%	1.50%
sigma(r_i)	11.54%	16.61%	10.57%
corr(A, B)	0.10		

Return $r_p = \frac{1}{2}r_A + \frac{1}{2}r_B$

But volatility $\sigma_p \leq \frac{1}{2}\sigma_A + \frac{1}{2}\sigma_B$

Why?

Return & risk of a portfolio with two assets

- $E\left(r_p\right) = \frac{1}{2}E(r_A) + \frac{1}{2}E(r_B)$
- $\sigma^2\left(r_p\right) = E\left\{\left[r_p - E\left(r_p\right)\right]^2\right\}$

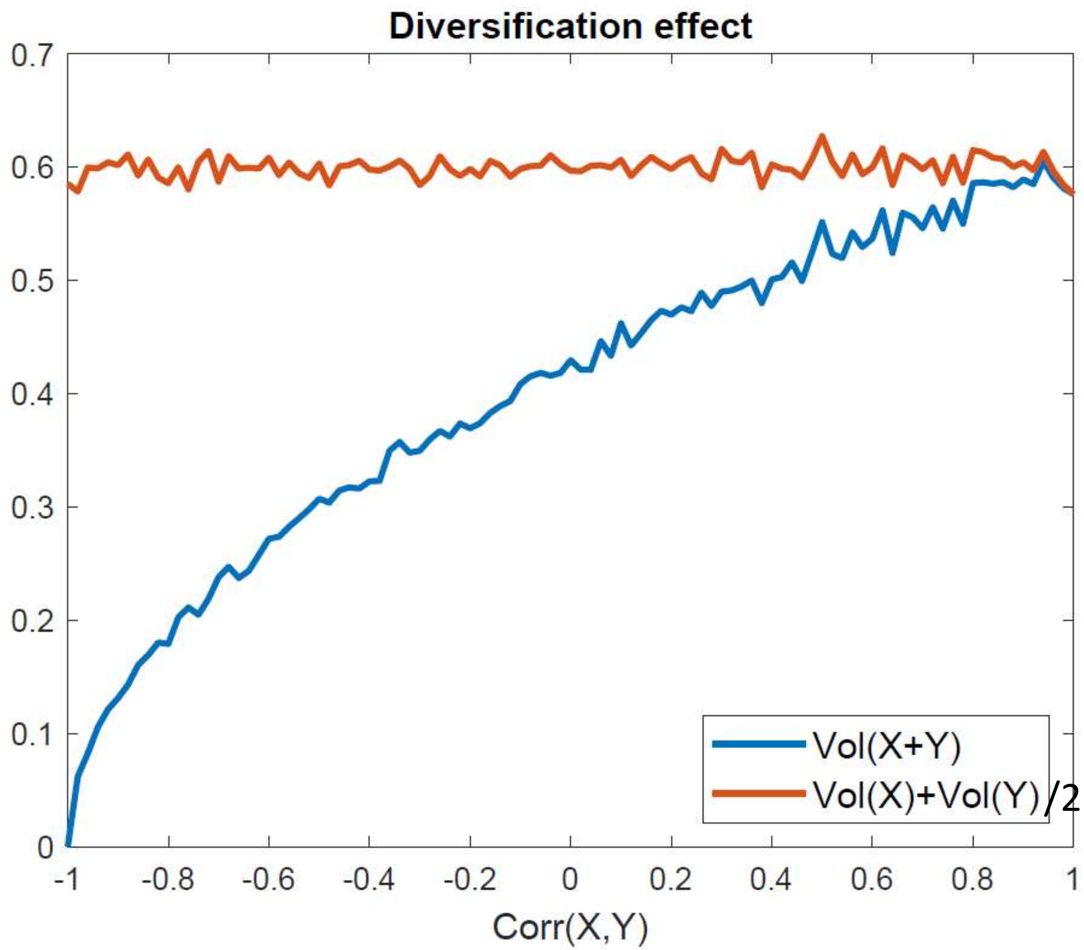
➢ $= E\left\{\left[\frac{1}{2}\left(r_A - E(r_A)\right) + \frac{1}{2}\left(r_B - E(r_B)\right)\right]^2\right\}$

➢ $= E\left\{\frac{1}{4}[r_A - E(r_A)]^2 + \frac{1}{4}[r_B - E(r_B)]^2 + \frac{1}{2}\left(r_A - E(r_A)\right)\left(r_B - E(r_B)\right)\right\}$

➢ $= \frac{1}{4}\sigma_A^2 + \frac{1}{4}\sigma_B^2 + \frac{1}{2}\rho_{AB}\sigma_A\sigma_B$

➢ $\leq \left[\frac{1}{2}\sigma_A + \frac{1}{2}\sigma_B\right]^2$

Return & risk of a portfolio with two assets



Return & risk of a portfolio with two assets

- $\sigma_p \leq \frac{1}{2}\sigma_A + \frac{1}{2}\sigma_B$ is nothing more than the mathematical version of the proverb “Don’t put your eggs in the same basket”:
  - As long as baskets do not always break at the same time (i.e. ρ_{AB} is strictly smaller than 1)…
  - … you are safer putting half of your eggs in one basket and half of your eggs in the other basket

- Does this mean that I can make my investment infinitely safe by adding ever more stocks to the portfolio?
  - To answer this, one needs to make a distinction between the various kinds of news that affect stock prices and returns

Firm-specific vs. market-wide news

Two types of news can affect the future cash-flows of a company (and thus its expected returns)

- Firm-specific news
  - Good or bad news about an individual company
  - E.g., company is granted a new patent; gets a new CEO who has a very good track-record; is sued by customers due to discovery of poisonous ingredients in the flagship product
- Market-wide news
  - News that affects all stocks, such as news about the economy
  - E.g., new growth forecasts by the central statistics authorities; the reduction of barriers to trade; new president and new corporate tax rules

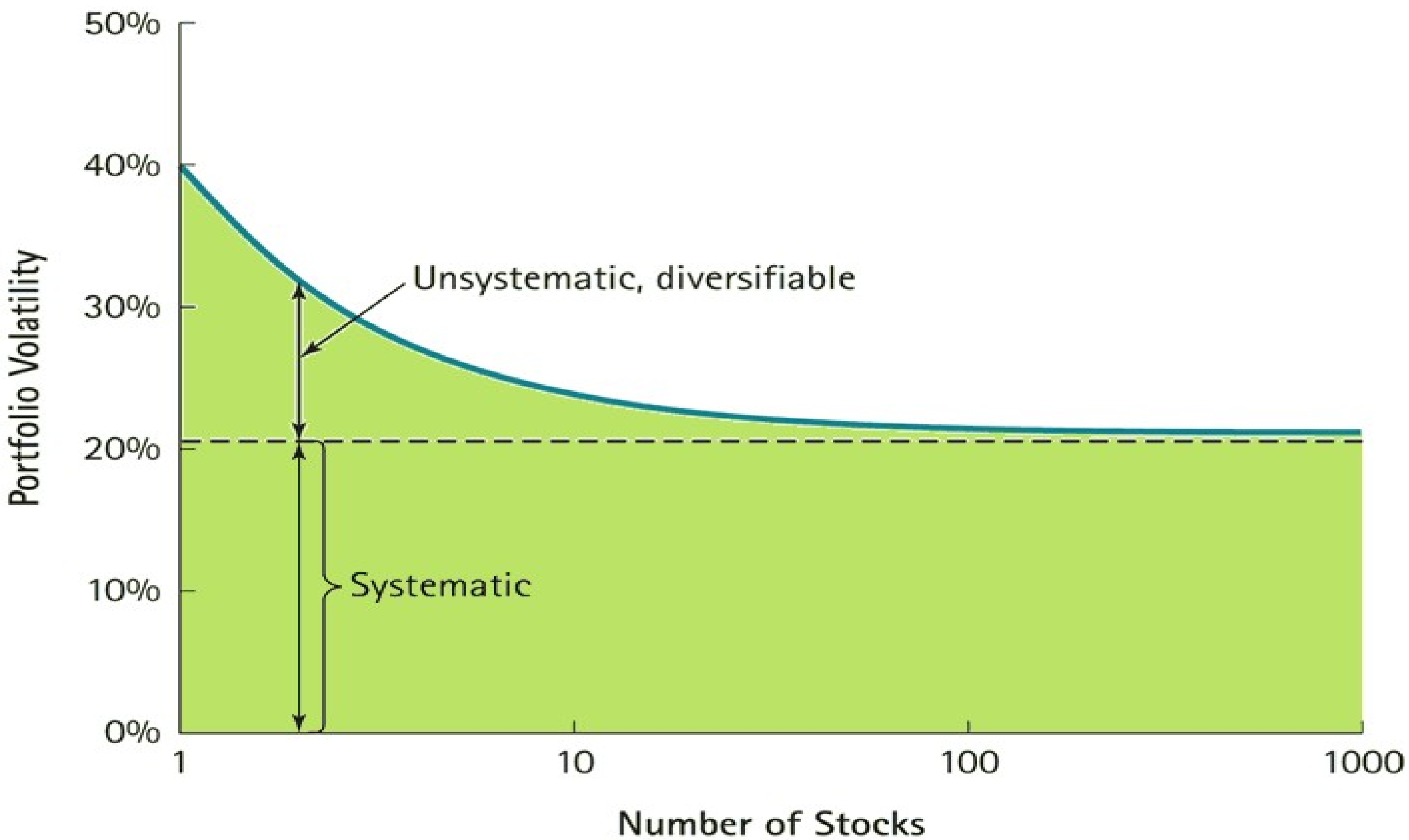
Idiosyncratic and systematic risk

- Diversification
  - The process of combining many stocks into a large portfolio
    - E.g., instead of buying $1,000 worth of stocks of a single company, you buy stocks of a large number of companies, worth $1,000 in total
  - The result of diversification is that firm-specific risks for each stock will average out and overall volatility will be reduced.
  - The systematic risk, however, will affect all firms and will not be reduced.
  - Intuitively, some firms are sometimes hit with good news, sometimes with bad news; however, the average impact will be constant. The economy-wide systematic risk that affects all firms similarly will still remain

Keyword:
Diversification

Volatility of an equally weighted portfolio versus the number of stocks

No. Stocks	Portfolio Volatility
1	40.0%
2	32.0%
3	28.8%
4	27.1%
5	26.0%
10	23.7%
15	22.9%
20	22.5%
25	22.2%
30	22.1%
50	21.7%
100	21.5%
1000	21.2%



Idiosyncratic risk and compensation for risk

- **Risk premium**
  - Compensation for holding a risky asset (e.g. a high-tech stock) and instead of a risk-free asset (e.g., a US government bond)
    - If there was no extra compensation for holding a risky asset, why bother? Everyone would prefer a risk-free one
  - The risk premium is the additional return that we can expect an asset to earn (compared to a risk-free asset) as a compensation for the additional risk in that asset
    - Expected Return = Risk-free Return + Risk Premium

Keyword:
Risk premium

Sharpe ratio

- The Sharpe ratio is the average return earned in excess of the risk-free rate per unit of volatility or total risk.

$$SR = \frac{E[R] - r_f}{\sigma}$$

- It was developed by Nobel laureate William F. Sharpe. The Sharpe ratio has become the industry standard for calculating risk-adjusted return.
- It is equal to the equity risk premium scaled by the volatility of returns.

Keyword:
Sharpe ratio

Idiosyncratic risk and compensation for risk

- **The risk premium for diversifiable risk is zero**
  - Investors are not compensated for holding firm-specific risk, because it is easy to get rid of it (by diversifying → putting several stocks in a portfolio)
  - If the diversifiable risk of stocks were compensated with an additional risk premium (i.e., prices of these stocks are relatively low), then investors could buy the stocks, earn the additional premium, and simultaneously diversify and eliminate the risk.
  - As many investors would try to do that, the price of these stocks will increase quickly, which means that the expected return (and risk premium) will decrease quickly
    - Remember, it is not necessary that it is easy for YOU to do this, it is enough that SOME investors can do this (e.g., financial institutions)

Idiosyncratic risk and compensation for risk

- **The risk premium of a security is determined by its systematic risk and does not depend on its idiosyncratic (diversifiable) risk.**
  - This implies that a stock's volatility, which is a measure of total risk (that is, systematic risk plus idiosyncratic risk), is not especially useful in determining the risk premium that investors will earn.
  - We should therefore expect no clear relationship between volatility and average returns for individual securities.
  - Instead, to estimate a security's expected return, we need to find a measure of a security's **systematic risk**.

Keywords:
Idiosyncratic versus
systematic risk

Measuring systematic risk

- The lesson so far:
  - Idiosyncratic risk is easy to diversify, so there is no compensation (no risk premium) for bearing this type of risk
  - Systematic risk cannot be eliminated through diversification, and thus a compensation for this type of risk is paid
- To measure the systematic risk of a stock, determine how much of the variability of its return is due to systematic risk versus idiosyncratic risk.
  - To determine how sensitive a stock is to systematic risk, look at the average change in the return for each 1% change in the return of a portfolio that fluctuates solely due to systematic risk.

Measuring systematic risk

- Efficient portfolio
  - A portfolio that contains only systematic risk.
  - There is no way to reduce the volatility of the portfolio without lowering its expected return.
- Market portfolio
  - A portfolio that contains all shares and securities in the market
    - The S&P 500 is often used as a proxy for the market portfolio.
    - The CAC 40 or SBF 120 could be similarly used in France.
  - The market portfolio is an efficient portfolio that is very easy to construct: just put everything together!

Measuring systematic risk

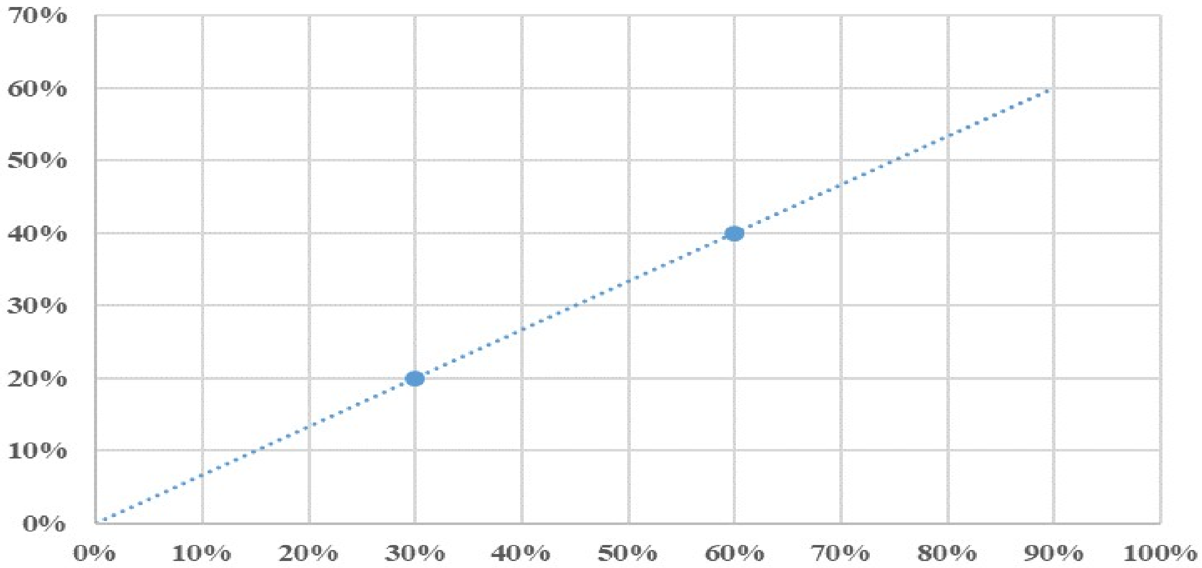
- Sensitivity of a stock's expected returns to systematic risk: Beta (β)
  - **The expected percent change in the return of a security for a 1% change in the return of the market portfolio.**
  - Beta differs from volatility. Volatility measures total risk (systematic plus idiosyncratic risk), while Beta is a measure of only systematic risk.

Keyword:
Beta

Example: Stock beta

- There can be 2 future states of the economy (strong or weak)
- Suppose the returns on the market portfolio are expected to be 60% when the economy is strong, and 30% when the economy is weak
- What is the Beta of a stock whose return is 40% when the economy is strong and 20% when the economy is weak?

Return on individual stock



Return on market portfolio

Beta = slope coefficient of the line connecting the two scenarios

Example: Stock beta

- Solution
  - To get the Beta, we need to calculate how much the stock's return changes when the market return changes
  - We get this by calculating the change in the stock return per unit change in the market return
  - $\beta = \frac{0.40-0.20}{0.6-0.3}$=0.6667
    - Each 1% change in the market return leads to a 0.6667% change of the return on our stock

Measuring systematic risk

- Interpreting Beta (β)
  - A security's beta is related to how sensitive its underlying revenues and cash flows are to general economic conditions.
  - Stocks in cyclical industries (computers, high-tech, office equipment, luxury goods) are likely to be more sensitive to systematic risk and have higher betas than stocks in less cyclical industries.
- Just as the volatility of future returns, the Beta can be inferred from past return data for both the individual stock and the market portfolio
  - We will give details on this procedure in a later session

Betas with Respect to the S&P 500 for individual stocks (based on monthly data for 2007–2012)

Company	Ticker	Industry	Equity Beta
General Mills	GIS	Packaged Foods	0.20
Consolidated Edison	ED	Utilities	0.28
The Hershey Company	HSY	Packaged Foods	0.28
Abbott Laboratories	ABT	Pharmaceuticals	0.31
Newmont Mining	NEM	Gold	0.32
Wal-Mart Stores	WMT	Superstores	0.35
Clorox	CLX	Household Products	0.39
Kroger	KR	Food Retail	0.42
Altria Group	MO	Tobacco	0.43
Amgen	AMGN	Biotechnology	0.44
McDonald's	MCD	Restaurants	0.47
Procter & Gamble	PG	Household Products	0.47
Pepsico	PEP	Soft Drinks	0.51
Coca-Cola	KO	Soft Drinks	0.54
Johnson & Johnson	JNJ	Pharmaceuticals	0.59
PetSmart	PETM	Specialty Stores	0.75
Molson Coors Brewing	TAP	Brewers	0.78
Nike	NKE	Footwear	0.91
Microsoft	MSFT	Systems Software	1.01
Southwest Airlines	LUV	Airlines	1.09
Intel	INTC	Semiconductors	1.09
Whole Foods Market	WFM	Food Retail	1.10
Foot Locker	FL	Apparel Retail	1.11
Oracle	ORCL	Systems Software	1.12
Amazon.com	AMZN	Internet Retail	1.13
Google	GOOG	Internet Software and Services	1.14
Starbucks	SBUX	Restaurants	1.20
Walt Disney	DIS	Movies and Entertainment	1.21
Cisco Systems	CSCO	Communications Equipment	1.23
Apple	AAPL	Computer Hardware	1.26
PulteGroup	PHM	Homebuilding	1.28
Dell	DELL	Computer Hardware	1.41
salesforce.com	CRM	Application Software	1.47
Marriott International	MAR	Hotels and Resorts	1.48
eBay	EBAY	Internet Software and Services	1.48
Coach	COH	Apparel and Luxury Goods	1.60
Macy's	M	Department Stores	1.67
Juniper Networks	JNPR	Communications Equipment	1.71
Williams-Sonoma	WSM	Home Furnishing Retail	1.72
Tiffany & Co.	TIF	Apparel and Luxury Goods	1.80
Caterpillar	CAT	Construction Machinery	1.85
Ethan Allen Interiors	ETH	Home Furnishings	1.95
Autodesk	ADSK	Application Software	2.14
Harley-Davidson	HOG	Motorcycle Manufacturers	2.23
Advanced Micro Devices	AMD	Semiconductors	2.24
Ford Motor	F	Automobile Manufacturers	2.38
Sotheby's	BID	Auction Services	2.39
Wynn Resorts Ltd.	WYNN	Casinos and Gaming	2.41
United States Steel	X	Steel	2.52
Saks	SKS	Department Stores	2.57

Source: CapitalIQ