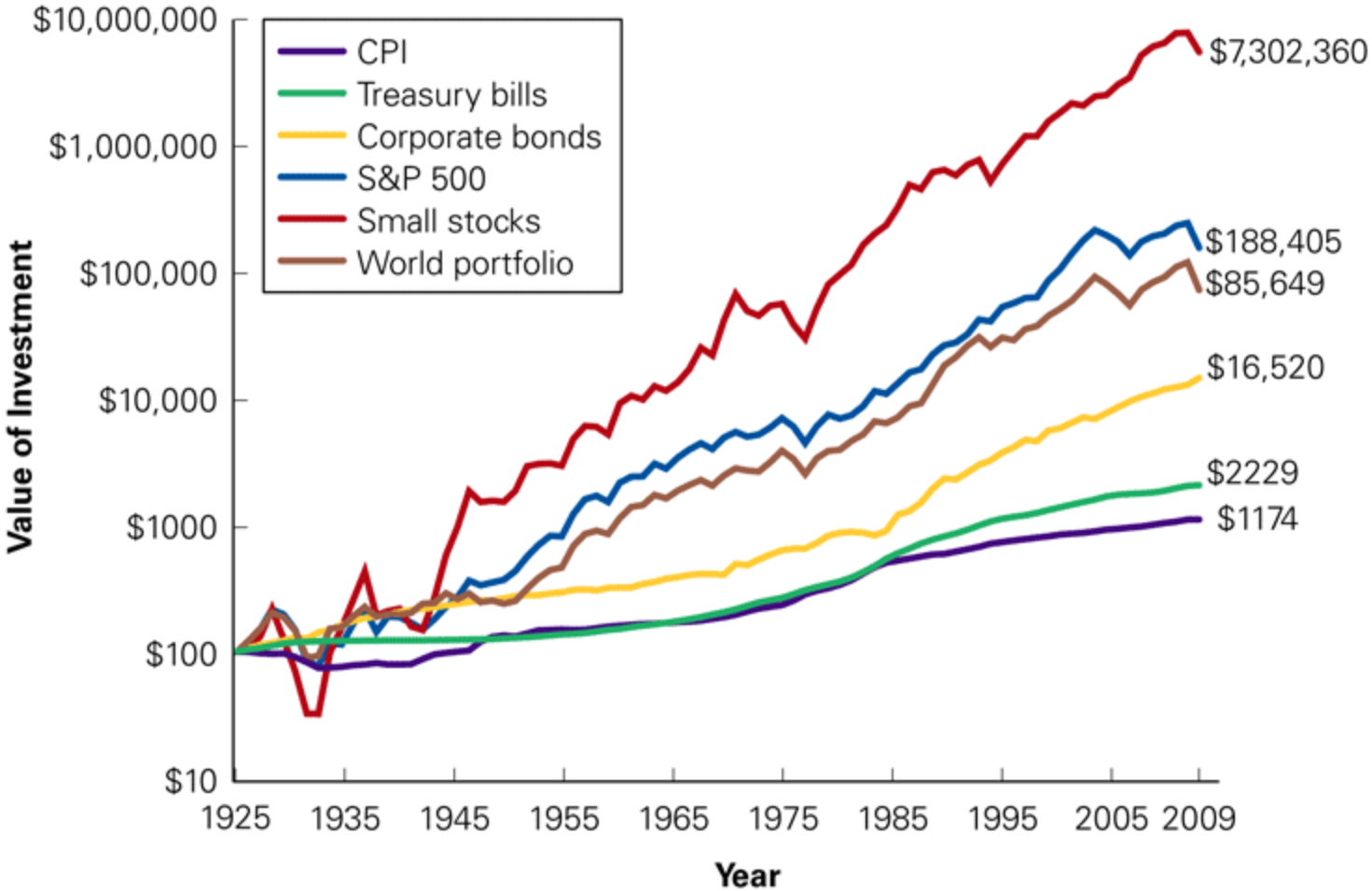
Risk and Return

Lecture Outline

- Define a probability distribution, the mean, the variance, the standard deviation, and the volatility
- Discuss the volatility and return characteristics of large portfolios.
- Describe the relationship between volatility and return of individual stocks.
- Define and contrast idiosyncratic and systematic risk.

Value of $100 Invested at the End of 1925



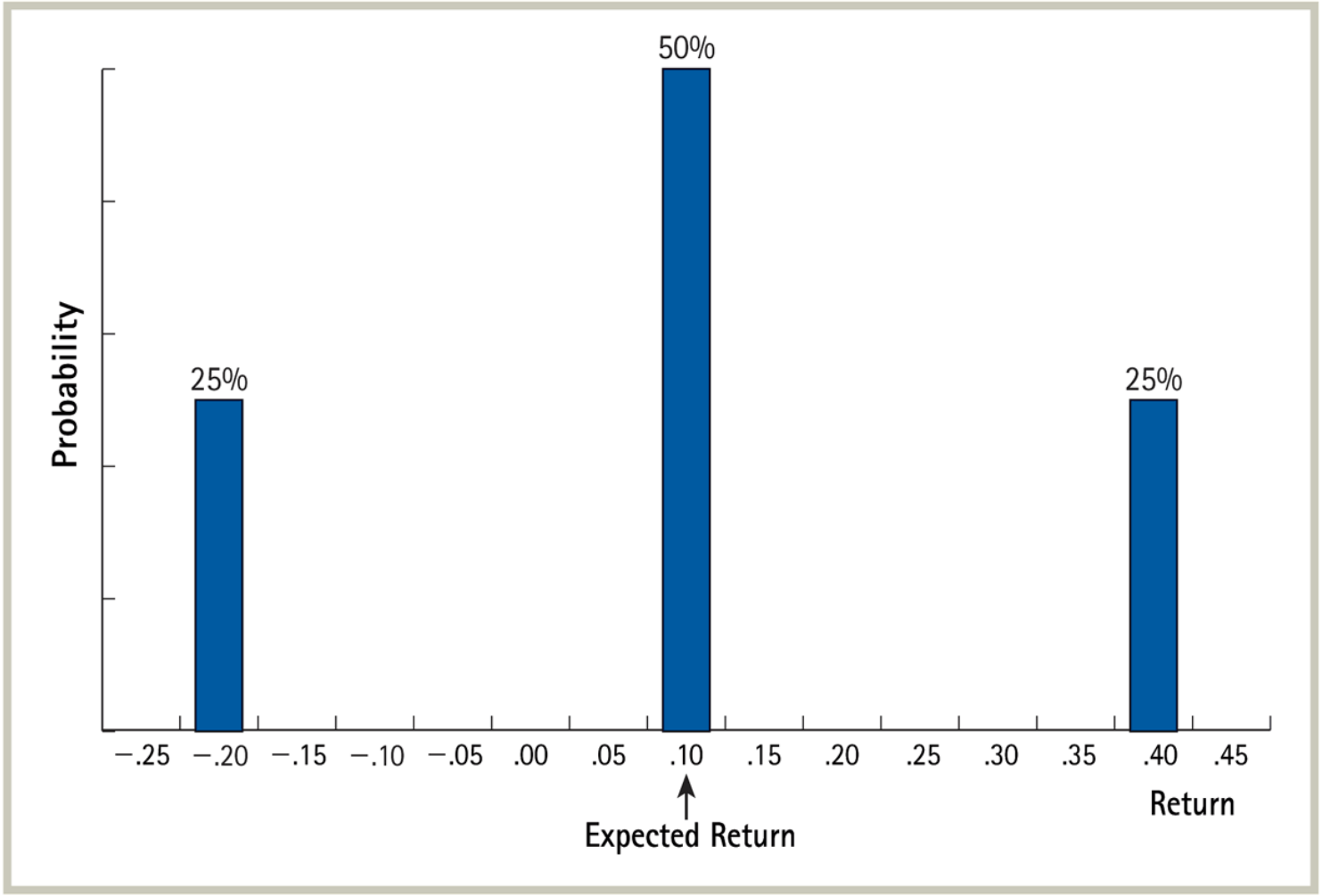
A First Look at Risk and Return

- Small stocks had the highest long-term returns, while T-Bills had the lowest long-term returns.
- Small stocks had the largest fluctuations in price, while T-Bills had the lowest.
  - Higher risk requires a higher return.

Common Measures of Risk and Return

- Probability Distribution
  - When an investment is risky, there are different returns it may earn. Each possible return has some likelihood of occurring. This information is summarized with a probability distribution, which assigns a probability, P_R , that each possible return, R , will occur.

Assume BFI stock currently trades for $100 per share. In one year, there is a 25% chance the share price will be $140, a 50% chance it will be $110, and a 25% chance it will be $80.



Expected Return

- Expected (Mean) Return
  - Calculated as a weighted average of the possible returns, where the weights correspond to the probabilities.

$$\text{Expected Return} = E[R] = \sum_R P_R \times R$$

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

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
  - The square root of the variance

$$SD(R) = \sqrt{Var(R)}$$

- Both are measures of the risk of a probability distribution

Variance and Standard Deviation

- For BFI, the variance and standard deviation are:

$$Var\left[R_{BFI}\right] = 25\% \times (-0.20 - 0.10)^2 + 50\% \times (0.10 - 0.10)^2 + 25\% \times (0.40 - 0.10)^2 = 0.045$$

$$SD(R) = \sqrt{Var(R)} = \sqrt{0.045} = 21.2\%$$

- In finance, the standard deviation of a return is also referred to as its volatility. The standard deviation is easier to interpret because it is in the same units as the returns themselves.

Historical Returns of Stocks and Bonds

- Computing Historical Returns
  - Realized Return
    - The return that actually occurs over a particular time period.

$$R_{t+1} = \frac{Div_{t+1} + P_{t+1}}{P_t} - 1 = \frac{Div_{t+1}}{P_t} + \frac{P_{t+1} - P_t}{P_t}$$

$$= \text{Dividend Yield} + \text{Capital Gain Rate}$$

Historical Returns of Stocks and Bonds

- Computing Historical Returns
  - If you hold the stock beyond the date of the first dividend, then to compute your return you must specify how you invest any dividends you receive in the interim. Let's assume 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 $R_{Q1}, \ldots, R_{Q4}$ 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

Realized Returns for GM Stock

Problem

What were the realized annual returns for GM stock in 1999 and in 2004?

Solution

First we look up GM stock price data at the start and end of the year, as well as at any dividend dates (see the book's Web site for online sources of stock price and dividend data). From these data we can construct the following table:

Date	Price ($)	Dividend ($)	Return	Date	Price ($)	Dividend ($)	Return
12/31/98	71.56			12/31/03	53.40		
2/2/99	89.44	0.50	25.68%	2/11/04	49.80	0.50	−5.81%
5/11/99	85.75	0.50	−3.57%	5/12/04	44.48	0.50	−9.68%
5/28/99[5]	69.00	13.72	−3.53%	8/11/04	41.74	0.50	−5.04%
8/10/99	60.81	0.50	−11.14%	11/4/04	39.50	0.50	−4.17%
11/8/99	69.06	0.50	14.39%	12/31/04	40.06		1.42%
12/31/99	72.69		5.26%				

We compute each period's return using Eq. 10.4. For example, the return from December 31, 1998, until February 2, 1999, is equal to

$$\frac{0.50 + 89.44}{71.56} - 1 = 25.68\%$$

We then determine the annual returns using Eq. 10.5:

$$R_{1999} = (1.2568)(0.9643)(0.9647)(0.8886)(1.1439)(1.0526) - 1 = 25.09\%$$

$$R_{2004} = (0.9419)(0.9032)(0.9496)(0.9583)(1.0142) - 1 = -21.48\%$$

The Empirical Distribution of Annual Returns for U.S. Large Stocks (S&P 500), Small Stocks, Corporate Bonds, and Treasury Bills, 1926–2004

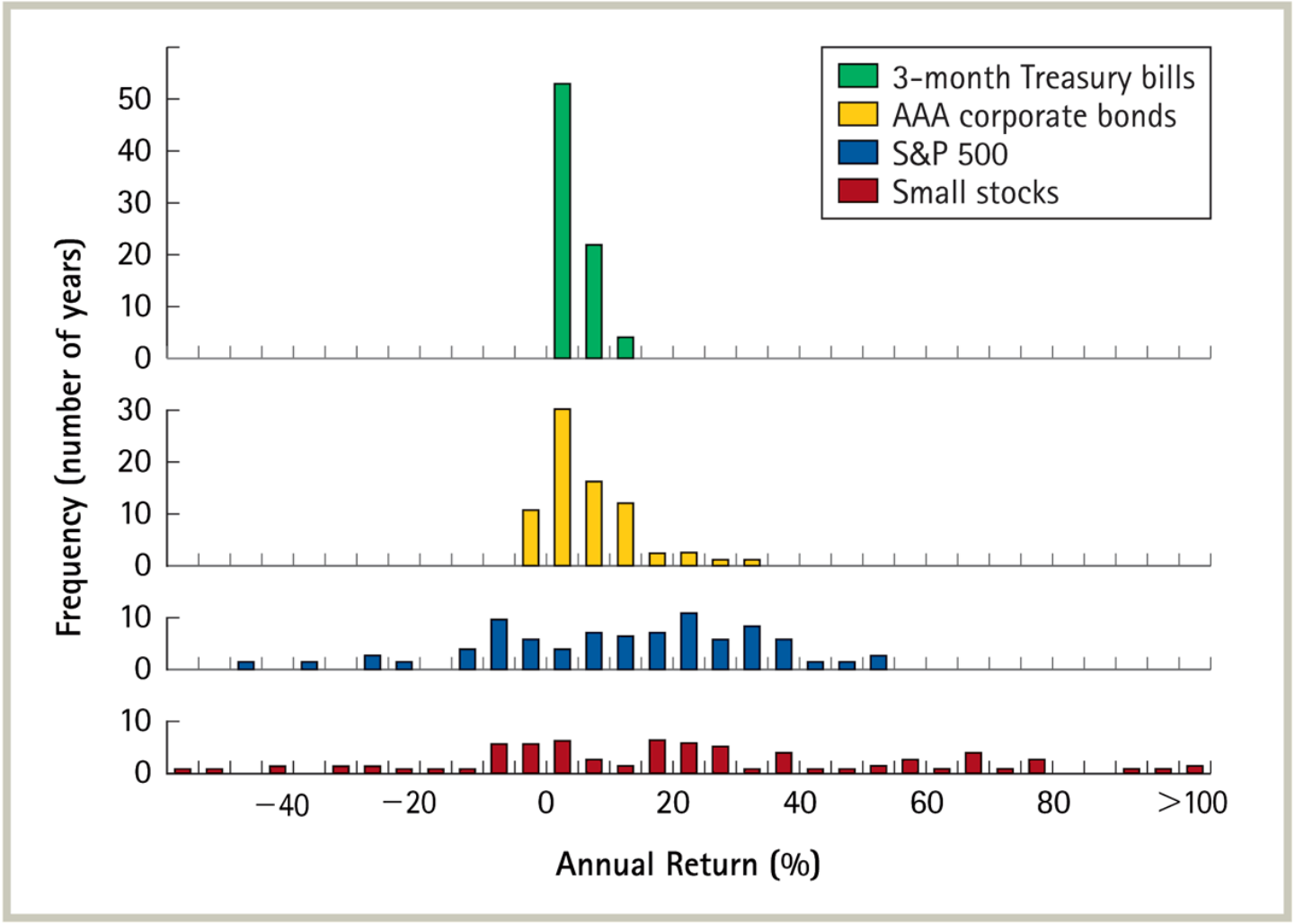


TABLE 10.3 **Average Annual Returns for U.S. Small Stocks, Large Stocks (S&P 500), Corporate Bonds, and Treasury Bills, 1926–2004**

Investment	Average Annual Return
Small stocks	22.11%
S&P 500	12.32%
Corporate bonds	6.52%
Treasury bills	3.87%

TABLE 10.4 **Volatility of U.S. Small Stocks, Large Stocks (S&P 500), Corporate Bonds, and Treasury Bills, 1926–2004**

Investment	Return Volatility (Standard Deviation)
Small stocks	42.75%
S&P 500	20.36%
Corporate bonds	7.17%
Treasury bills	3.18%

Average Annual 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

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

- The estimate of the standard deviation is the square root of the variance.

Average Annual Return

- Standard Error of the Estimate of the Expected Return

$$SD(\text{Average of Independent, Identical Risks}) = \frac{SD(\text{Individual Risk})}{\sqrt{\text{Number of Observations}}}$$

- 95% Confidence Interval

$$\text{Historical Average Return} \pm (2 \times \text{Standard Error})$$

  - For the S&P 500 (1926–2004)

$$12.3\% \pm 2\left(\frac{20.36\%}{\sqrt{79}}\right) = 12.3\% \pm 4.6\%$$

    - Or a range from 7.7% to 19.9%

The Historical Tradeoff Between Risk and Return

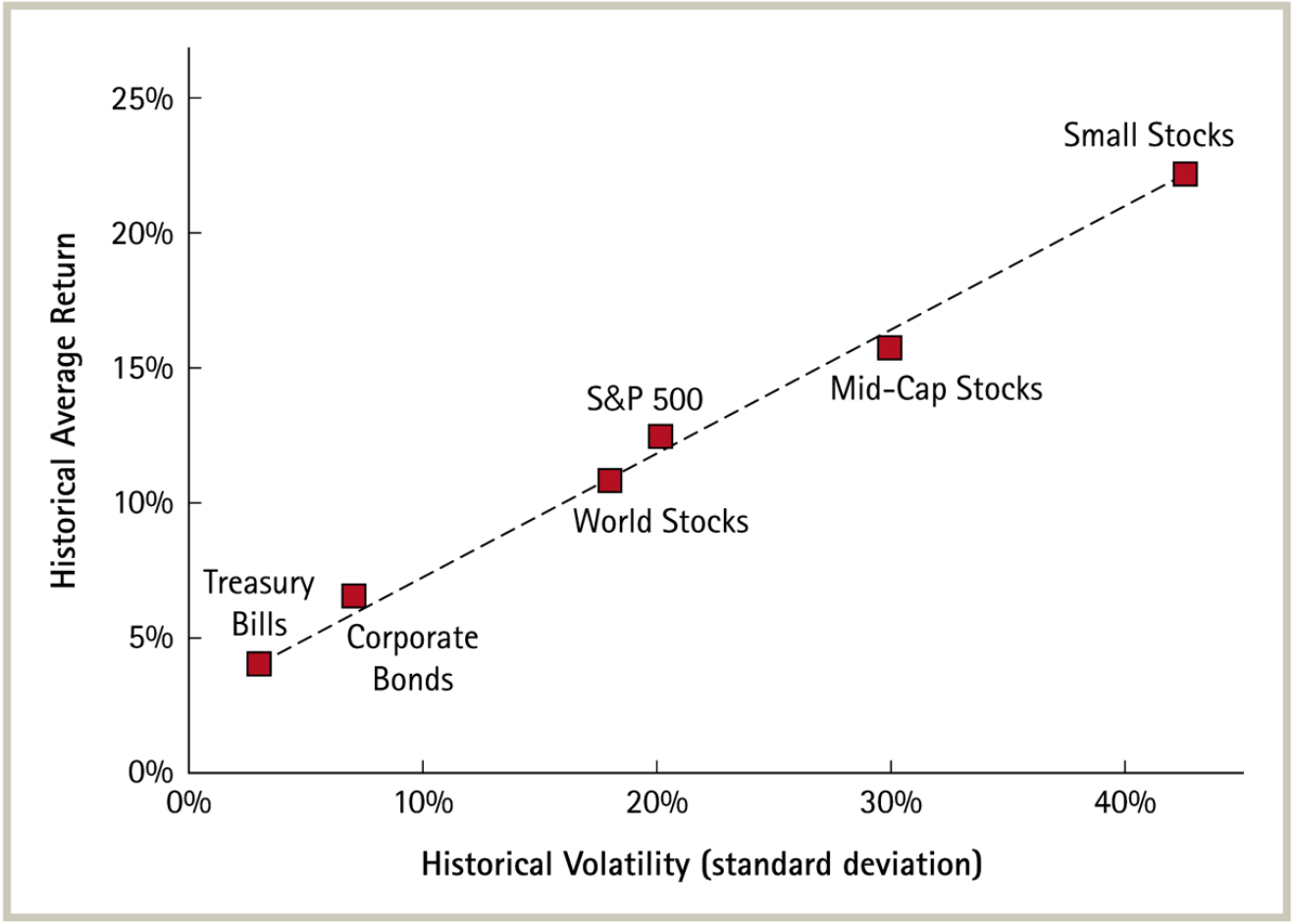
- The Returns of Large Portfolios
  - Excess Returns
    - The difference between the average return for an investment and the average return for T-Bills
    - Risk premium

TABLE 10.5

Volatility Versus Excess Return of U.S. Small Stocks, Large Stocks (S&P 500), Corporate Bonds, and Treasury Bills, 1926–2004

Investment	Return Volatility (Standard Deviation)	Excess Return (Average Return in Excess of Treasury Bills)
Small stocks	42.75%	18.24%
S&P 500	20.36%	8.45%
Corporate bonds	7.17%	2.65%
Treasury bills	3.18%	0.00%

Risk and Return in Large Portfolios, 1926–2004

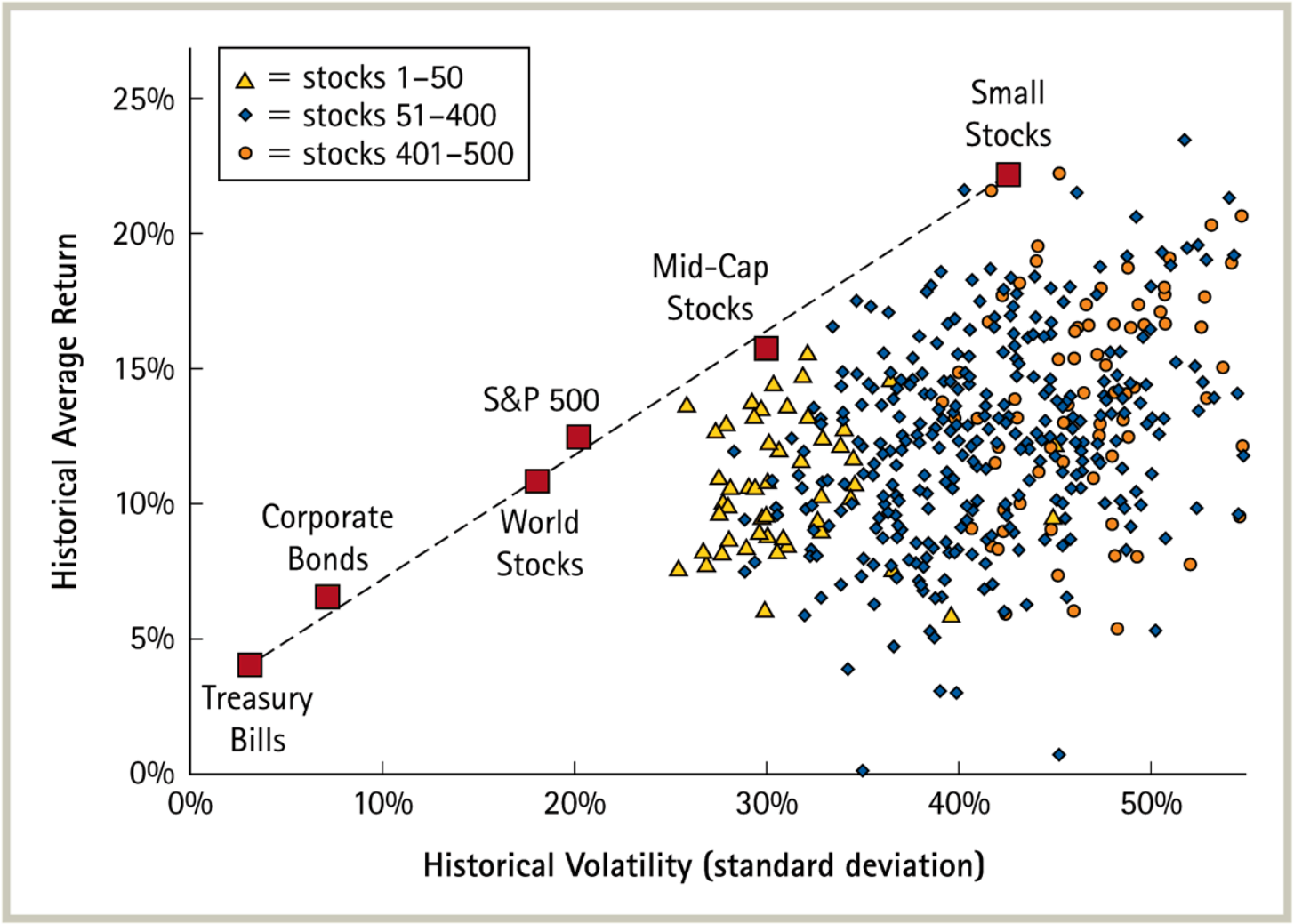


- Note the positive relationship between volatility and average returns for large portfolios.

The Returns of Individual Stocks

- Is there a positive relationship between volatility and average returns for individual stocks?

Historical Volatility and Return for 500 Individual Stocks, by Size, 1926–2004



Common Versus Independent Risk

- Common Risk
  - Risk that is perfectly correlated
    - Risk that affects all securities
- Independent Risk
  - Risk that is uncorrelated
    - Risk that affects a particular security
- Diversification
  - The averaging out of independent risks in a large portfolio

Diversification in Stock Portfolios

- Firm-Specific Versus Systematic Risk
  - Firm Specific News
    - Good or bad news about an individual company
  - Market-Wide News
    - News that affects all stocks, such as news about the economy

Diversification in Stock Portfolios

- Independent Risks
  - Due to firm-specific news
    - Also known as:
      - Firm-Specific Risk
      - Idiosyncratic Risk
      - Unique Risk
      - Unsystematic Risk
      - Diversifiable Risk

Diversification in Stock Portfolios

- Common Risks
  - Due to market-wide news
    - Also known as:
      - Systematic Risk
      - Undiversifiable Risk
      - Market Risk

Example

Diversifiable Versus Systematic Risk

Problem

Which of the following risks of a stock are likely to be firm-specific, diversifiable risks, and which are likely to be systematic risks? Which risks will affect the risk premium that investors will demand?

a. The risk that the founder and CEO retires
b. The risk that oil prices rise, increasing production costs
c. The risk that a product design is faulty and the product must be recalled
d. The risk that the economy slows, reducing demand for the firm's products

Solution

Because oil prices and the health of the economy affect all stocks, risks (b) and (d) are systematic risks. These risks are not diversified in a large portfolio, and so will affect the risk premium that investors require to invest in a stock. Risks (a) and (c) are firm-specific risks, and so are diversifiable. While these risks should be considered when estimating a firm's future cash flows, they will not affect the risk premium that investors will require and, therefore, will not affect a firm's cost of capital.

Diversification in Stock Portfolios

- Firm-Specific Versus Systematic Risk
  - When many stocks are combined in a large portfolio, the firm-specific risks for each stock will average out and be diversified.
  - The systematic risk, however, will affect all firms and will not be diversified.

Diversification in Stock Portfolios

- Consider two types of firms:
  - Type S firms are affected only by systematic risk. There is a 50% chance the economy will be strong and type S stocks will earn a return of 40%; There is a 50% change the economy will be weak and their return will be –20%. Because all these firms face the same systematic risk, holding a large portfolio of type S firms will not diversify the risk.
  - Type I firms are affected only by firm-specific risks. Their returns are equally likely to be 35% or –25%, based on factors specific to each firm's local market. Because these risks are firm specific, if we hold a portfolio of the stocks of many type I firms, the risk is diversified.

Example

Portfolio Volatility

Problem

What is the volatility of the average return of ten type S firms? What is the volatility of the average return of ten type I firms?

Solution

Type S firms have equally likely returns of 40% or −20%. Their expected return is $\frac{1}{2}(40\%) + \frac{1}{2}(-20\%) = 10\%$, so

$$SD(R_S) = \sqrt{\tfrac{1}{2}(0.40 - 0.10)^2 + \tfrac{1}{2}(-0.20 - 0.10)^2} = 30\%$$

Because all type S firms have high or low returns at the same time, the average return of ten type S firms is also 40% or −20%. Thus it has the same volatility of 30%, as shown in Figure 10.8.

Type I firms have equally likely returns of 35% or −25%. Their expected return is $\frac{1}{2}(35\%) + \frac{1}{2}(-25\%) = 5\%$, so

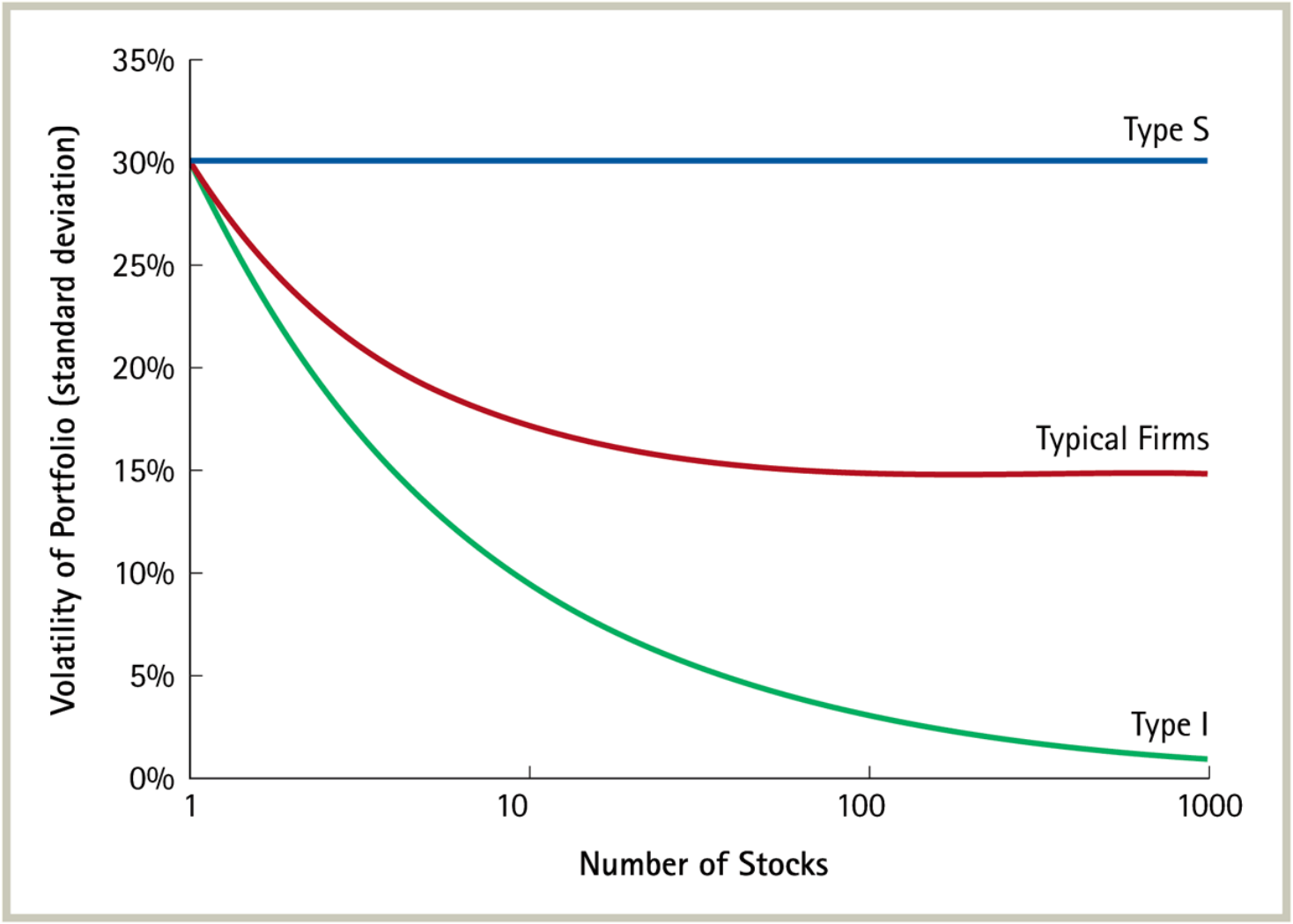
$$SD(R_I) = \sqrt{\tfrac{1}{2}(0.35 - 0.05)^2 + \tfrac{1}{2}(-0.25 - 0.05)^2} = 30\%$$

Because the returns of type I firms are independent, using Eq. 10.8, the average return of ten type I firms has volatility of $30\% / \sqrt{10} = 9.5\%$, as shown in Figure 10.8.

Diversification in Stock Portfolios

- Firm-Specific Versus Systematic Risk
  - Actual firms are affected by both market-wide risks and firm-specific risks. When firms carry both types of risk, only the unsystematic risk will be diversified when many firm's stocks are combined into a portfolio. The volatility will therefore decline until only the systematic risk remains.

Diversification in Stock Portfolios



No Arbitrage and the Risk Premium

- *The risk premium for diversifiable risk is zero, so investors are not compensated for holding firm-specific risk.*
  - If the diversifiable risk of stocks were compensated with an additional risk premium, then investors could buy the stocks, earn the additional premium, and simultaneously diversify and eliminate the risk. By doing so, investors could earn an additional premium without taking on additional risk.

No Arbitrage and the Risk Premium

- *The risk premium of a security is determined by its systematic risk and does not depend on its diversifiable risk.*
  - This implies that a stock's volatility, which is a measure of total risk (that is, systematic risk plus diversifiable risk), is not especially useful in determining the risk premium that investors will earn.
- Standard deviation is not an appropriate measure of risk for an individual security. There should be no clear relationship between volatility and average returns for individual securities.

Measuring Systematic Risk

- To measure the systematic risk of a stock, determine how much of the variability of its return is due to systematic risk versus unsystematic 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
  - An efficient portfolio that contains all shares and securities in the market
    - The S&P 500 is often used as a proxy for the market portfolio.

Measuring Systematic Risk

- Beta (β)
  - *The expected percent change in the excess return of a security for a 1% change in the excess return of the market portfolio.*
    - Beta differs from volatility. Volatility measures total risk (systematic plus unsystematic risk), while beta is a measure of only systematic risk.
  - A security's beta is related to how sensitive its underlying revenues and cash flows are to general economic conditions. Stocks in cyclical industries, are likely to be more sensitive to systematic risk and have higher betas than stocks in less sensitive industries.

TABLE 10.6 **Betas With Respect to the S&P 500 for Individual Stocks and Average Betas for Stocks in Their Industries (based on monthly data for 2000–2005)**

Industry	Beta	Ticker	Firm	Beta
Gold and Silver	−0.04	NEM	Newmont Mining Corporation	0.02
Beverages (Alcoholic)	0.23	BUD	Anheuser-Busch Companies, Inc.	0.10
Personal and Household Prods.	0.25	PG	The Procter & Gamble Company	0.19
Food Processing	0.34	HNZ	H. J. Heinz Company	0.37
		HSY	The Hershey Company	−0.10
Beverages (Nonalcoholic)	0.43	KO	The Coca-Cola Company	0.50
Electric Utilities	0.48	EIX	Edison International	0.50
Major Drugs	0.48	PFE	Pfizer Inc.	0.54
Restaurants	0.69	SBUX	Starbucks Corporation	0.60
Retail (Grocery)	0.74	SWY	Safeway Inc.	0.67
Conglomerates	0.84	GE	General Electric Company	0.85
Forestry and Wood Products	0.95	WY	Weyerhaeuser Company	0.96
Recreational Products	1.00	HDI	Harley-Davidson, Inc.	1.14
Apparel/Accessories	1.12	LIZ	Liz Claiborne, Inc.	0.90
Retail (Home Improvement)	1.22	HD	Home Depot, Inc.	1.43
Auto and Truck Manufacturers	1.44	GM	General Motors Corporation	1.20
Computer Hardware	1.60	AAPL	Apple Computer, Inc.	1.35
Software and Programming	1.74	ADBE	Adobe Systems, Inc.	1.84
		MSFT	Microsoft Corporation	1.12
Computer Services	1.77	YHOO	Yahoo! Inc.	2.80
Communications Equipment	2.20	CSCO	Cisco Systems, Inc.	2.28
Semiconductors	2.59	AMD	Advanced Micro Devices, Inc.	3.23
		INTC	Intel Corporation	2.17

Measuring Systematic Risk

- Estimating a Traded Security's Expected Return from Its Beta

$$E[R] = \text{Risk-Free Interest Rate} + \text{Risk Premium}$$
$$= r_f + \beta \times (E[R_{Mkt}] - r_f)$$

Risk and the Cost of Capital

- A firm's cost of capital for a project is the expected return that its investors could earn on other investments with the same risk.
  - Systematic risk determines expected returns, thus the cost of capital for an investment is the expected return available on securities with the same beta.

Risk and the Cost of Capital

- The cost of capital for investing in a project is:

$$r = r_f + \beta \times (E[R_{Mkt}] - r_f)$$

- It is often referred to as the **Capital Asset Pricing Model (CAPM)**. It is the most important method for estimating the cost of capital that is used in practice.

Example

Computing the Cost of Capital

Problem

Suppose that in the coming year, you expect Microsoft stock to have a volatility of 23% and a beta of 1.28, and McDonald's stock to have a volatility of 37% and a beta of 0.99. Which stock carries more total risk? Which has more systematic risk? If the risk-free interest rate is 4% and the market's expected return is 10%, estimate the cost of capital for a project with the same beta as McDonald's stock and a project with the same beta as Microsoft stock. Which project has a higher cost of capital?

Solution

Total risk is measured by volatility; therefore, McDonald's stock has more total risk. Systematic risk is measured by beta. Microsoft has a higher beta, so it has more systematic risk.

Given the estimated beta for Microsoft of 1.28, we expect the price for Microsoft's stock to move by 1.28% for every 1% move of the market. Therefore, Microsoft's risk premium will be 1.28 times the risk premium of the market, and the cost of capital for investing in a project with the same risk as Microsoft stock is

$$E[R_{MSFT}] = r_f + 1.28 \times 6\% = 4\% + 7.7\% = 11.7\%$$

McDonald's stock has a lower beta of 0.99. The cost of capital for investing in a project with the same risk as McDonald's stock is

$$E[R_{McD}] = r_f + 0.99 \times 6\% = 4\% + 5.9\% = 9.9\%$$

Because systematic risk cannot be diversified, it is systematic risk that determines the cost of capital; thus Microsoft has a higher cost of capital than McDonald's, even though it is less volatile.

Summary and Conclusions

- Risk and return
- Idiosyncratic risk (特质风险)和Systematic risk (系统风险）
- How to measure systematic risk?