



Risk and Return: The Basics

Basic return concepts

Basic risk concepts

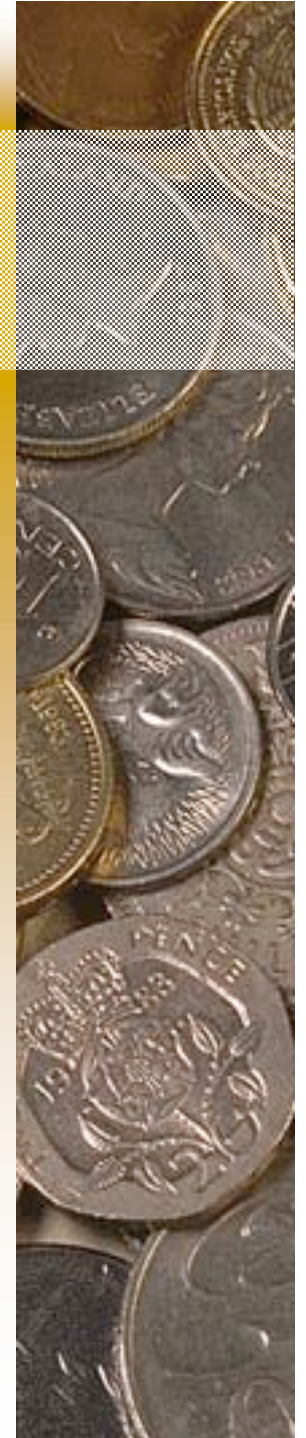
Stand-alone risk

Portfolio (market) risk

Risk and return: CAPM/SML

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.



What is the return on an investment that costs \$1,000 and is sold after 1 year for \$1,100?

■ **Dollar return:**

$$\begin{array}{r} \$ \text{ Received} - \$ \text{ Invested} \\ \$1,100 - \$1,000 = \$100. \end{array}$$

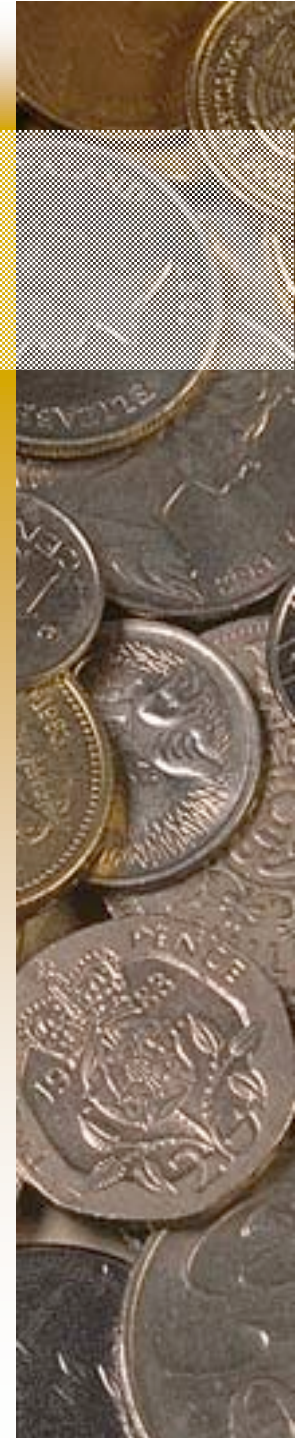
■ **Percentage return:**

$$\begin{array}{r} \$ \text{ Return}/\$ \text{ Invested} \\ \$100/\$1,000 = 0.10 = 10\%. \end{array}$$

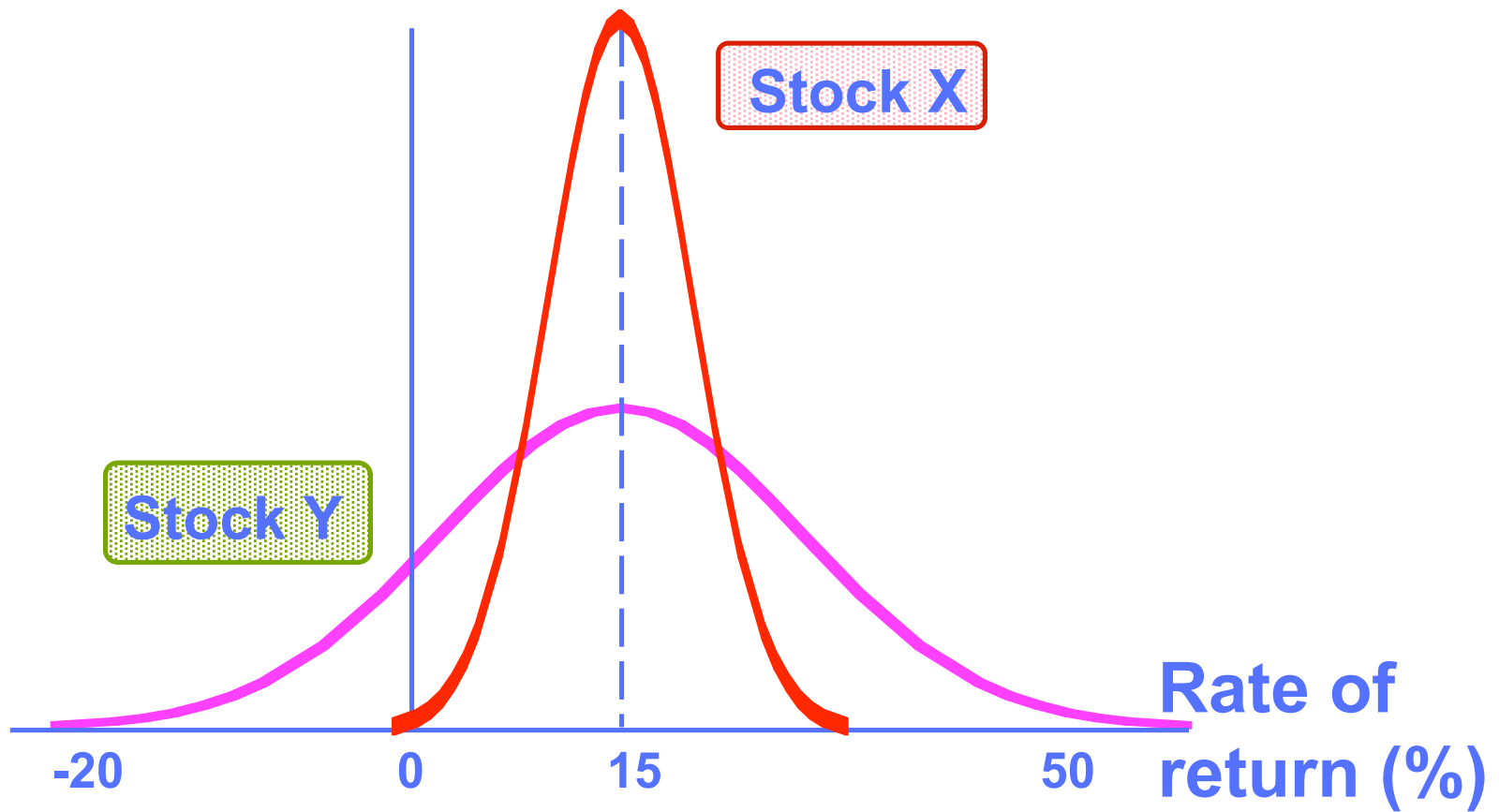


What is investment risk?

- 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?

Assume the Following Investment Alternatives

<u>Economy</u>	<u>Prob.</u>	<u>T-Bill</u>	<u>Alta</u>	<u>Repo</u>	<u>Am F.</u>	<u>MP</u>
Recession	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
Average	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	<u>0.10</u>	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.



Do the returns of Alta Inds. and Repo Men move with or counter to 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.

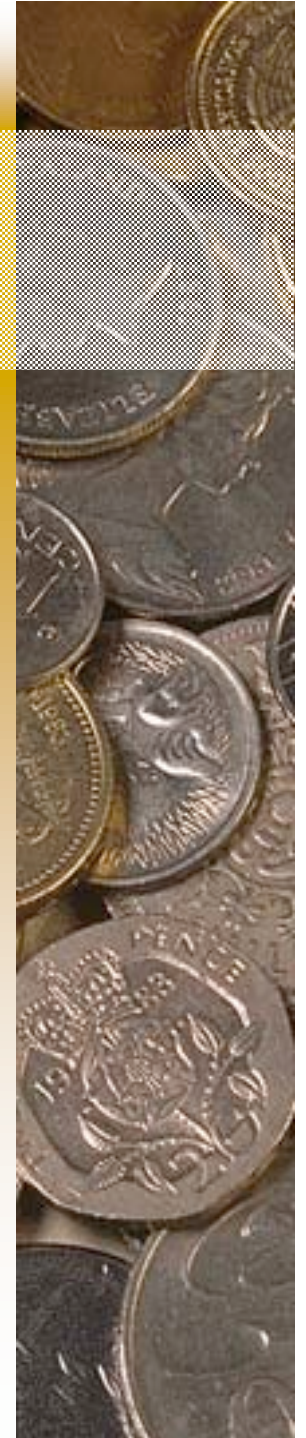


Calculating the expected rate of return on each alternative.

\hat{r} = expected rate of return.

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

$$\begin{aligned} \hat{r}_{\text{Alta}} &= 0.10(-22\%) + 0.20(-2\%) \\ &\quad + 0.40(20\%) + 0.20(35\%) \\ &\quad + 0.10(50\%) = \mathbf{17.4\%}. \end{aligned}$$



The expected rate of return on each alternative.

	<u>r</u>
Alta	17.4%
Market	15.0
Am. Foam	13.8
T-bill	8.0
Repo Men	1.7

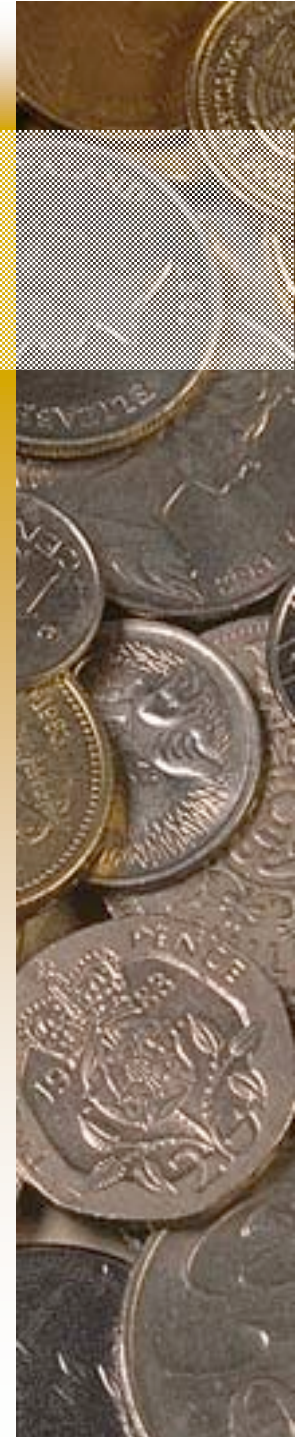
- Alta has the highest rate of return.
- Does that make it best?



What is the standard deviation of returns for each alternative?

σ = Standard deviation

$$\begin{aligned}\sigma &= \sqrt{\text{Variance}} = \sqrt{\sigma^2} \\ &= \sqrt{\sum_{i=1}^n (r_i - \bar{r})^2 P_i}\end{aligned}$$



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

Alta Inds:

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

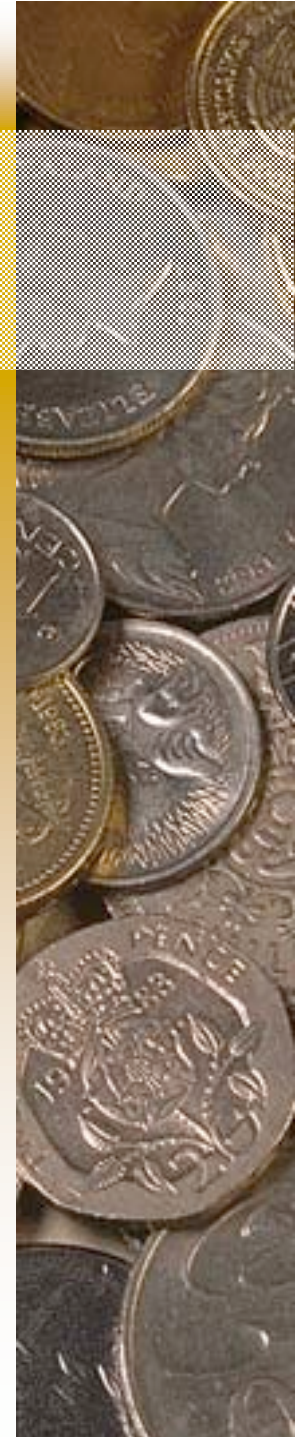
$$\sigma_{\text{T-bills}} = 0.0\%$$

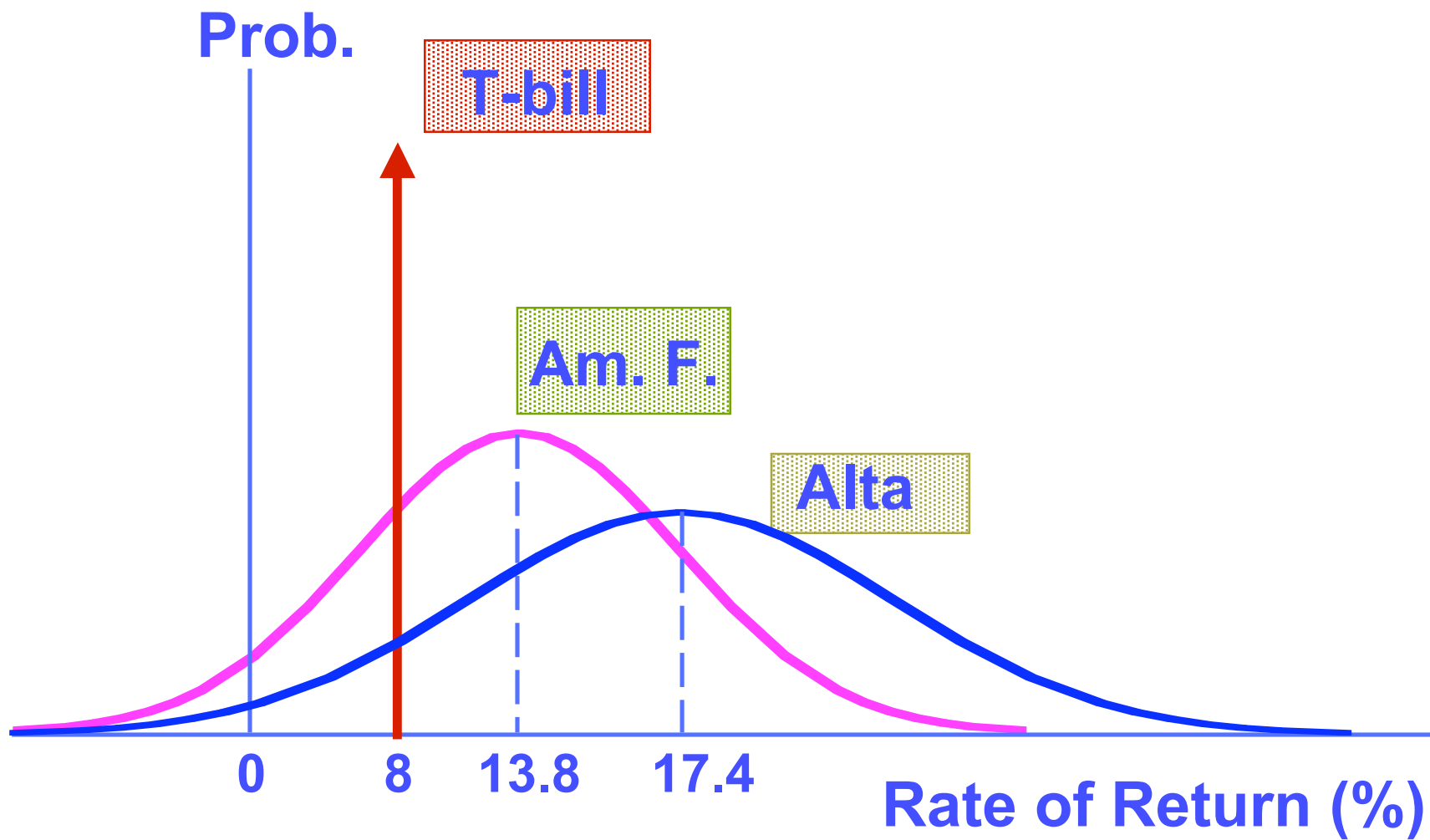
$$\sigma_{\text{Alta}} = 20.0\%$$

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

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

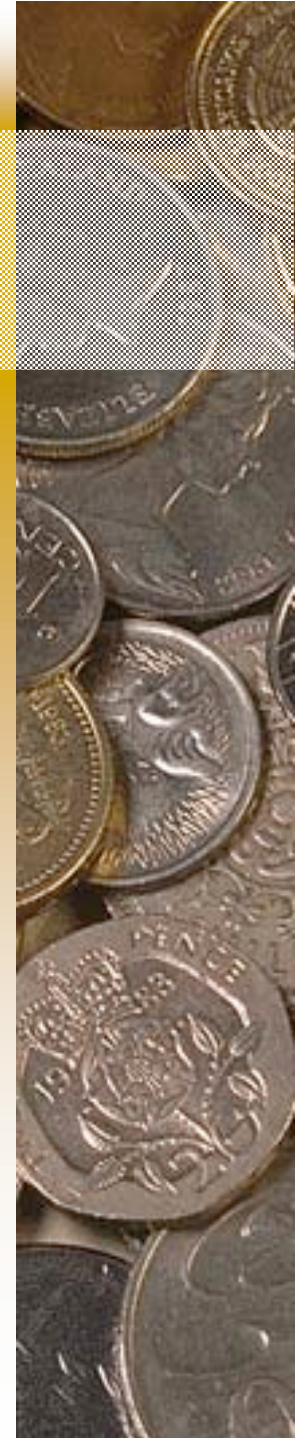
$$\sigma_{\text{Market}} = 15.3\%$$





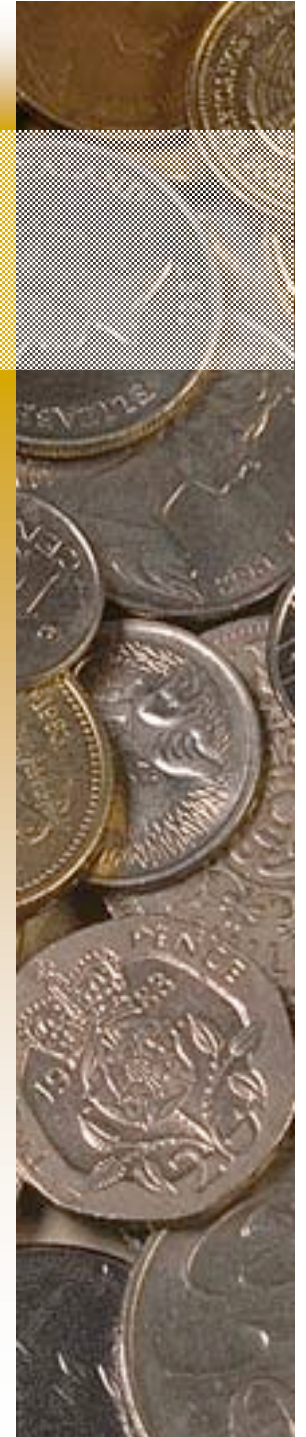
Implications

- **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.
- **Coefficient of variation** is an alternative measure of stand-alone risk.



Expected Return versus Risk

<u>Security</u>	<u>Expected return</u>	<u>Risk, σ</u>
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:

$CV = \text{Standard deviation} / \text{Expected return.}$

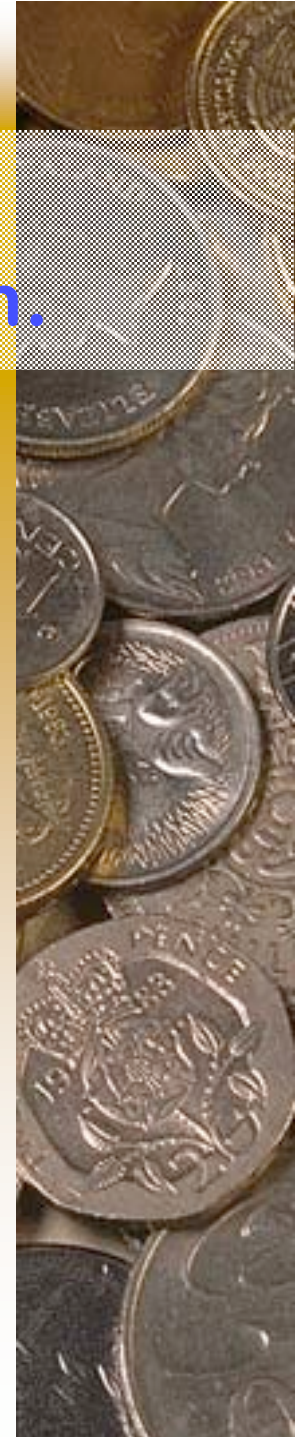
$$CV_{\text{T-BILLS}} = 0.0\% / 8.0\% = 0.0.$$

$$CV_{\text{Alta Inds}} = 20.0\% / 17.4\% = 1.1.$$

$$CV_{\text{Repo Men}} = 13.4\% / 1.7\% = 7.9.$$

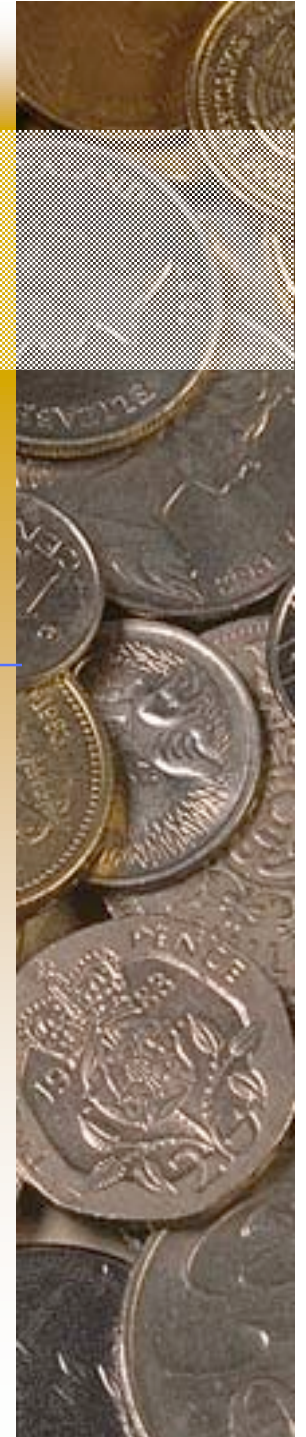
$$CV_{\text{Am. Foam}} = 18.8\% / 13.8\% = 1.4.$$

$$CV_{\text{M}} = 15.3\% / 15.0\% = 1.0.$$

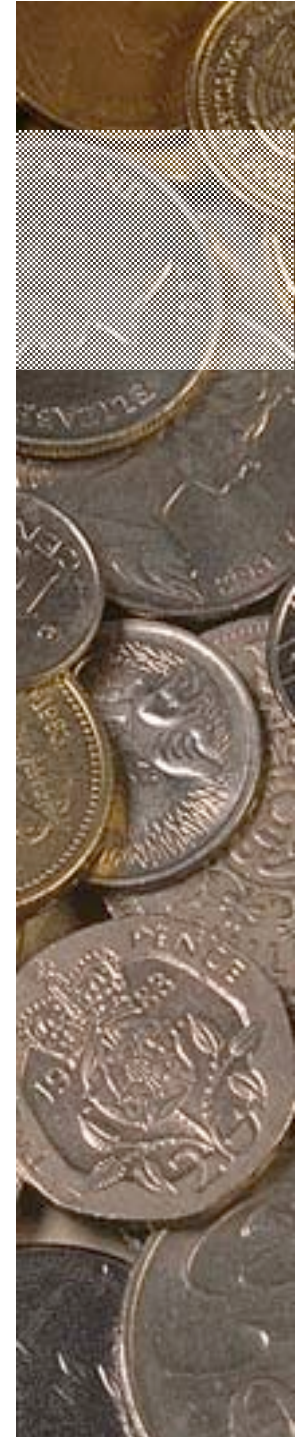
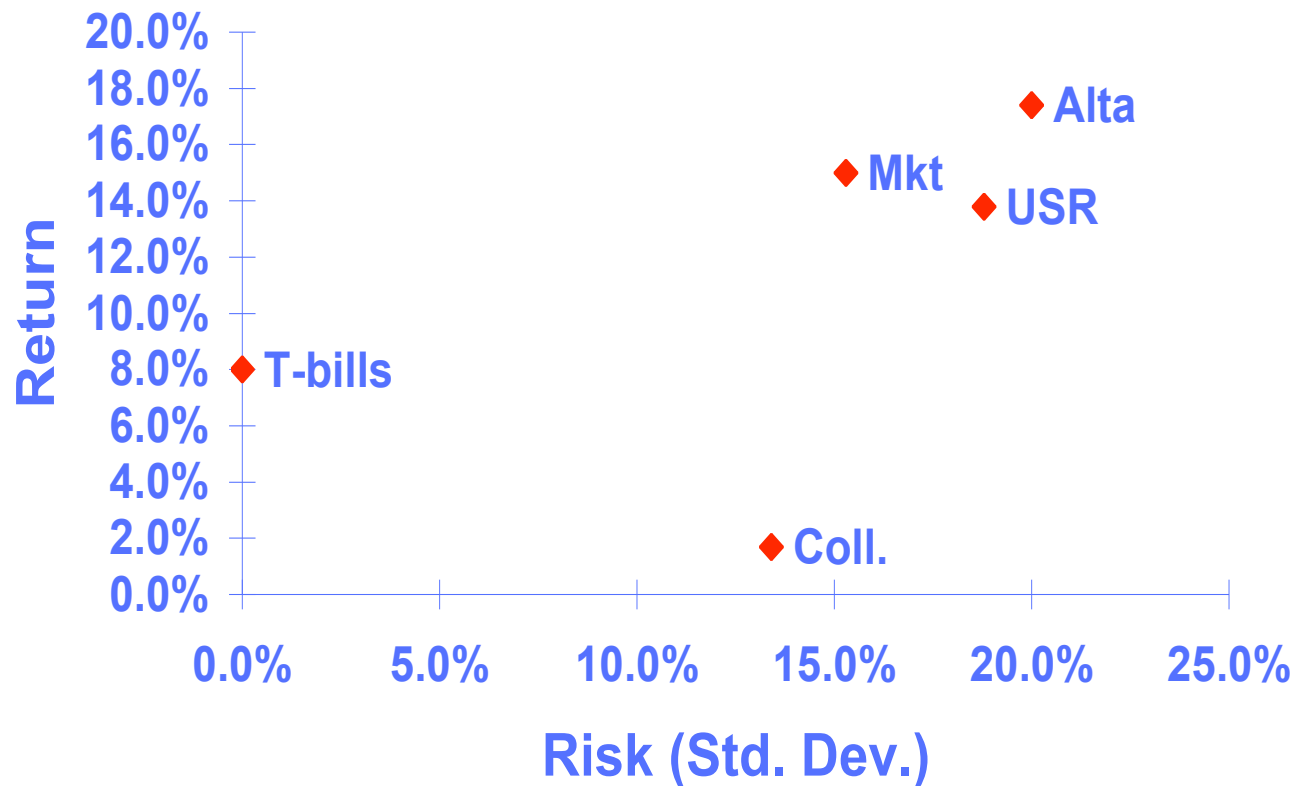


Expected Return versus Coefficient of Variation

<i>Security</i>	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



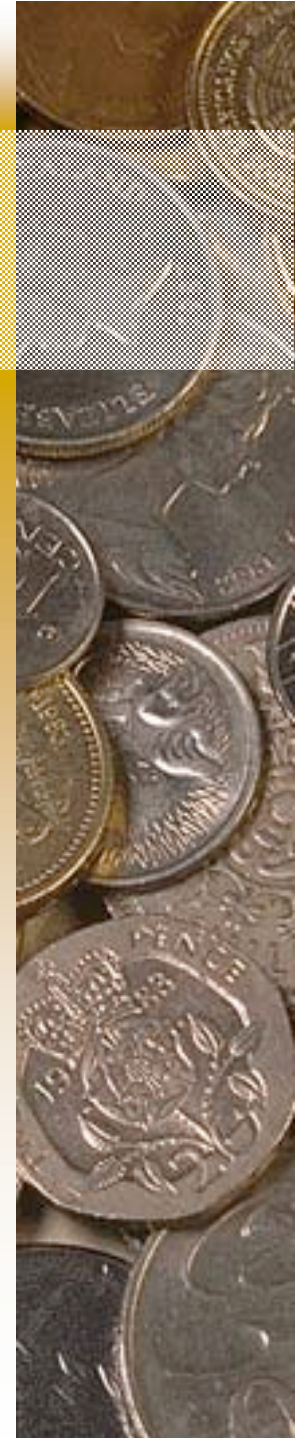
Return vs. Risk (Std. Dev.): Which investment is best?



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 σ_p .



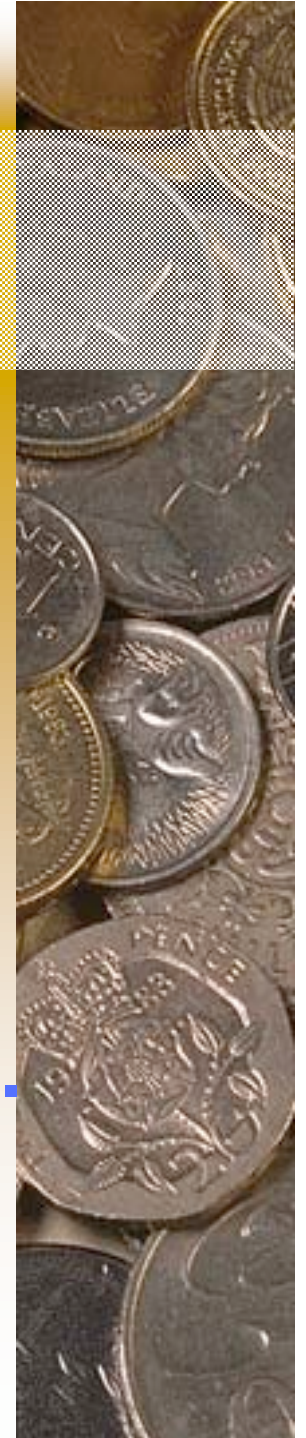
Portfolio Return, \hat{r}_p

\hat{r}_p is a weighted average:

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

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

\hat{r}_p is between \hat{r}_{Alta} and \hat{r}_{Repo} .



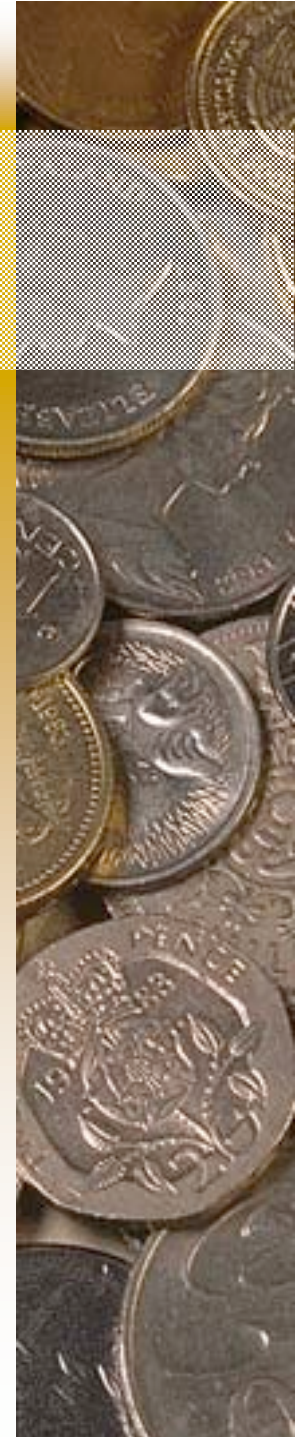
Alternative Method

Estimated Return

<u>Economy</u>	<u>Prob.</u>	<u>Alta</u>	<u>Repo</u>	<u>Port.</u>
Recession	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

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

(More...)



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

σ_p is much lower than:

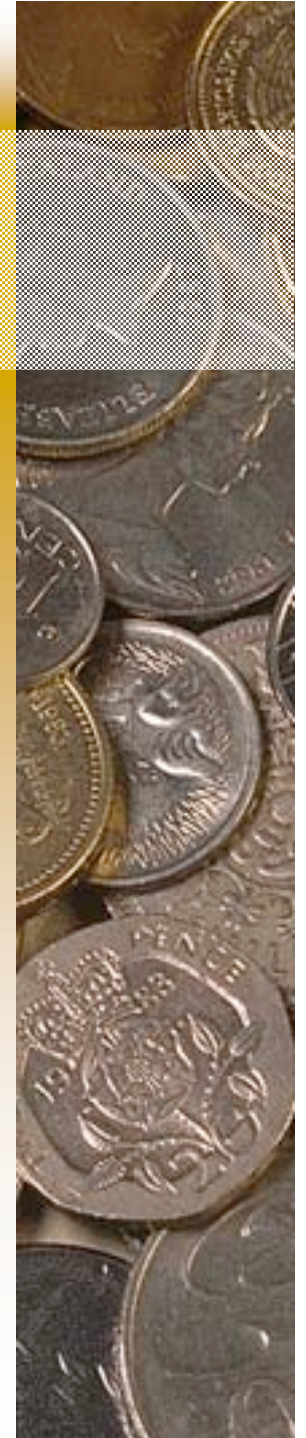
- either stock (20% and 13.4%).
- average of Alta and Repo (16.7%).

The portfolio provides average return but much lower risk.

The key here
is negative correlation

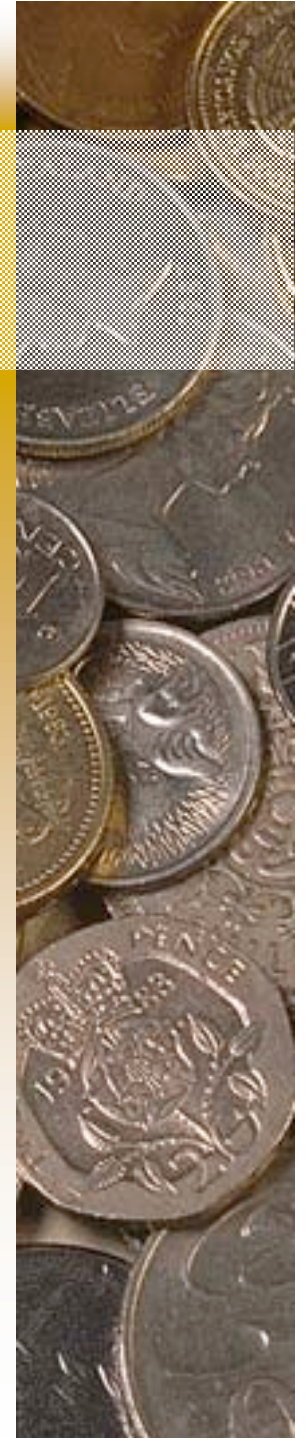
Two-Stock Portfolios

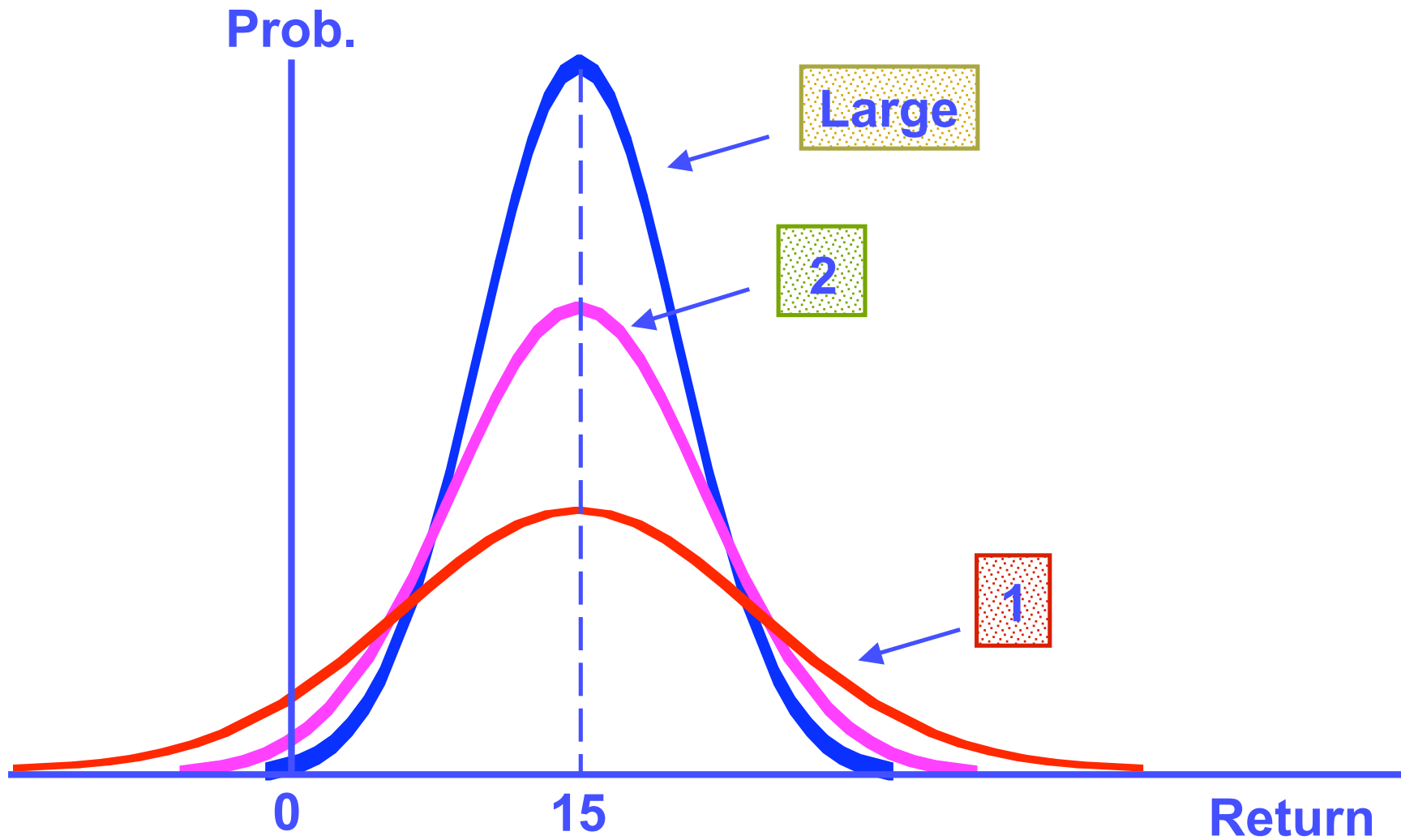
- Two stocks can be combined to form a riskless portfolio if $\rho = -1.0$.
- Risk is not reduced at all if the two stocks have $\rho = +1.0$.
- In general, stocks have $\rho \approx 0.65$, so risk is lowered but not eliminated.
- Investors typically hold many stocks.
- What happens when $\rho = 0$?



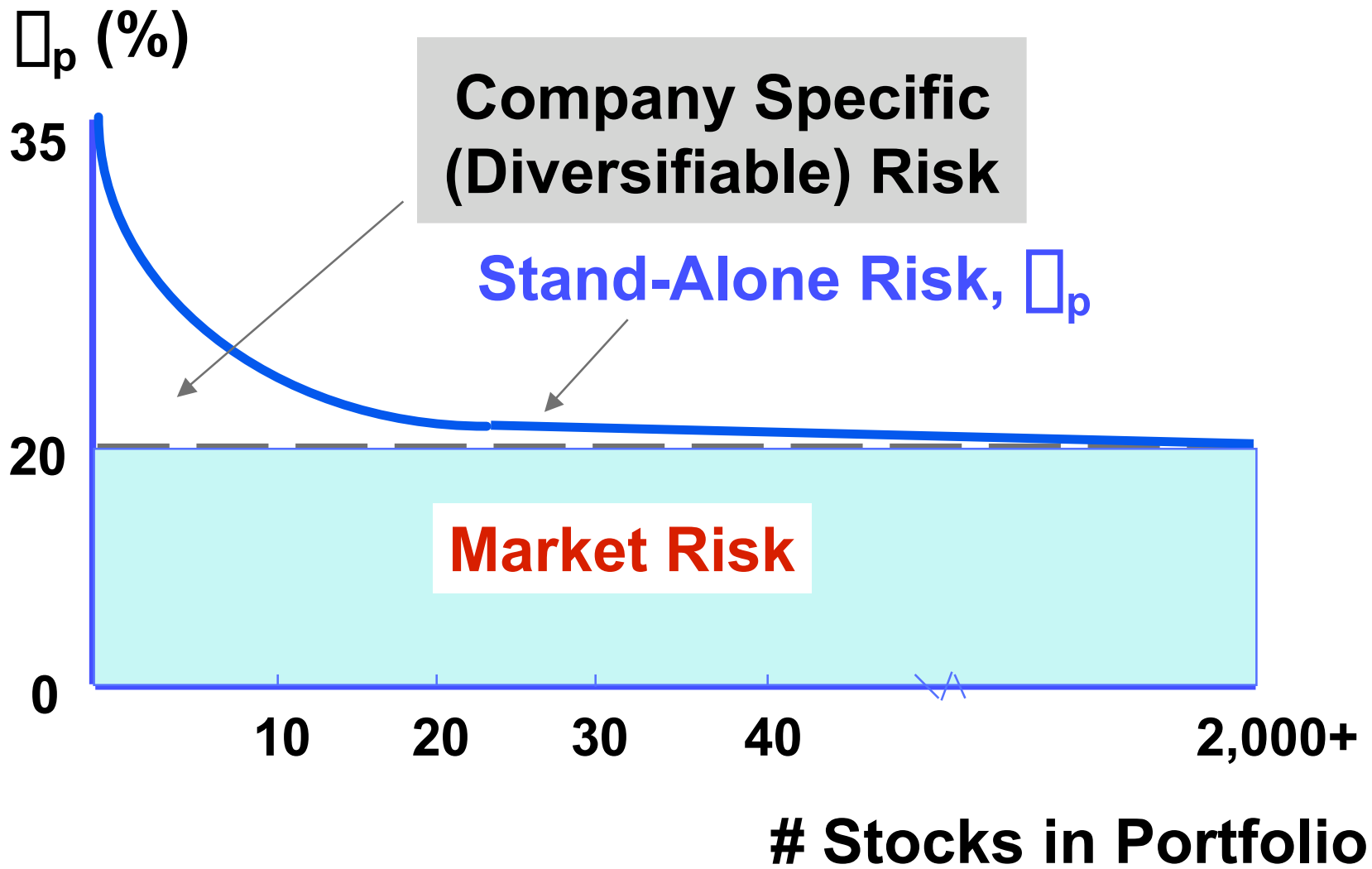
What happens to the risk of an average 1-stock portfolio when more randomly selected stocks are added?

σ_p would decrease because the added stocks would not be perfectly correlated, but r_p would remain relatively constant.





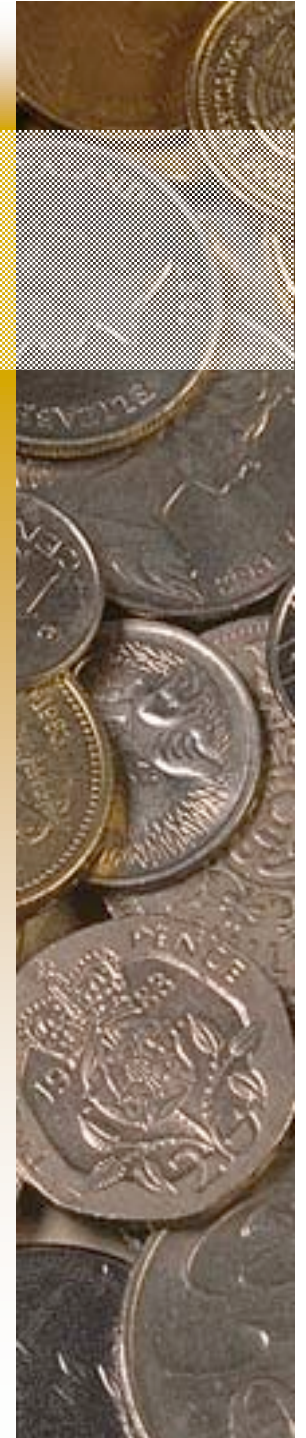
$\sigma_1 \approx 35\%$; $\sigma_{\text{Large}} \approx 20\%$.



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.



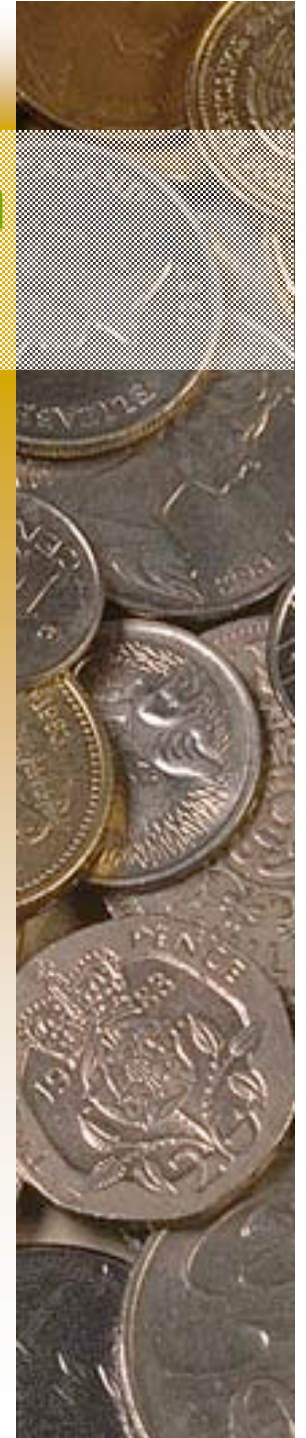
Conclusions

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



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

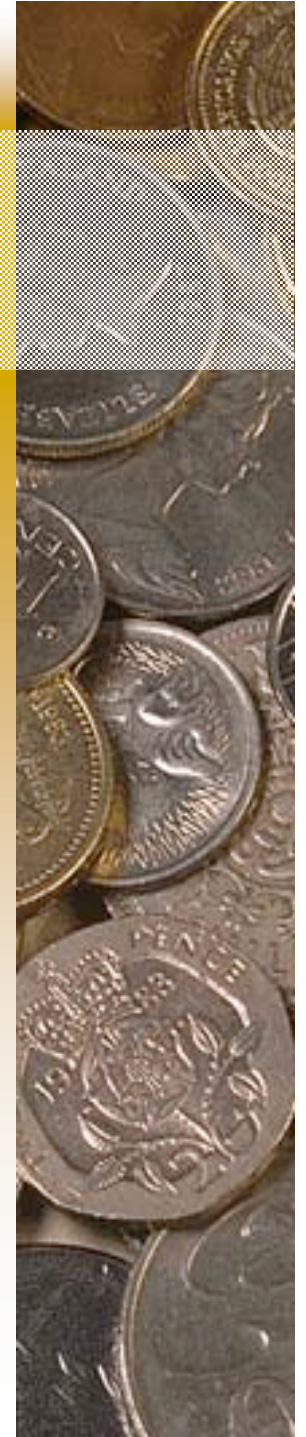
- No. Rational investors will minimize risk by holding portfolios.
- They bear only market risk, so prices and returns reflect this lower risk.
- The one-stock investor bears higher (stand-alone) risk, so the return is less than that required by the risk.



How is market risk measured for individual securities?

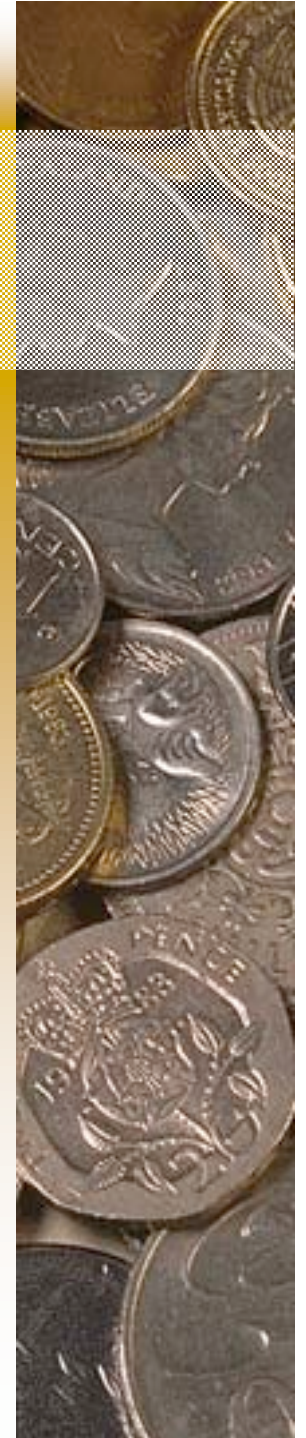
- Market risk, which is relevant for stocks held in well-diversified portfolios, is defined as the **contribution** of a security to the **overall riskiness of the portfolio**.
- It is measured by a stock's **beta coefficient**. For stock i , its beta is:

$$b_i = (\sigma_{iM} / \sigma_i) / \sigma_M$$



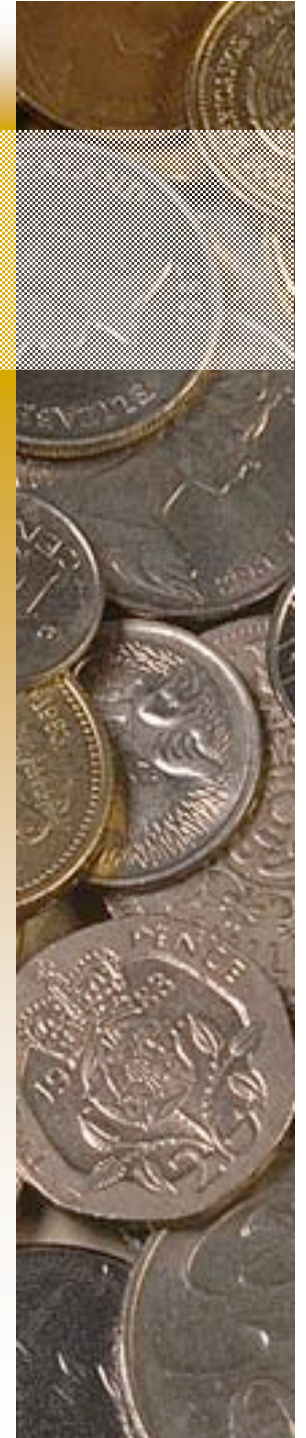
How are betas calculated?

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



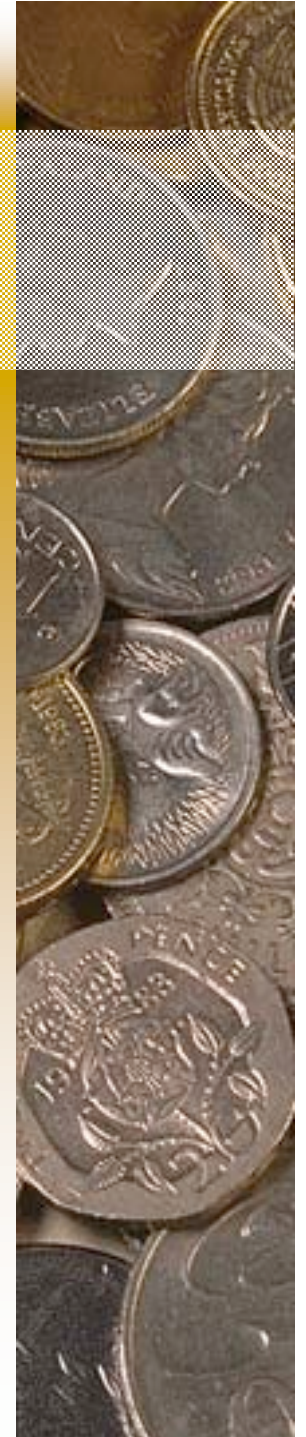
Using a Regression to Estimate Beta

- 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***.

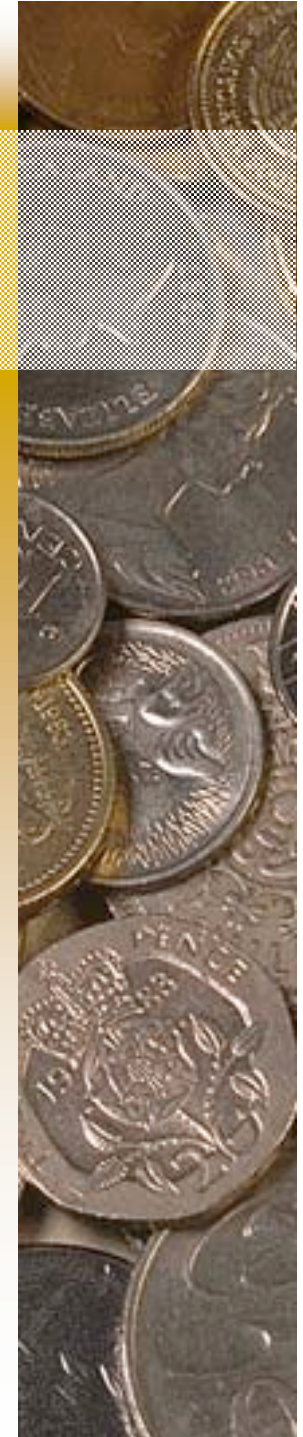
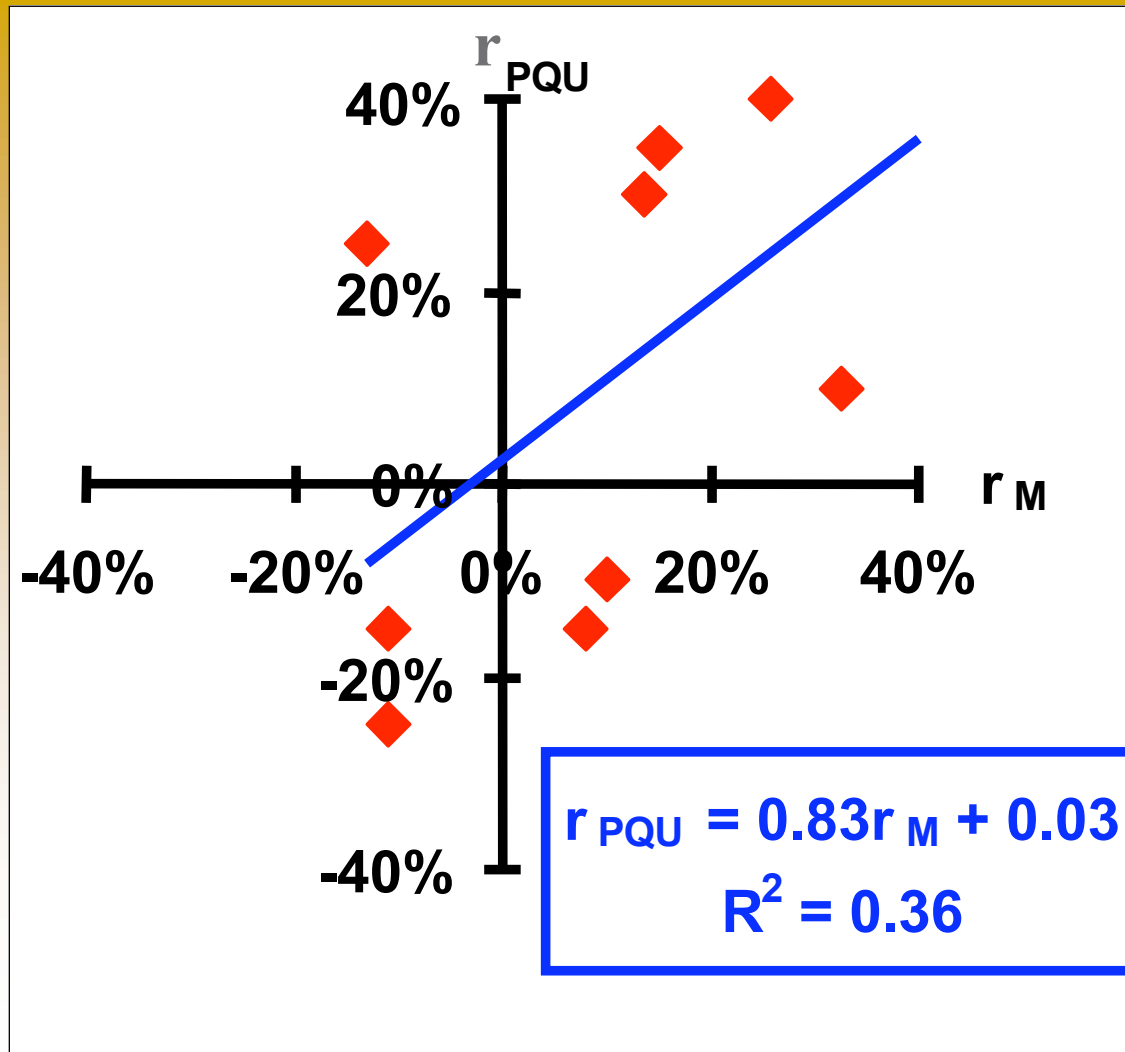


Use the historical stock returns to calculate the beta for PQU.

<u>Year</u>	<u>Market</u>	<u>PQU</u>
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%

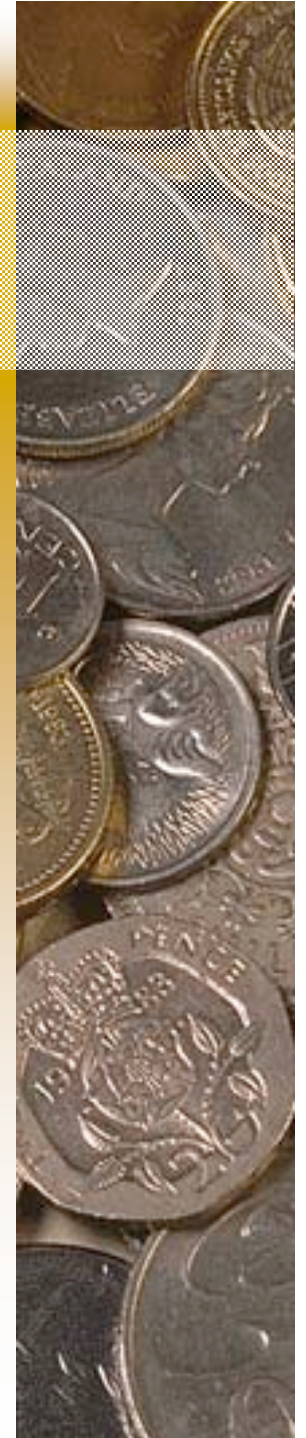


Calculating Beta for PQU



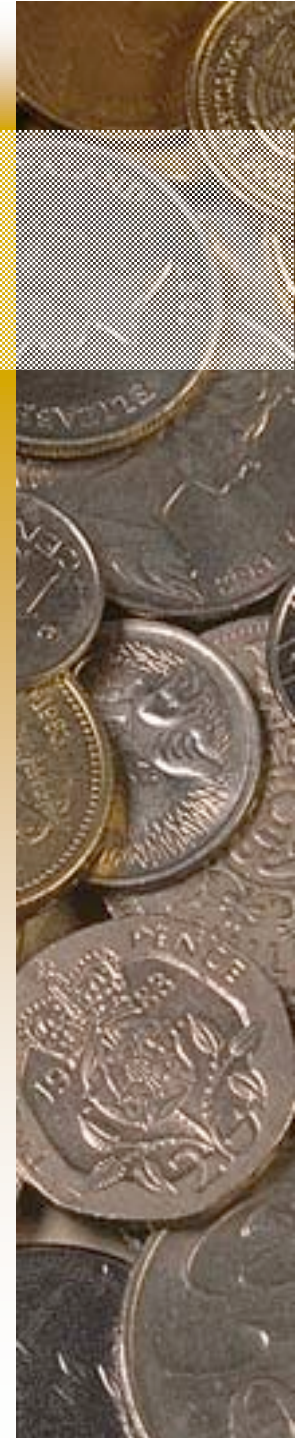
What is beta for PQU?

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



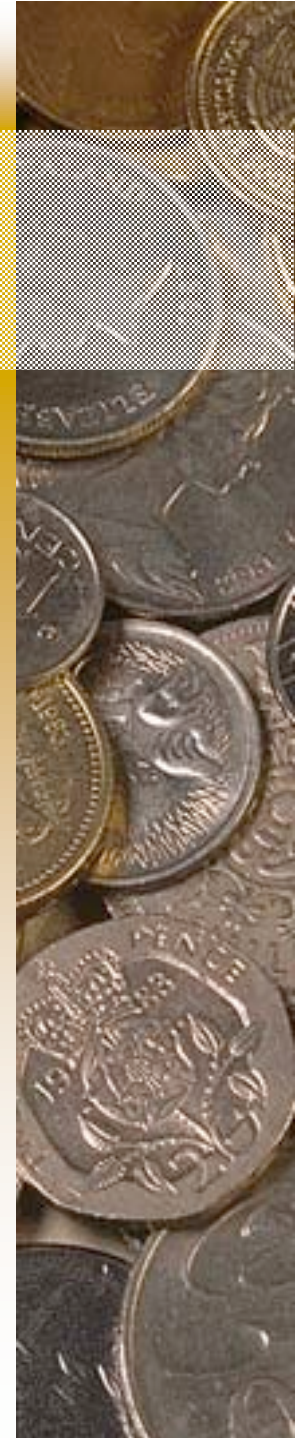
Calculating Beta in Practice

- 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?

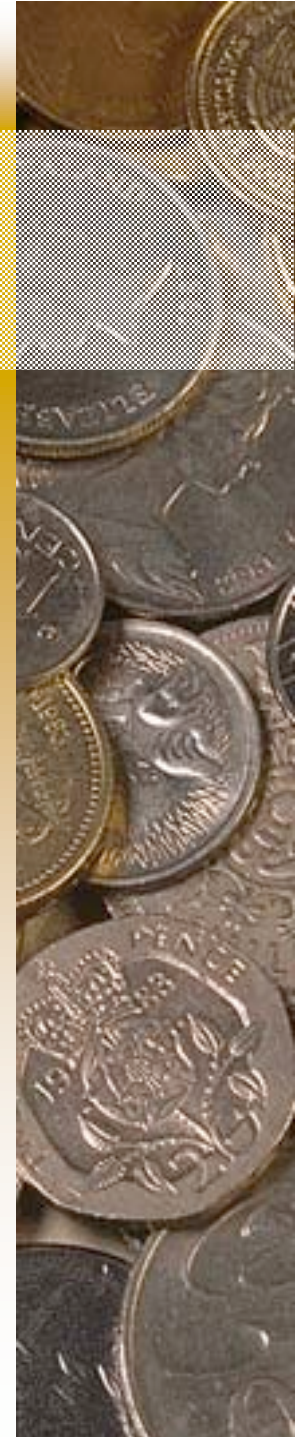
- If $b = 1.0$, stock has average risk.
- If $b > 1.0$, stock is riskier than average.
- If $b < 1.0$, stock is less risky than average.
- Most stocks have betas in the range of 0.5 to 1.5.
- *Can a stock have a negative beta?*



Expected Return versus Market Risk

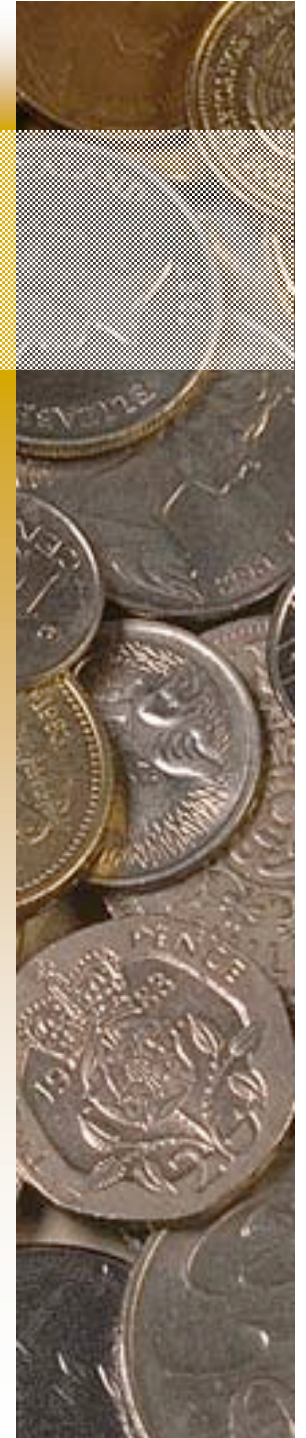
<u>Security</u>	<u>Expected return</u>	<u>Risk, b</u>
Alta	17.4%	1.29
Market	15.0	1.00
Am. Foam	13.8	0.68
T-bills	8.0	0.00
Repo Men	1.7	-0.86

- Which of the alternatives is best?



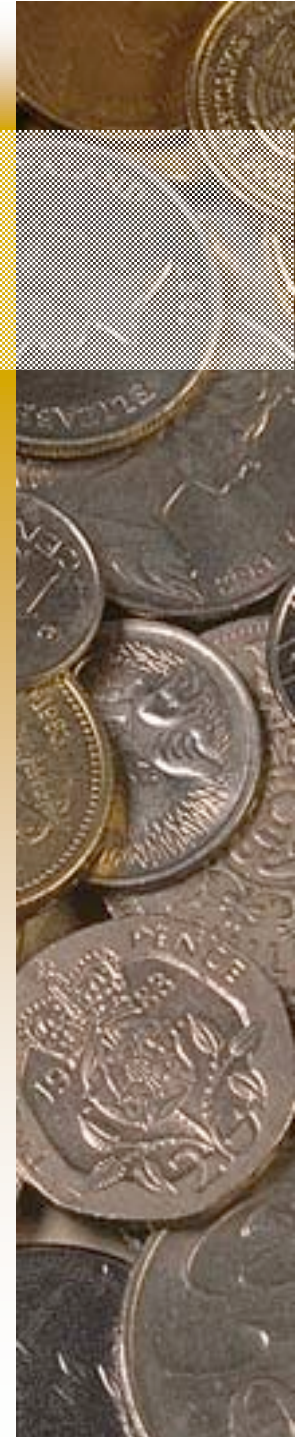
Use the SML to calculate each alternative's required return.

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



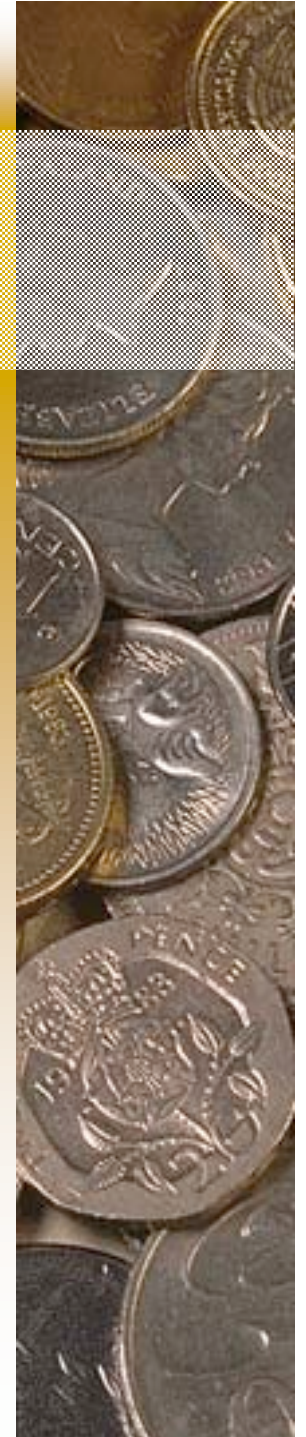
Required Rates of Return

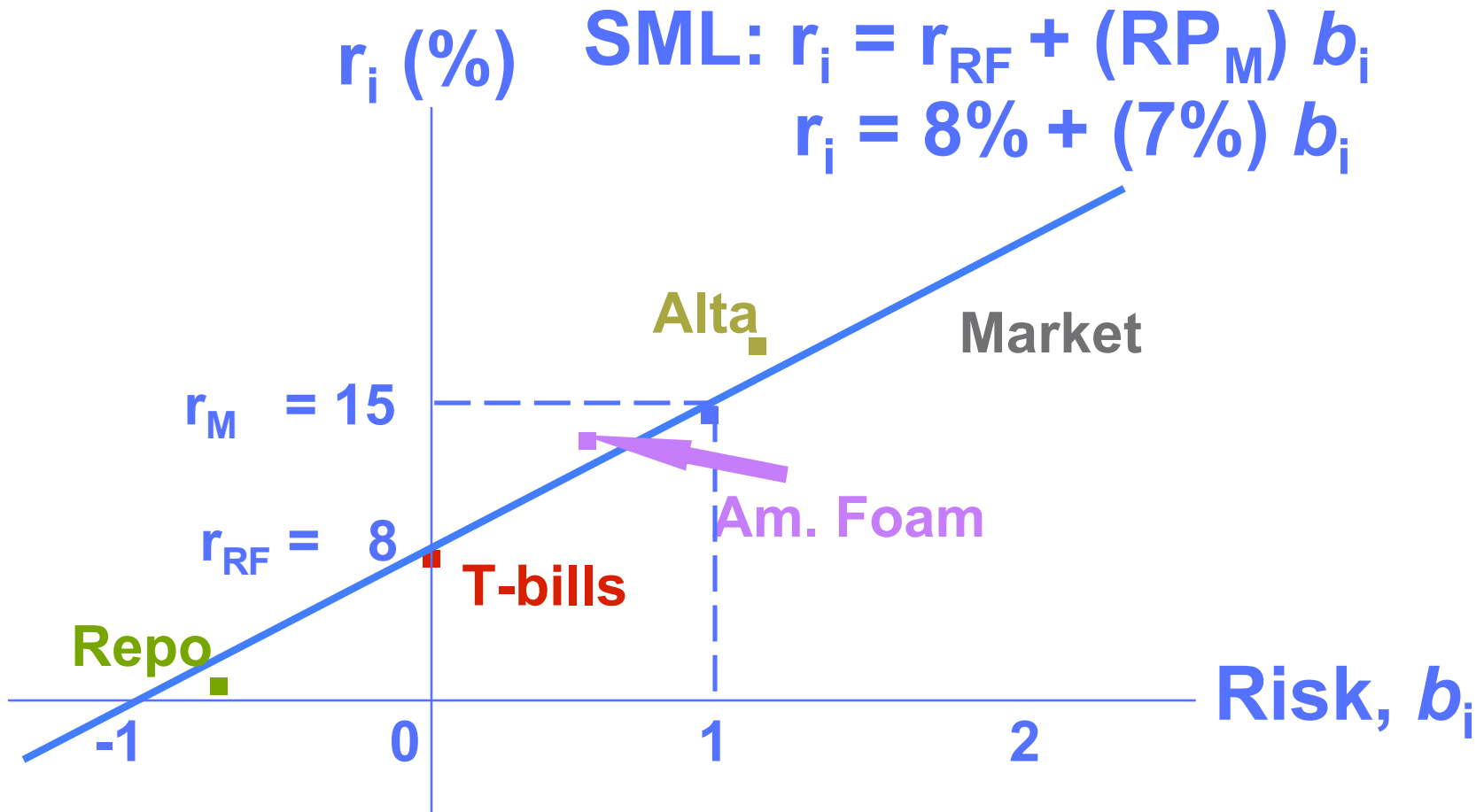
$$\begin{aligned}r_{\text{Alta}} &= 8.0\% + (7\%)(1.29) &= 17.0\%. \\ &= 8.0\% + 9.0\% \\ r_{\text{M}} &= 8.0\% + (7\%)(1.00) &= 15.0\%. \\ r_{\text{Am. F.}} &= 8.0\% + (7\%)(0.68) &= 12.8\%. \\ r_{\text{T-bill}} &= 8.0\% + (7\%)(0.00) &= 8.0\%. \\ r_{\text{Repo}} &= 8.0\% + (7\%)(-0.86) &= 2.0\%.\end{aligned}$$



Expected versus Required Returns

	\hat{r}	r	
Alta	17.4%	17.0%	Undervalued
Market	15.0	15.0	Fairly valued
Am. F.	13.8	12.8	Undervalued
T-bills	8.0	8.0	Fairly valued
Repo	1.7	2.0	Overvalued

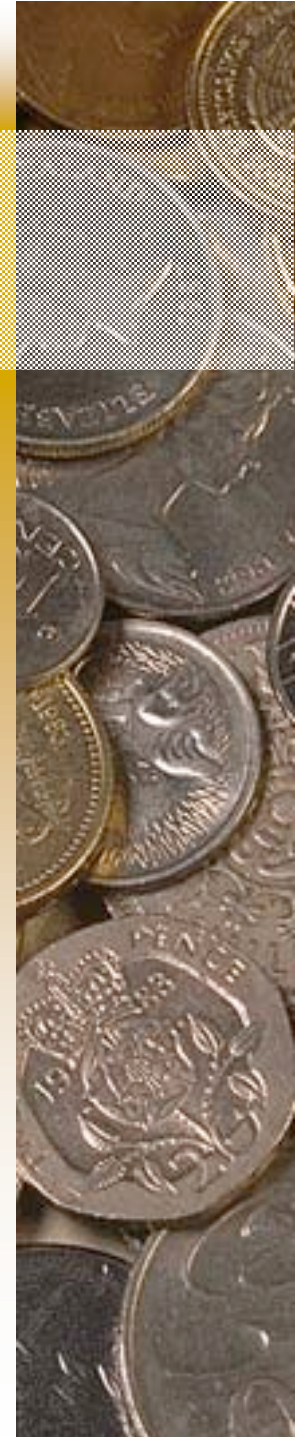




SML and Investment Alternatives

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

$$\begin{aligned} b_p &= \text{Weighted average} \\ &= 0.5(b_{\text{Alta}}) + 0.5(b_{\text{Repo}}) \\ &= 0.5(1.29) + 0.5(-0.86) \\ &= \mathbf{0.22.} \end{aligned}$$

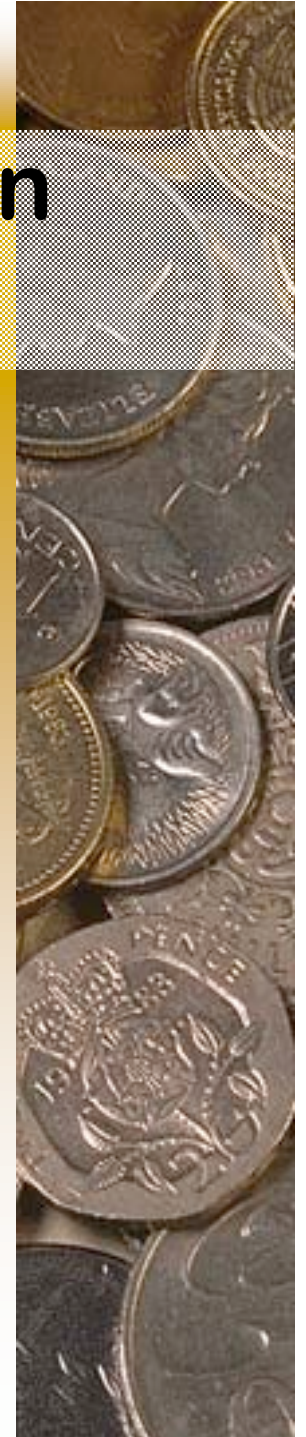


What is the required rate of return on the Alta/Repo portfolio?

$$\begin{aligned} r_p &= \text{Weighted average } r \\ &= 0.5(17\%) + 0.5(2\%) = 9.5\%. \end{aligned}$$

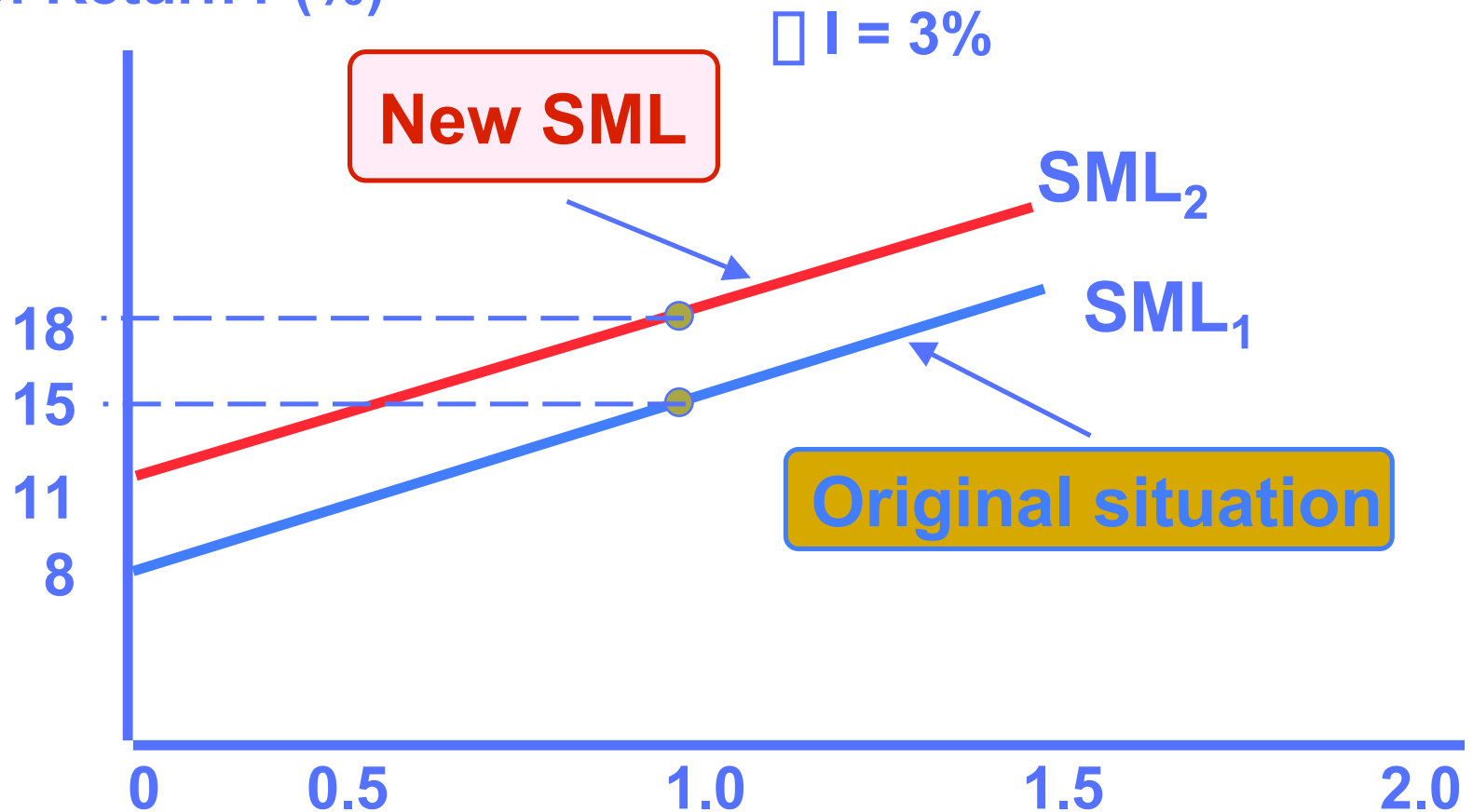
Or use SML:

$$\begin{aligned} r_p &= r_{RF} + (RP_M) b_p \\ &= 8.0\% + 7\%(0.22) = 9.5\%. \end{aligned}$$

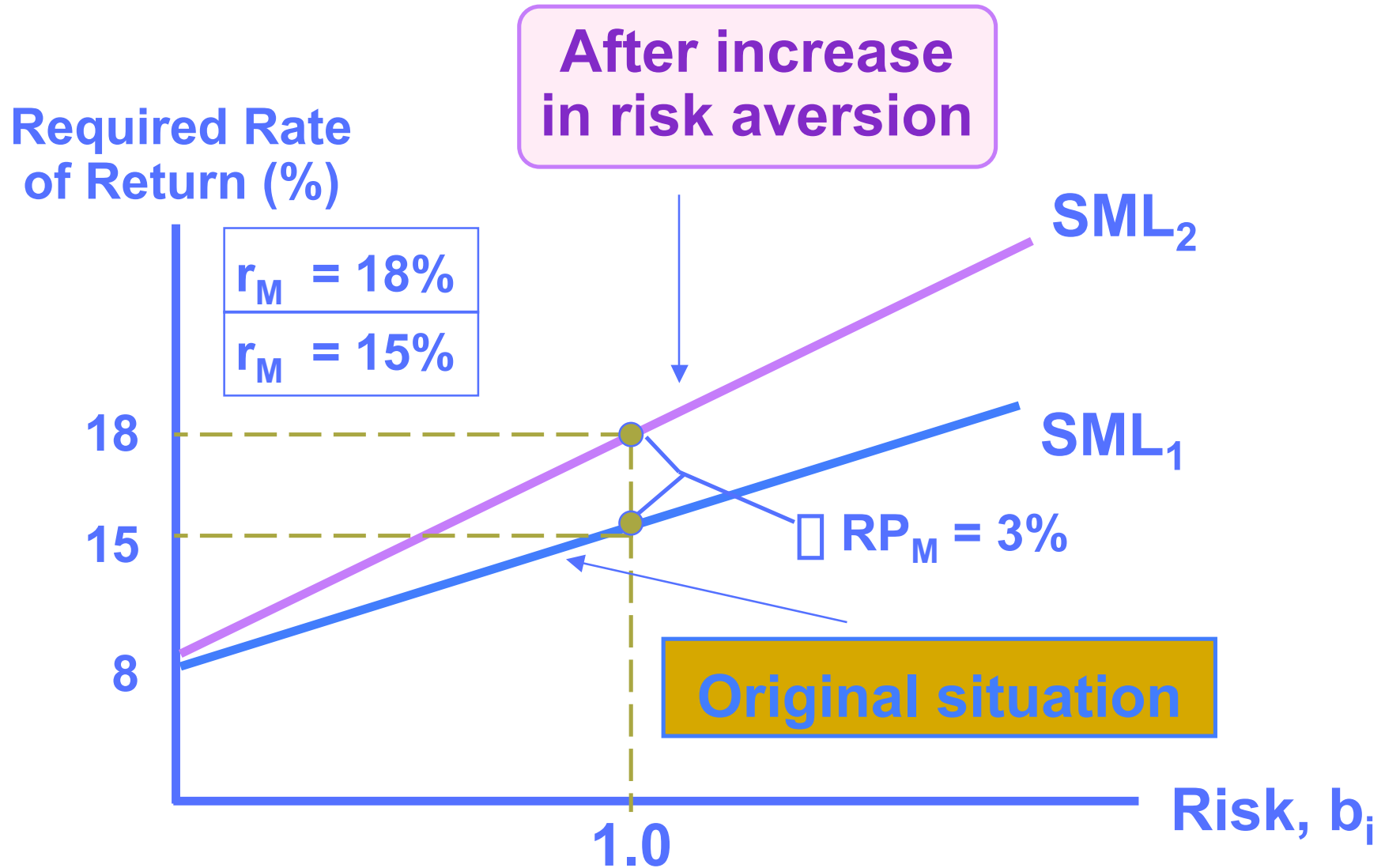


Impact of Inflation Change on SML

Required Rate
of Return r (%)



Impact of Risk Aversion Change



Has the CAPM been completely confirmed or refuted through empirical tests?

- **No. The statistical tests have problems that make empirical verification or rejection virtually impossible.**
 - Investors' required returns are based on future risk, but betas are calculated with historical data.
 - Investors may be concerned about both stand-alone and market risk.

