# CHAPTER 6

Risk, Return, and the Capital Asset Pricing Model



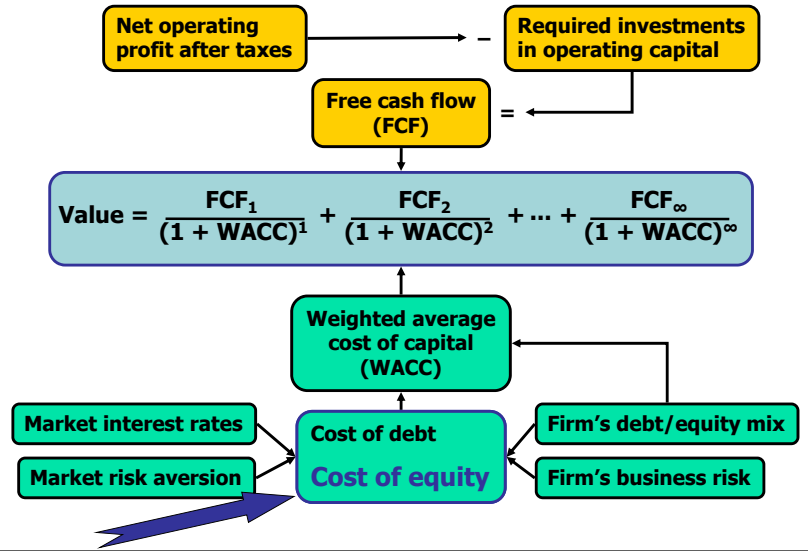
## Topics in Chapter

- Basic return concepts
- Basic risk concepts
- Stand-alone risk
- Portfolio (market) risk
- Risk and return: CAPM/SML



**Determinants of Intrinsic Value:**

**The Cost of Equity**




## What are investment returns?

- Investment returns measure the financial results of an investment.
- Returns may be historical or prospective (anticipated).
- Returns can be expressed in:
  - Dollar terms.
  - Percentage terms.

## An investment costs $1,000 and is sold after 1 year for $1,100.

Dollar return:

$ Received - $ Invested
$1,100 - $1,000 = $100.

Percentage return:

$ Return/$ Invested
$100/$1,000 = 0.10 = 10%.

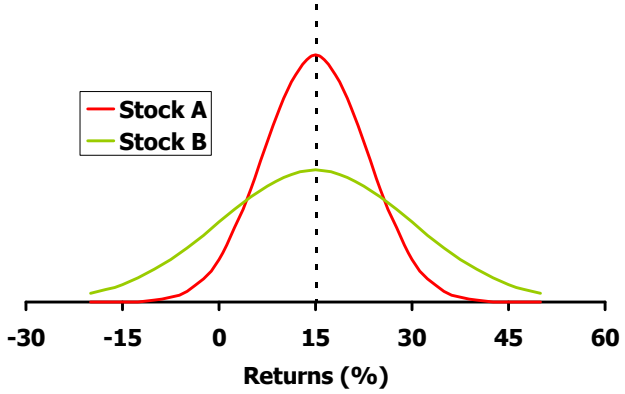


## What is investment risk?

- Typically, investment returns are not known with certainty.
- Investment risk pertains to the probability of earning a return less than that expected.
- The greater the chance of a return far below the expected return, the greater the risk.



## Probability Distribution: Which stock is riskier? Why?






## Consider the Following Investment Alternatives

| Econ. | Prob. | T-Bill | Alta | Repo | Am F. | MP |
|---|---|---|---|---|---|---|
| Bust | 0.10 | 8.0% | -22.0% | 28.0% | 10.0% | -13.0% |
| Below avg. | 0.20 | 8.0 | -2.0 | 14.7 | -10.0 | 1.0 |
| Avg. | 0.40 | 8.0 | 20.0 | 0.0 | 7.0 | 15.0 |
| Above avg. | 0.20 | 8.0 | 35.0 | -10.0 | 45.0 | 29.0 |
| Boom | 0.10 | 8.0 | 50.0 | -20.0 | 30.0 | 43.0 |
| | 1.00 | | | | | |

## What is unique about the T-bill return?

- The T-bill will return 8% regardless of the state of the economy.
- Is the T-bill riskless? Explain.



## Alta Inds. and Repo Men vs. the Economy

- Alta Inds. moves with the economy, so it is positively correlated with the economy. This is the typical situation.
- Repo Men moves counter to the economy. Such negative correlation is unusual.



## Calculate the expected rate of return on each alternative.

$\hat{r}$ = expected rate of return.

$$\hat{r} = \sum_{i=1}^{n} r_i P_i.$$

$$\hat{r}_{Alta} = 0.10(-22\%) + 0.20(-2\%) + 0.40(20\%) + 0.20(35\%) + 0.10(50\%) = 17.4\%.$$



## Alta has the highest rate of return. Does that make it best?

| | $\hat{r}$ |
|---|---|
| Alta | 17.4% |
| Market | 15.0 |
| Am. Foam | 13.8 |
| T-bill | 8.0 |
| Repo Men | 1.7 |

## What is the standard deviation of returns for each alternative?

$\sigma$ = Standard deviation

$$\sigma = \sqrt{\text{Variance}} = \sqrt{\sigma^2}$$

$$= \sqrt{\sum_{i=1}^{n} (r_i - \hat{r})^2 P_i}.$$



## Standard Deviation of Alta Industries

$$\sigma = [(-22 - 17.4)^2 0.10 + (-2 - 17.4)^2 0.20 + (20 - 17.4)^2 0.40 + (35 - 17.4)^2 0.20 + (50 - 17.4)^2 0.10]^{1/2}$$
$$= 20.0\%.$$



## Standard Deviation of Alternatives

$\sigma_{\text{T-bills}} = 0.0\%.$

$\sigma_{\text{Alta}} = 20.0\%.$

$\sigma_{\text{Repo}} = 13.4\%.$

$\sigma_{\text{Am Foam}} = 18.8\%.$

$\sigma_{\text{Market}} = 15.3\%.$



## Stand-Alone Risk

- Standard deviation measures the stand-alone risk of an investment.
- The larger the standard deviation, the higher the probability that returns will be far below the expected return.

## Expected Return versus Risk

| Security | Expected Return | Risk, σ |
|---|---|---|
| Alta Inds. | 17.4% | 20.0% |
| Market | 15.0 | 15.3 |
| Am. Foam | 13.8 | 18.8 |
| T-bills | 8.0 | 0.0 |
| Repo Men | 1.7 | 13.4 |



## Coefficient of Variation (CV)

- CV = Standard deviation / Expected return
- CVT-BILLS = 0.0% / 8.0% = 0.0.
- CVAlta Inds = 20.0% / 17.4% = 1.1.
- CVRepo Men = 13.4% / 1.7% = 7.9.
- CVAm. Foam = 18.8% / 13.8% = 1.4.
- CVM = 15.3% / 15.0% = 1.0.

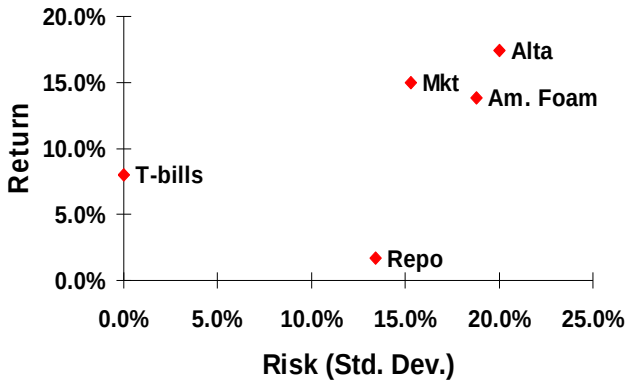


## Expected Return versus Coefficient of Variation

| Security | Expected Return | Risk: σ | Risk: CV |
|---|---|---|---|
| Alta Inds | 17.4% | 20.0% | 1.1 |
| Market | 15.0 | 15.3 | 1.0 |
| Am. Foam | 13.8 | 18.8 | 1.4 |
| T-bills | 8.0 | 0.0 | 0.0 |
| Repo Men | 1.7 | 13.4 | 7.9 |



## Return vs. Risk (Std. Dev.): Which investment is best?



## Portfolio Risk and Return

Assume a two-stock portfolio with $50,000 in Alta Inds. and $50,000 in Repo Men.

Calculate $\hat{r}_p$ and $\sigma_p$.



## Portfolio Expected Return

$\hat{r}_p$ is a weighted average ($w_i$ is % of portfolio in stock i):

$$\hat{r}_p = \sum_{i=1}^{n} w_i \hat{r}_i$$

$\hat{r}_p = 0.5(17.4\%) + 0.5(1.7\%) = 9.6\%.$



## Alternative Method: Find portfolio return in each economic state

| Economy | Prob. | Alta | Repo | Port.= 0.5(Alta) + 0.5(Repo) |
|---|---|---|---|---|
| Bust | 0.10 | -22.0% | 28.0% | 3.0% |
| Below avg. | 0.20 | -2.0 | 14.7 | 6.4 |
| Average | 0.40 | 20.0 | 0.0 | 10.0 |
| Above avg. | 0.20 | 35.0 | -10.0 | 12.5 |
| Boom | 0.10 | 50.0 | -20.0 | 15.0 |



## Use portfolio outcomes to estimate risk and expected return

$\hat{r}_p = (3.0\%)0.10 + (6.4\%)0.20 + (10.0\%)0.40 + (12.5\%)0.20 + (15.0\%)0.10 = 9.6\%$

$\sigma_p = ((3.0 - 9.6)^2 0.10 + (6.4 - 9.6)^2 0.20 + (10.0 - 9.6)^2 0.40 + (12.5 - 9.6)^2 0.20 + (15.0 - 9.6)^2 0.10)^{1/2} = 3.3\%$

$CV_p = 3.3\%/9.6\% = .34$

## Portfolio vs. Its Components

- Portfolio expected return (9.6%) is between Alta (17.4%) and Repo (1.7%) returns.
- Portfolio standard deviation is much lower than:
  - either stock (20% and 13.4%).
  - average of Alta and Repo (16.7%).
- The reason is due to negative correlation ($\rho$) between Alta and Repo returns.



## Two-Stock Portfolios

- Two stocks can be combined to form a riskless portfolio if $\rho = -1.0$.
- Risk is not reduced at all if the two stocks have $\rho = +1.0$.
- In general, stocks have $\rho \approx 0.35$, so risk is lowered but not eliminated.
- Investors typically hold many stocks.
- What happens when $\rho = 0$?



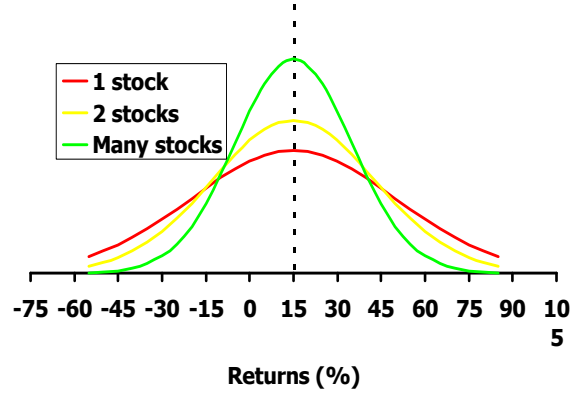
## Adding Stocks to a Portfolio

- What would happen to the risk of an average 1-stock portfolio as more randomly selected stocks were added?
- $\sigma_p$ would decrease because the added stocks would not be perfectly correlated, but the expected portfolio return would remain relatively constant.

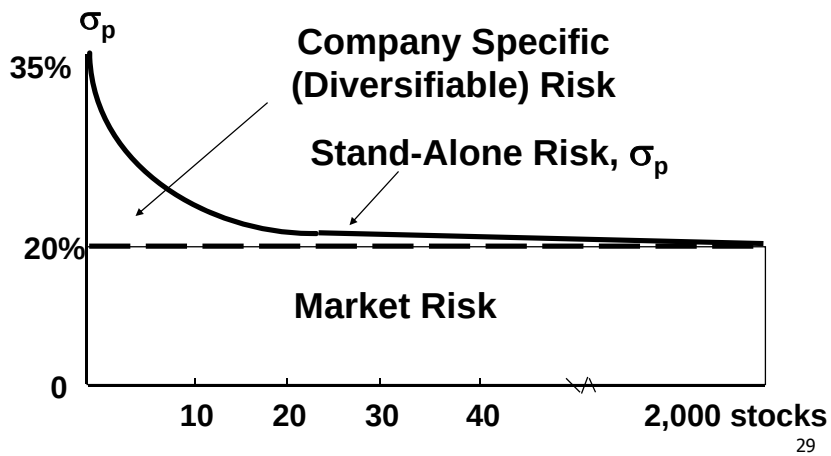


$\sigma_{1\ stock} \approx 35\%$

$\sigma_{Many\ stocks} \approx 20\%$



# Risk vs. Number of Stock in Portfolio






# Stand-alone risk = Market risk + Diversifiable risk

- Market risk is that part of a security's stand-alone risk that cannot be eliminated by diversification.
- Firm-specific, or diversifiable, risk is that part of a security's stand-alone risk that can be eliminated by diversification.



# Conclusions

- As more stocks are added, each new stock has a smaller risk-reducing impact on the portfolio.
- $\sigma_p$ falls very slowly after about 40 stocks are included. The lower limit for $\sigma_p$ is about 20% = $\sigma_M$ .
- By forming well-diversified portfolios, investors can eliminate about half the risk of owning a single stock.



# Can an investor holding one stock earn a return commensurate with its risk?

- No. Rational investors will minimize risk by holding portfolios.
- They bear only market risk, so prices and returns reflect this lower risk.
- The one-stock investor bears higher (stand-alone) risk, so the return is less than that required by the risk.

## How is market risk measured for individual securities?

- Market risk, which is relevant for stocks held in well-diversified portfolios, is defined as the contribution of a security to the overall riskiness of the portfolio.
- It is measured by a stock's beta coefficient. For stock i, its beta is:
- $b_i = (\rho_{i,M}\ \sigma_i) / \sigma_M$



## How are betas calculated?

- In addition to measuring a stock's contribution of risk to a portfolio, beta also measures the stock's volatility relative to the market.



## Using a Regression to Estimate Beta

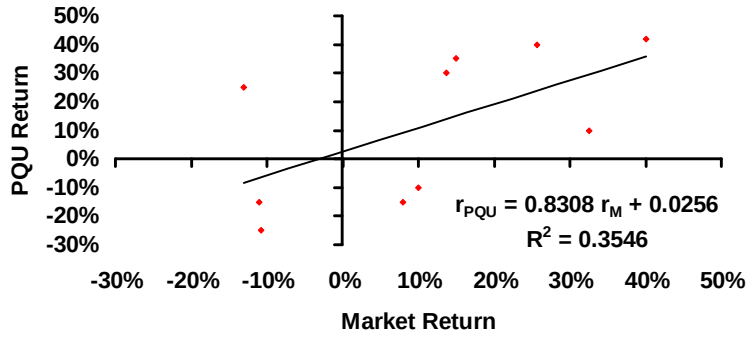
- Run a regression with returns on the stock in question plotted on the Y axis and returns on the market portfolio plotted on the X axis.
- The slope of the regression line, which measures relative volatility, is defined as the stock's beta coefficient, or b.



## Use the historical stock returns to calculate the beta for PQU.

| Year | Market | PQU |
|---|---|---|
| 1 | 25.7% | 40.0% |
| 2 | 8.0% | -15.0% |
| 3 | -11.0% | -15.0% |
| 4 | 15.0% | 35.0% |
| 5 | 32.5% | 10.0% |
| 6 | 13.7% | 30.0% |
| 7 | 40.0% | 42.0% |
| 8 | 10.0% | -10.0% |
| 9 | -10.8% | -25.0% |
| 10 | -13.1% | 25.0% |

# Calculating Beta for PQU






# What is beta for PQU?

- The regression line, and hence beta, can be found using a calculator with a regression function or a spreadsheet program. In this example, b = 0.83.



# Calculating Beta in Practice

- Many analysts use the S&P 500 to find the market return.
- Analysts typically use four or five years' of monthly returns to establish the regression line.
- Some analysts use 52 weeks of weekly returns.



# How is beta interpreted?

- If b = 1.0, stock has average risk.
- If b > 1.0, stock is riskier than average.
- If b < 1.0, stock is less risky than average.
- Most stocks have betas in the range of 0.5 to 1.5.
- Can a stock have a negative beta?

## Other Web Sites for Beta

- Go to http://finance.yahoo.com
- Enter the ticker symbol for a "Stock Quote", such as IBM or Dell, then click GO.
- When the quote comes up, select Key Statistics from panel on left.



## Expected Return versus Market Risk: Which investment is best?

| Security | Expected Return (%) | Risk, b |
|---|---|---|
| Alta | 17.4 | 1.29 |
| Market | 15.0 | 1.00 |
| Am. Foam | 13.8 | 0.68 |
| T-bills | 8.0 | 0.00 |
| Repo Men | 1.7 | -0.86 |



## Use the SML to calculate each alternative's required return.

- The Security Market Line (SML) is part of the Capital Asset Pricing Model (CAPM).
- SML: $r_i = r_{RF} + (RP_M)b_i$ .
- Assume $r_{RF} = 8\%$; $r_M = r_M = 15\%$.
- $RP_M = (r_M - r_{RF}) = 15\% - 8\% = 7\%$.



## Required Rates of Return

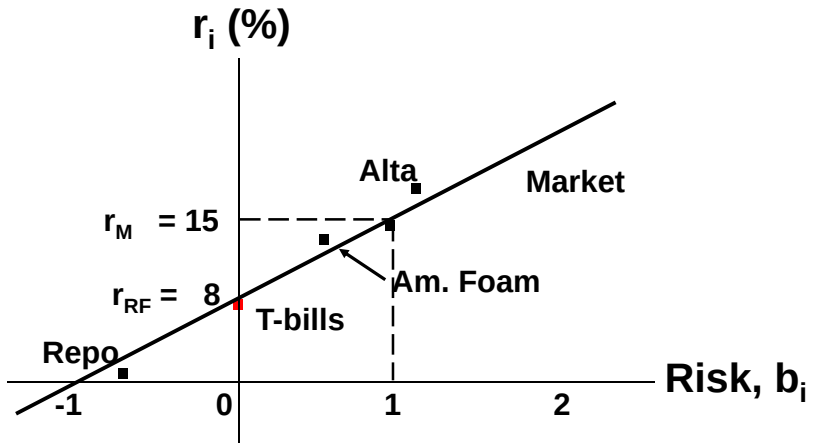
- $r_{Alta} = 8.0\% + (7\%)(1.29) = 17\%$.
- $r_M = 8.0\% + (7\%)(1.00) = 15.0\%$.
- $r_{Am.\ F.} = 8.0\% + (7\%)(0.68) = 12.8\%$.
- $r_{T\text{-}bill} = 8.0\% + (7\%)(0.00) = 8.0\%$.
- $r_{Repo} = 8.0\% + (7\%)(-0.86) = 2.0\%$.

## Expected versus Required Returns (%)

| | Exp. r | Req. r | |
|---|---|---|---|
| Alta | 17.4 | 17.0 | Undervalued |
| Market | 15.0 | 15.0 | Fairly valued |
| Am. Foam | 13.8 | 12.8 | Undervalued |
| T-bills | 8.0 | 8.0 | Fairly valued |
| Repo | 1.7 | 2.0 | Overvalued |



## SML: $r_i = r_{RF} + (RP_M)\, b_i$
## $r_i = 8\% + (7\%)\, b_i$






## Calculate beta for a portfolio with 50% Alta and 50% Repo

$b_p$ = Weighted average
$= 0.5(b_{Alta}) + 0.5(b_{Repo})$
$= 0.5(1.29) + 0.5(-0.86)$
$= 0.22.$



## Required Return on the Alta/Repo Portfolio?

$r_p$ = Weighted average r
$= 0.5(17\%) + 0.5(2\%) = 9.5\%.$

Or use SML:

$r_p = r_{RF} + (RP_M)\, b_p$
$= 8.0\% + 7\%(0.22) = 9.5\%.$