

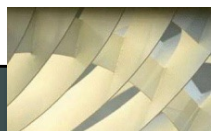
**Harry Markowitz
and
Modern Portfolio
Theory**

Topics Covered

- Harry Markowitz And The Birth Of Portfolio Theory
- The Relationship Between Risk and Return
- Validity and the Role of the CAPM
- Some Alternative Theories

Markowitz Portfolio Theory

- Combining stocks into portfolios can reduce standard deviation, below the level obtained from a simple weighted average calculation.
- Correlation coefficients make this possible.
- The various weighted combinations of stocks that create this standard deviations constitute the set of *efficient portfolios*.

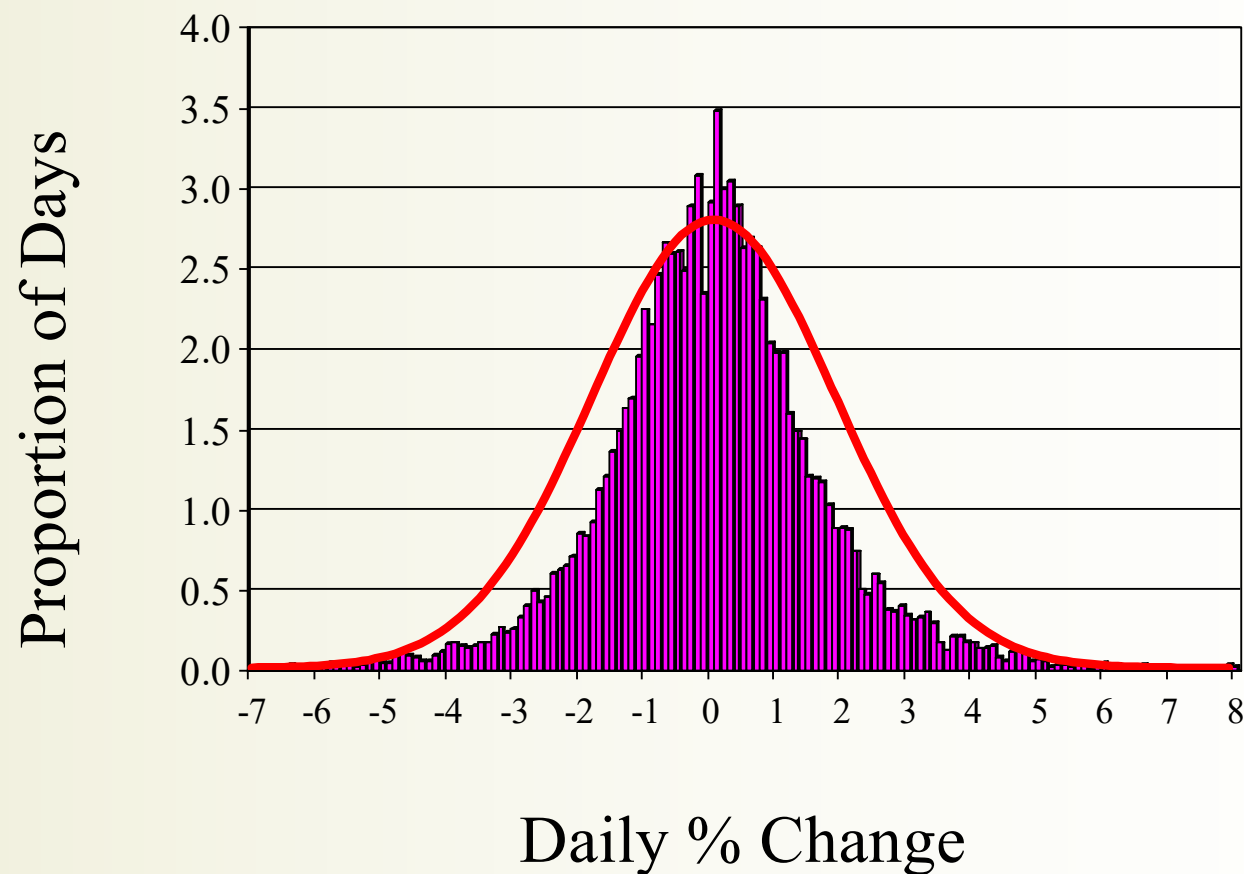


Markowitz Portfolio Theory

8-4

Price changes vs. Normal distribution

IBM - Daily % change 1988-2008

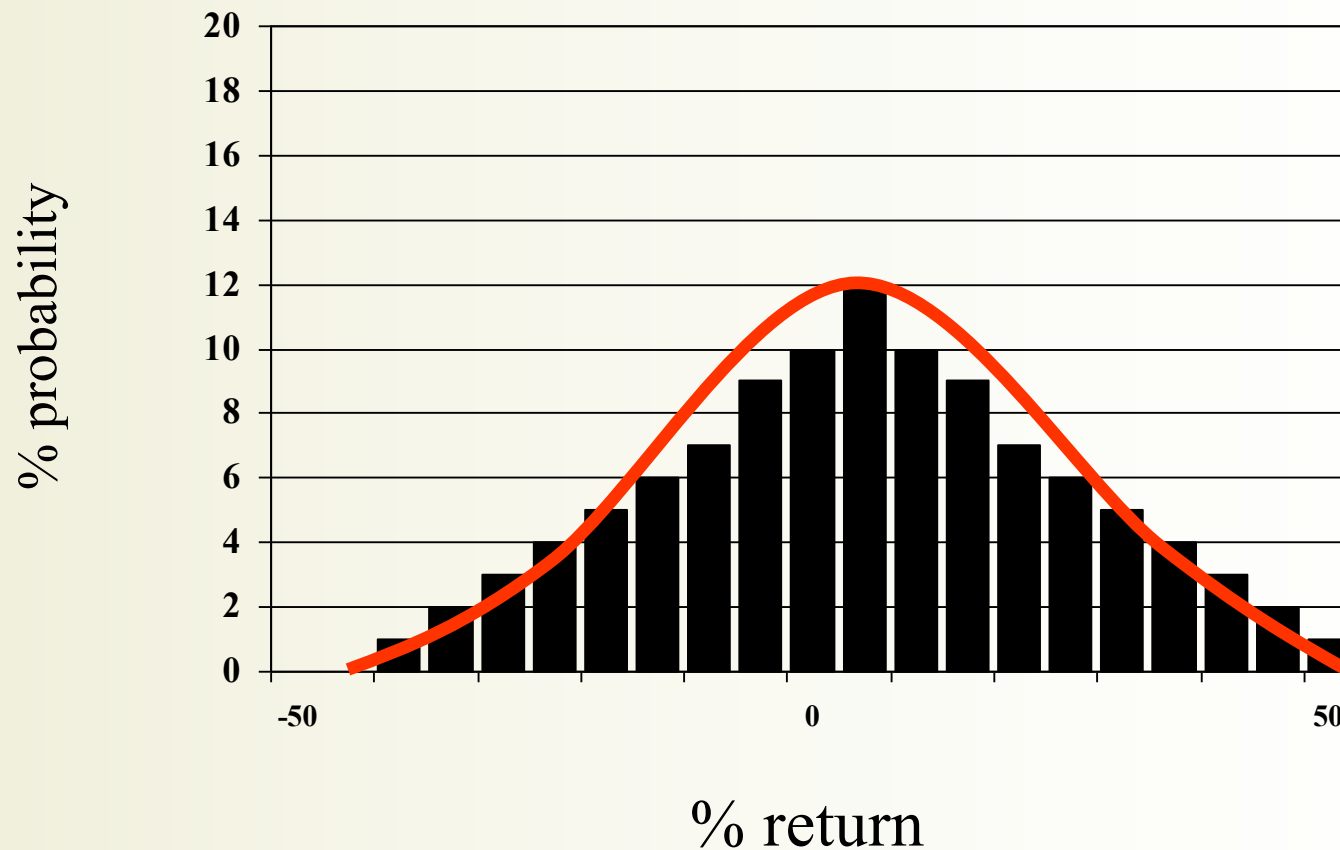


Markowitz Portfolio Theory

8-5

Standard Deviation VS. Expected Return

Investment A

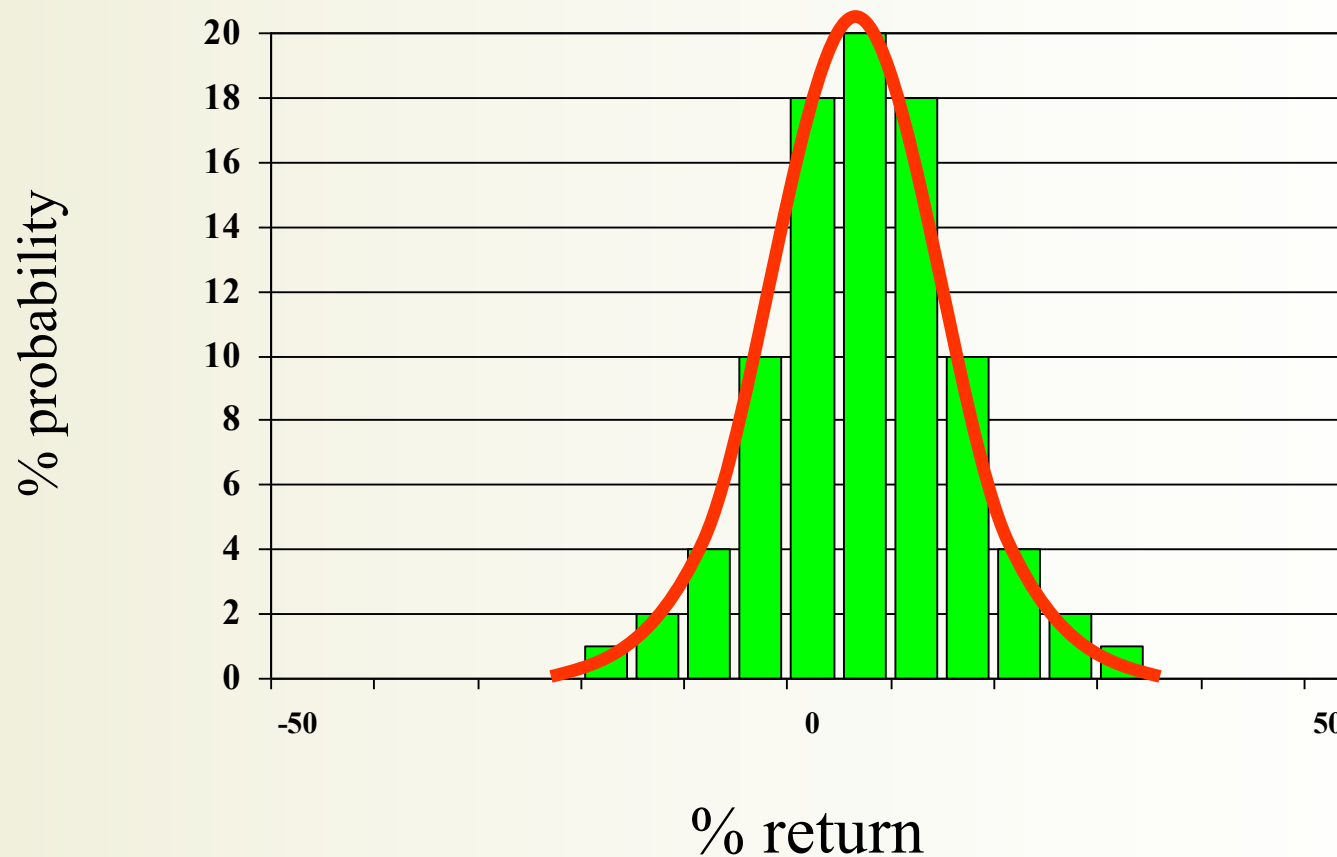


Markowitz Portfolio Theory

8-6

Standard Deviation VS. Expected Return

Investment B

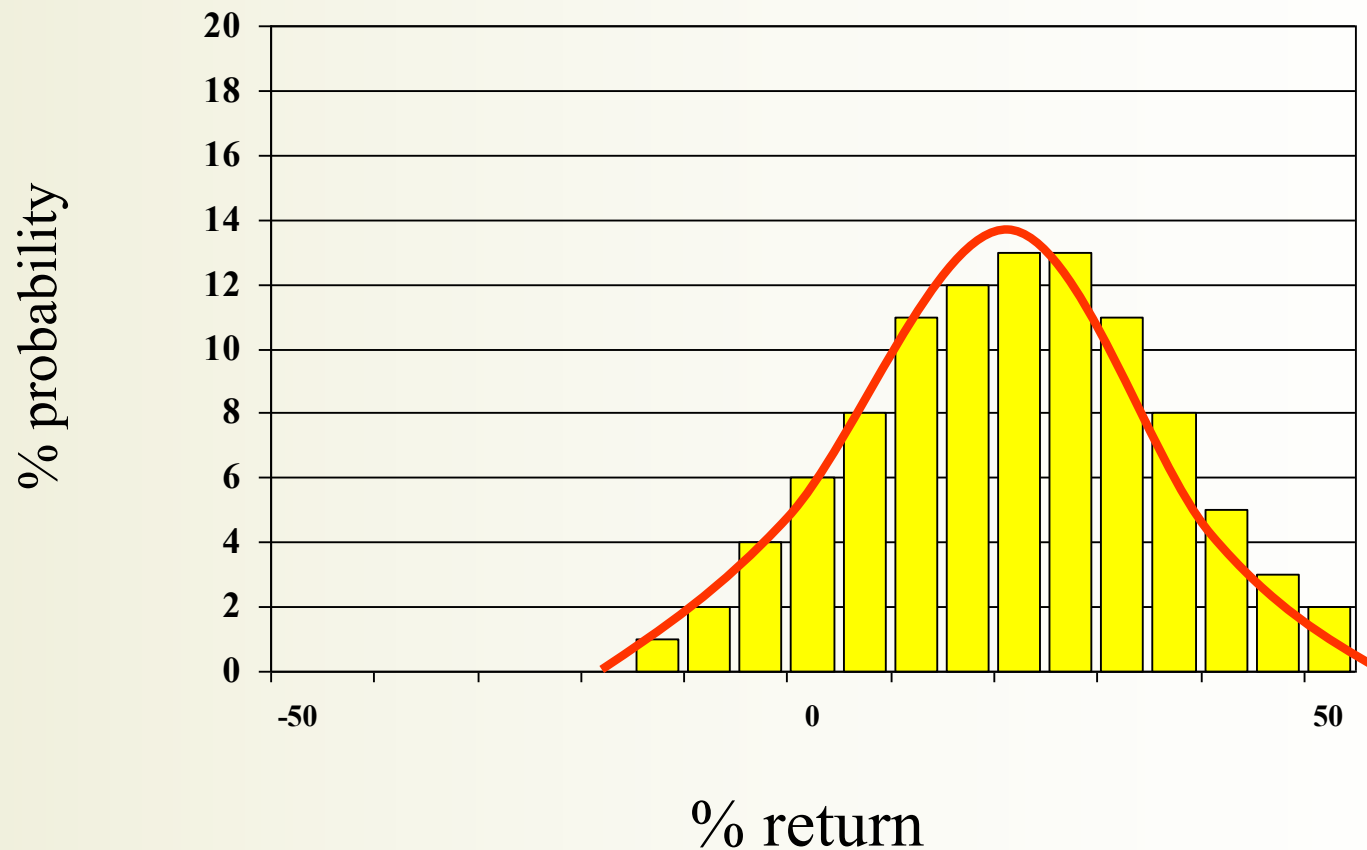


Markowitz Portfolio Theory

8-7

Standard Deviation VS. Expected Return

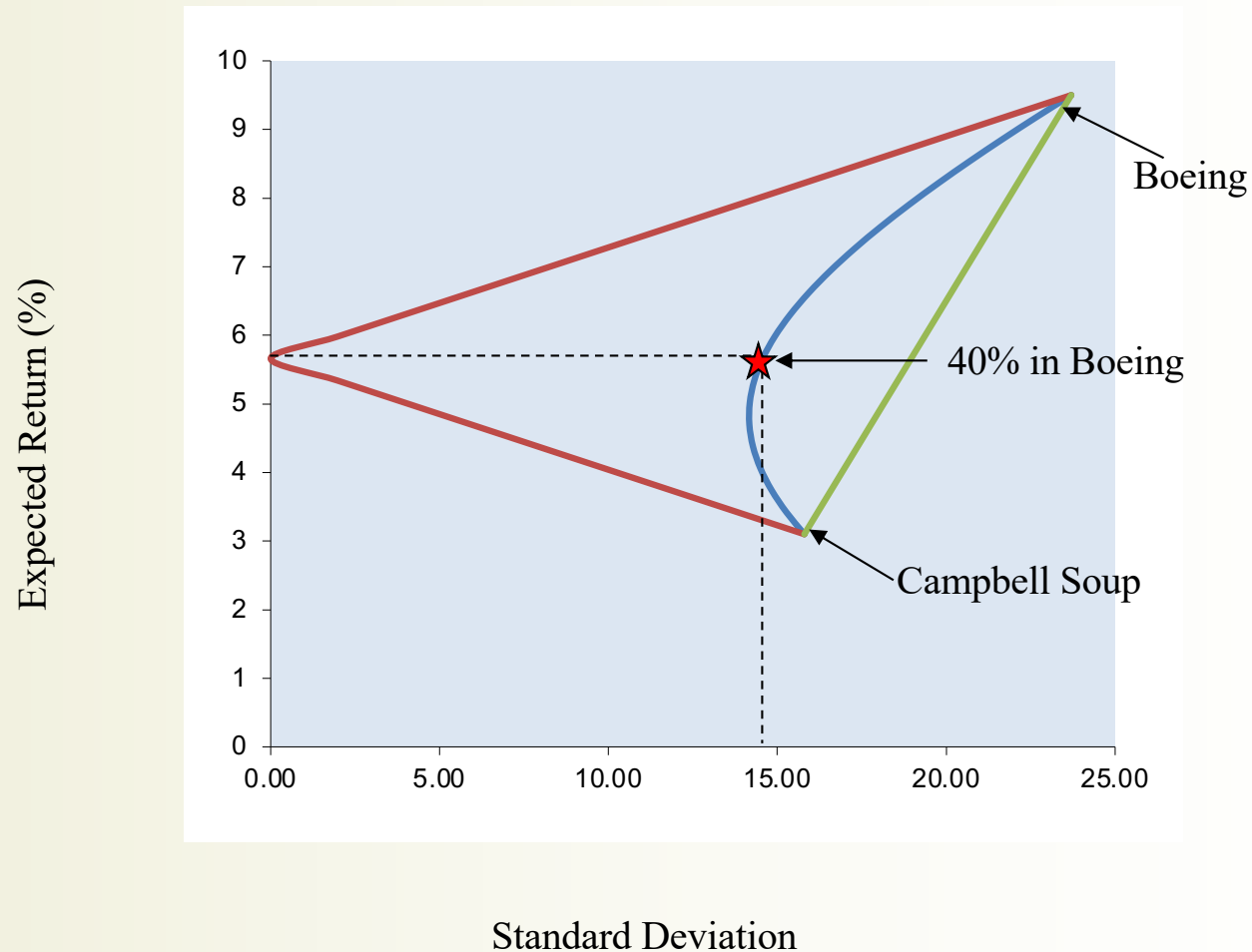
Investment C



Markowitz Portfolio Theory

8-8

Expected Returns and Standard Deviations vary given different weighted combinations of the stocks



Efficient Frontier

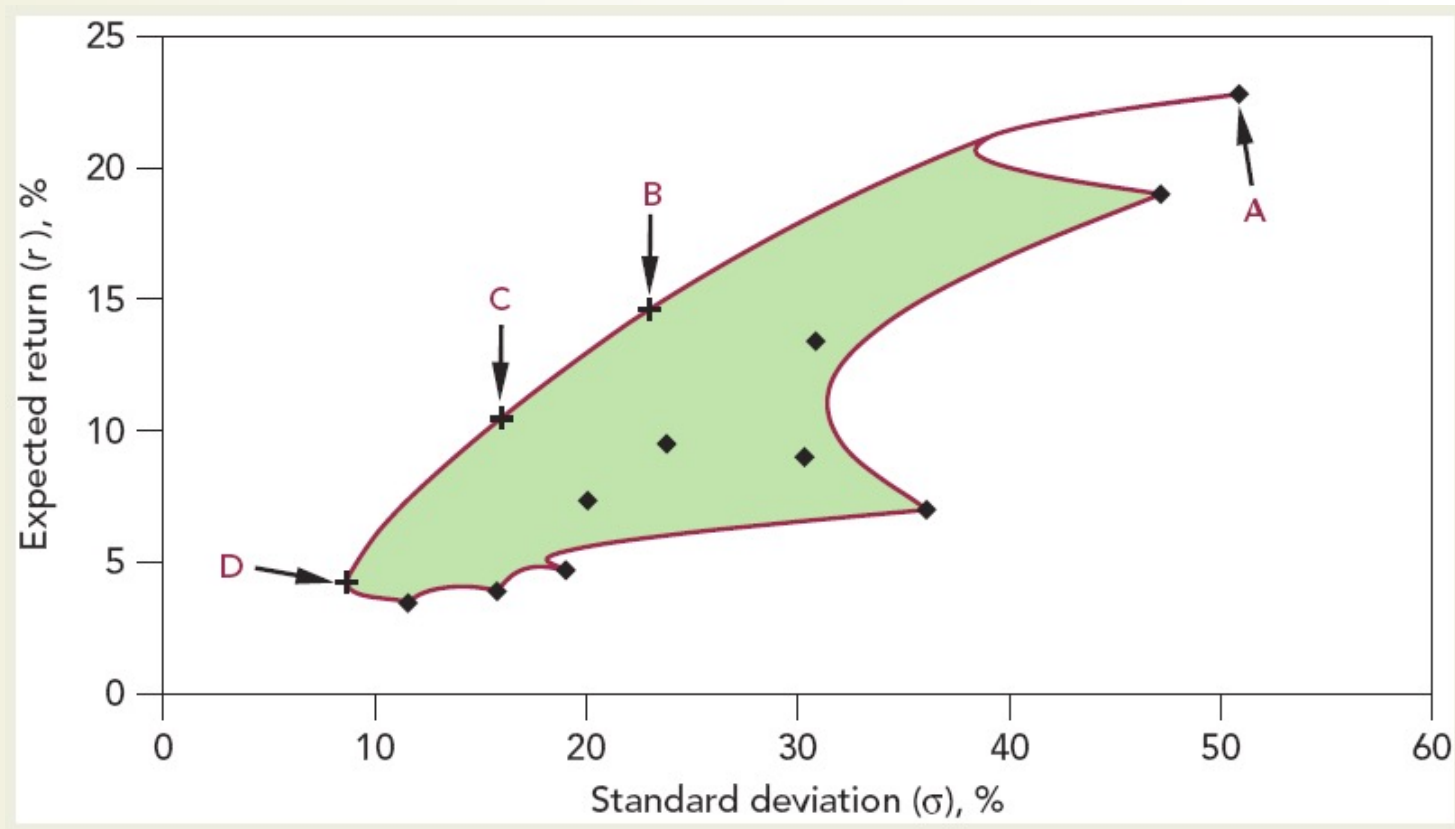
TABLE 8.1 Examples of efficient portfolios chosen from 10 stocks.

Note: Standard deviations and the correlations between stock returns were estimated from monthly returns January 2004-December 2008. Efficient portfolios are calculated assuming that short sales are prohibited.

Stock	Expected Return	Standard Deviation	Efficient Portfolios – Percentages Allocated to Each Stock			
			A	B	C	D
Amazon.com	22.8%	50.9%	100	19.1	10.9	
Ford	19.0	47.2		19.9	11.0	
Dell	13.4	30.9		15.6	10.3	
Starbucks	9.0	30.3		13.7	10.7	3.6
Boeing	9.5	23.7		9.2	10.5	
Disney	7.7	19.6		8.8	11.2	
Newmont	7.0	36.1			9.9	10.2
ExxonMobil	4.7	19.1			9.7	18.4
Johnson & Johnson	3.8	12.6			7.4	33.9
Soup	3.1	15.8			8.4	33.9
Expected portfolio return			22.8	14.1	10.5	4.2
Portfolio standard deviation			50.9	22.0	16.0	8.8

Efficient Frontier

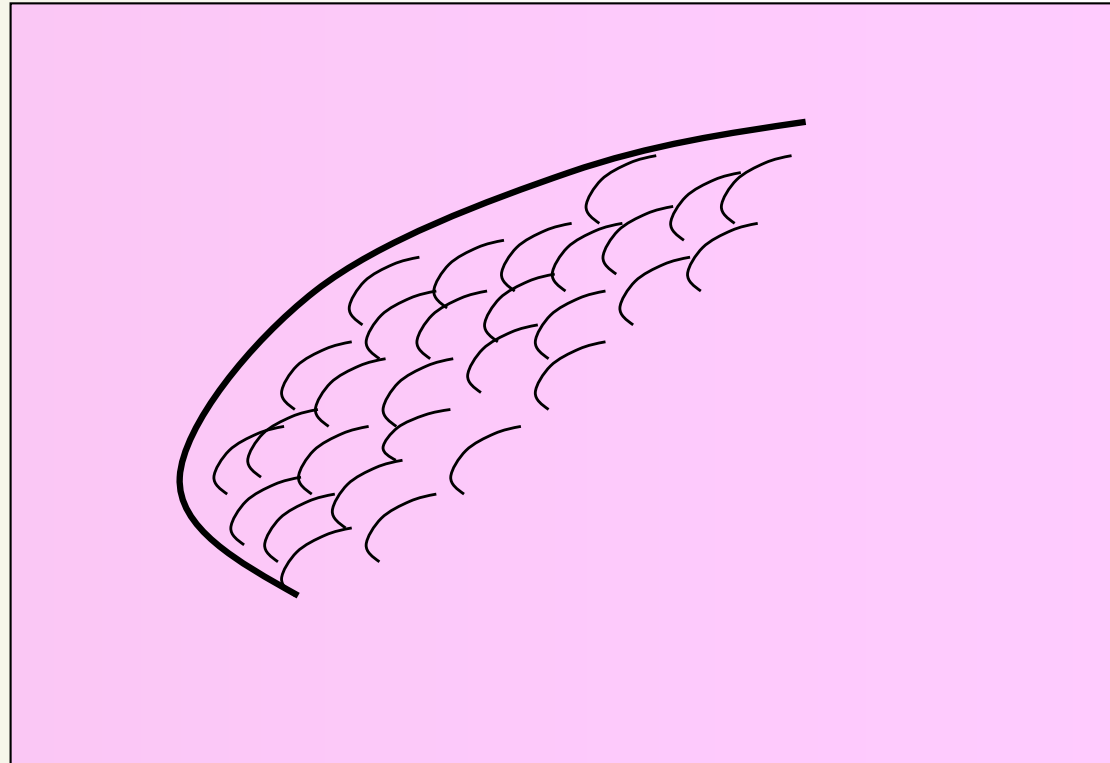
4 Efficient Portfolios all from the same 10 stocks



Efficient Frontier

- Each half egg shell represents the possible weighted combinations for two stocks.
- The composite of all stock sets constitutes the efficient frontier

Expected Return (%)

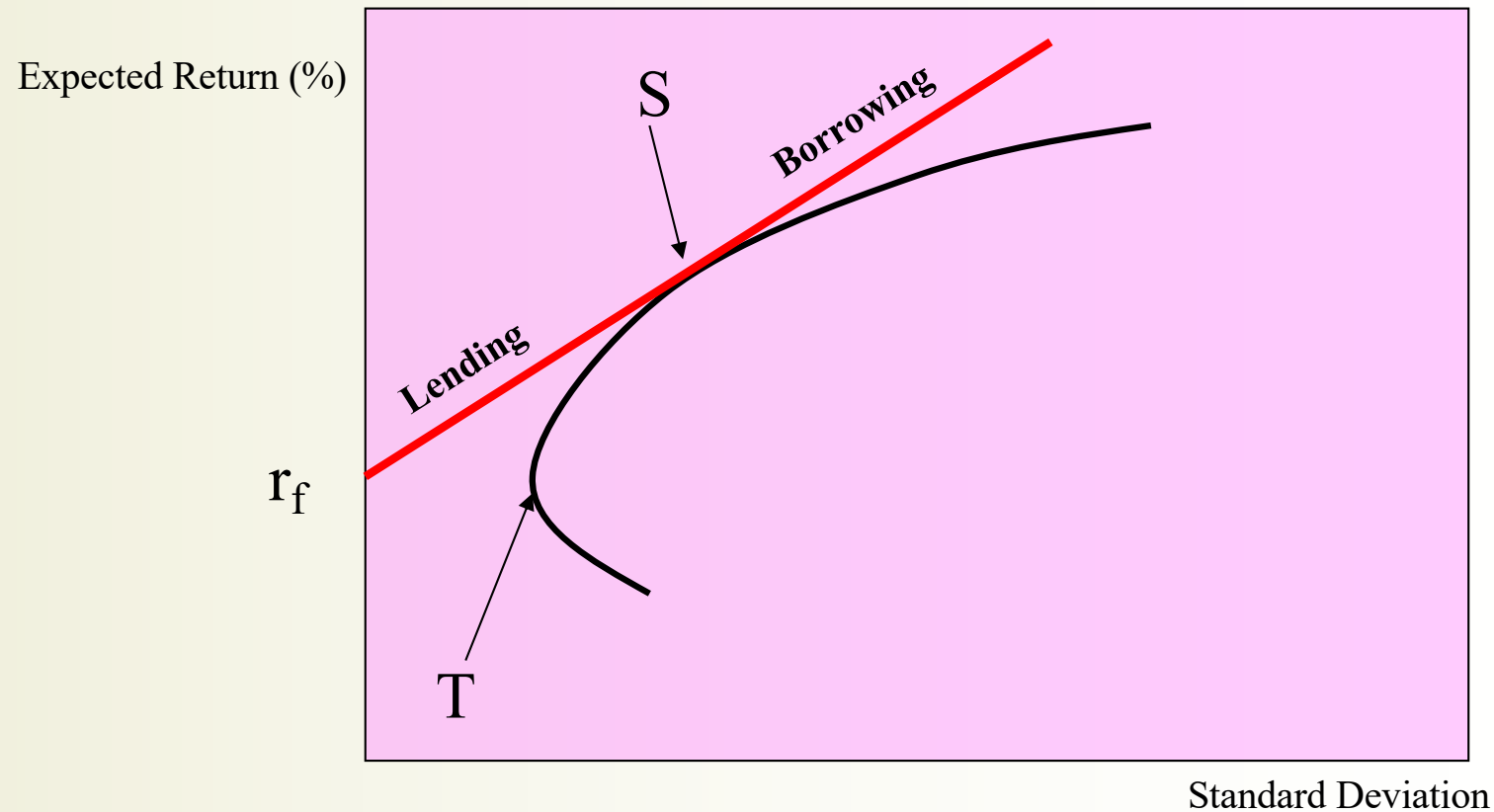


Standard Deviation



Efficient Frontier

Lending or Borrowing at the risk free rate (r_f) allows us to exist outside the efficient frontier.



Efficient Frontier

Book Example

Correlation Coefficient = .18

<u>Stocks</u>	<u>σ</u>	<u>% of Portfolio</u>	<u>Avg Return</u>
Campbell	15.8	60%	3.1%
Boeing	23.7	40%	9.5%

Standard Deviation = weighted avg = 19.0

Standard Deviation = Portfolio = 14.6

Return = weighted avg = Portfolio = 5.7%

NOTE: Higher return & Lower risk

How did we do that?

DIVERSIFICATION



Efficient Frontier

Another Example

Correlation Coefficient = .4

<u>Stocks</u>	<u>σ</u>	<u>% of Portfolio</u>	<u>Avg Return</u>
ABC Corp	28	60%	15%
Big Corp	42	40%	21%

Standard Deviation = weighted avg = 33.6

Standard Deviation = Portfolio = 28.1

Return = weighted avg = Portfolio = 17.4%



Efficient Frontier

Another Example

Correlation Coefficient = .4

<u>Stocks</u>	<u>σ</u>	<u>% of Portfolio</u>	<u>Avg Return</u>
ABC Corp	28	60%	15%
Big Corp	42	40%	21%

Standard Deviation = weighted avg = 33.6

Standard Deviation = Portfolio = 28.1

Return = weighted avg = Portfolio = 17.4%

Let's Add stock New Corp to the portfolio



Efficient Frontier

Previous Example

Correlation Coefficient = .3

<u>Stocks</u>	<u>σ</u>	<u>% of Portfolio</u>	<u>Avg Return</u>
Portfolio	28.1	50%	17.4%
<i>New Corp</i>	30	50%	19%

NEW Standard Deviation = weighted avg = 31.80

NEW Standard Deviation = Portfolio = 23.43

NEW Return = weighted avg = Portfolio = 18.20%



Efficient Frontier

Previous Example

Correlation Coefficient = .3

<u>Stocks</u>	<u>σ</u>	<u>% of Portfolio</u>	<u>Avg Return</u>
Portfolio	28.1	50%	17.4%
New Corp	30	50%	19%

NEW Standard Deviation = weighted avg = 31.80

NEW Standard Deviation = Portfolio = 23.43

NEW Return = weighted avg = Portfolio = 18.20%

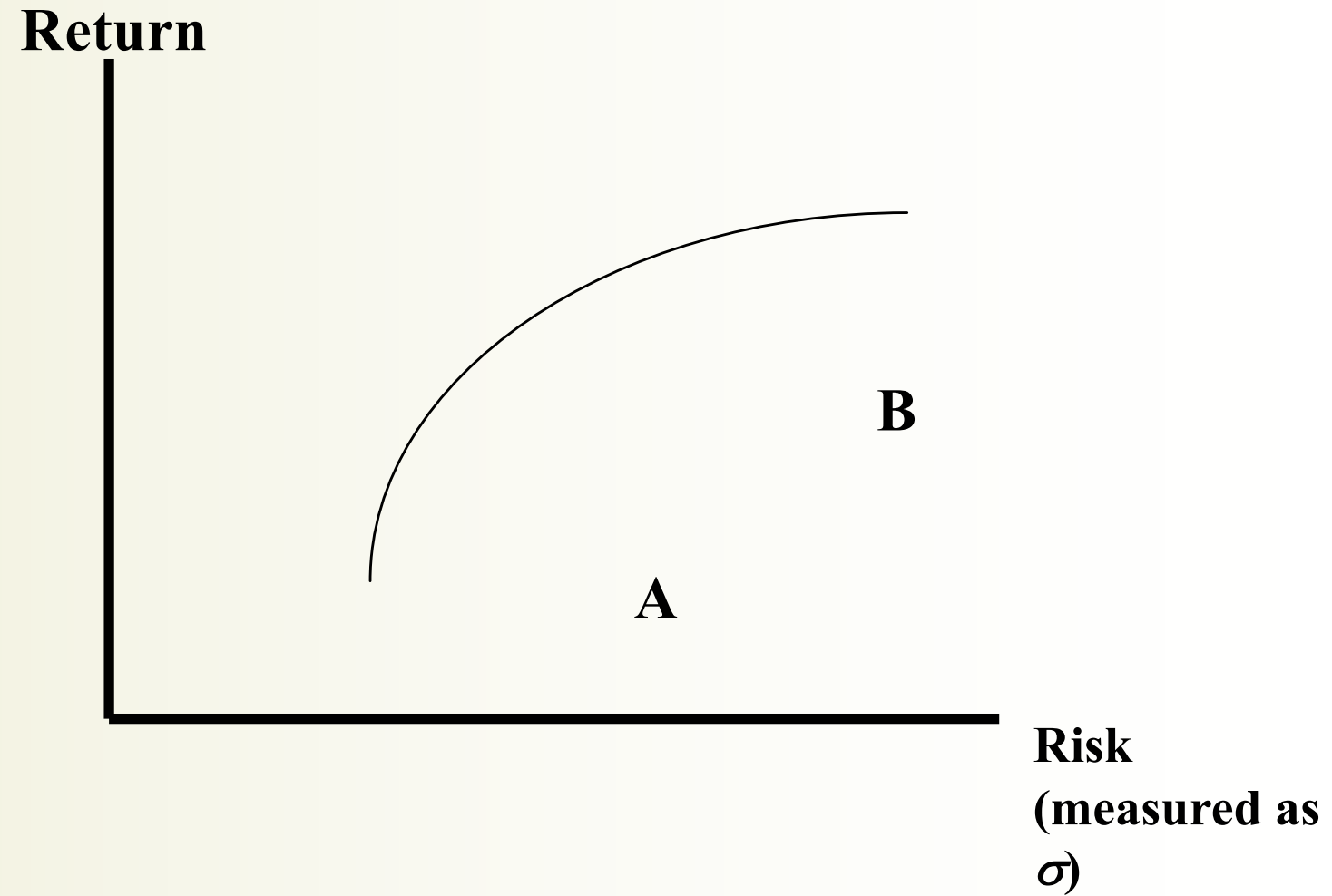
NOTE: Higher return & Lower risk

How did we do that?

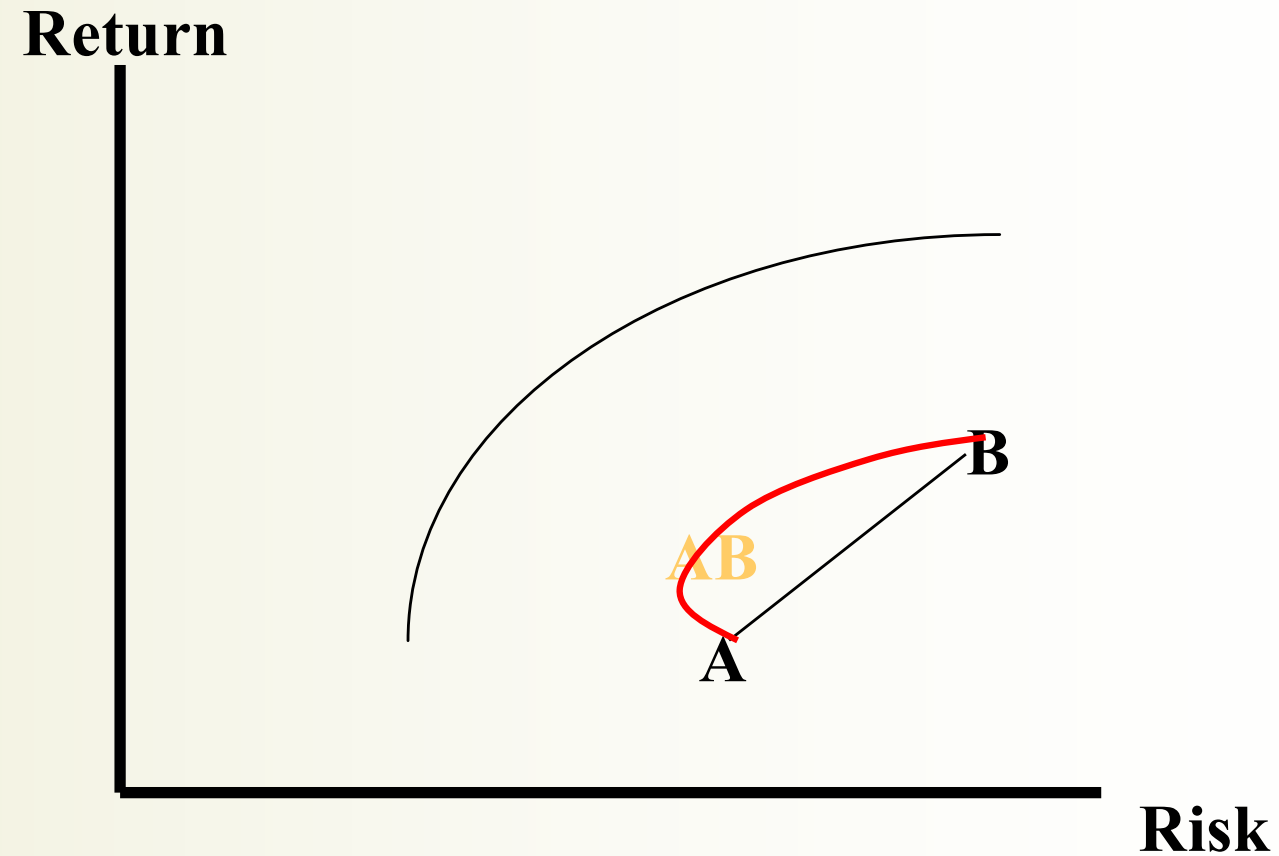
DIVERSIFICATION



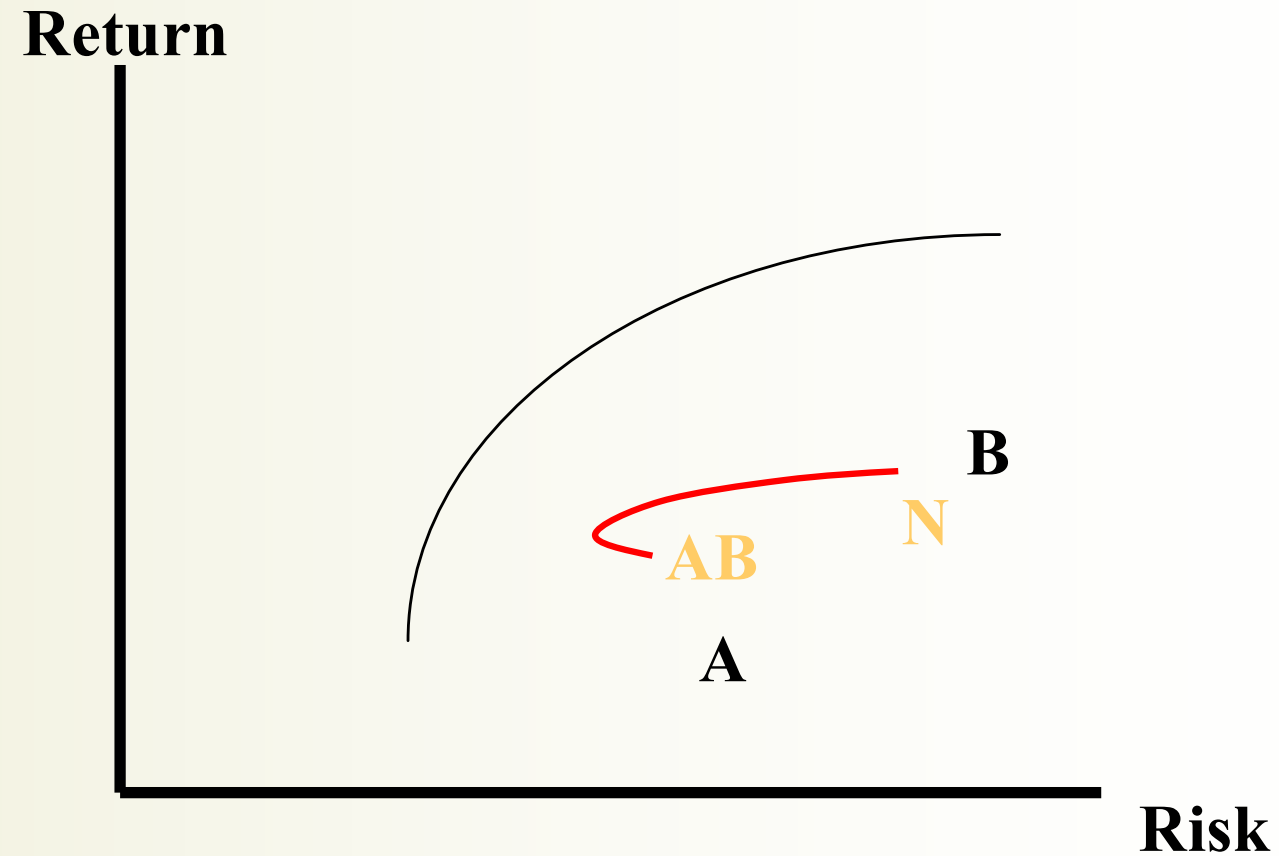
Efficient Frontier



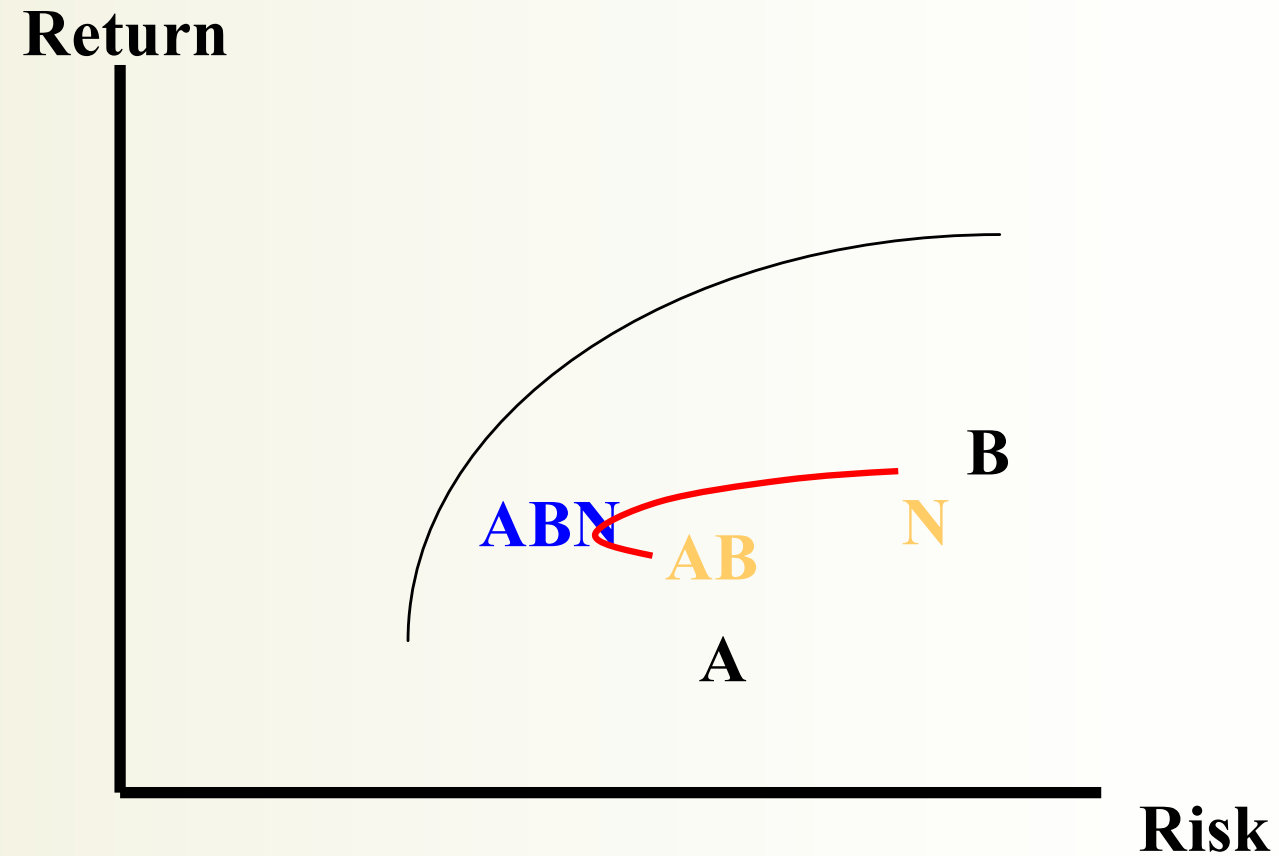
Efficient Frontier



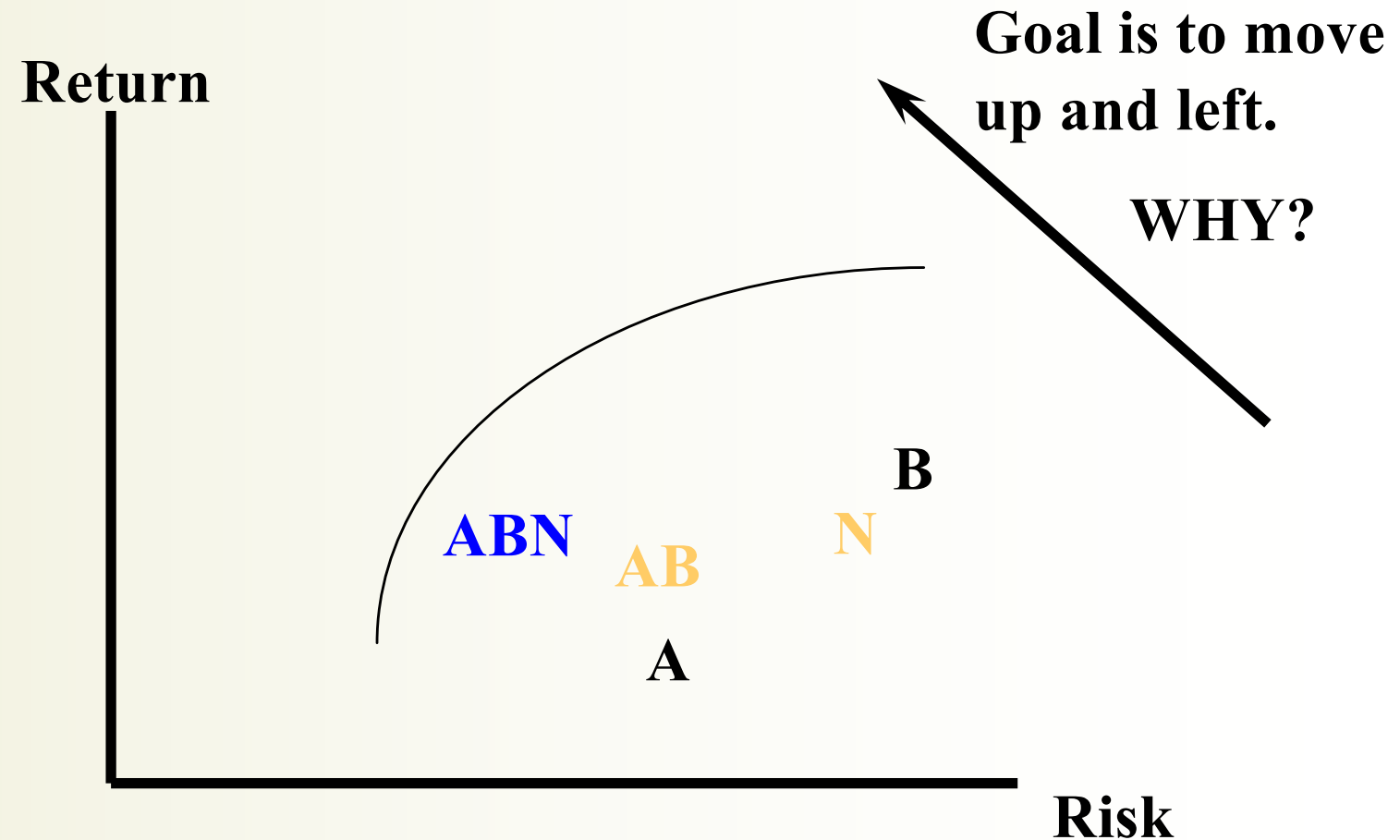
Efficient Frontier



Efficient Frontier



Efficient Frontier



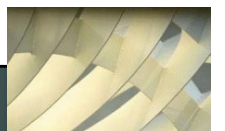
Efficient Frontier

The ratio of the risk premium to the standard deviation is called the Sharpe ratio:

**Goal is to move
up and left.**

WHY?

$$\text{Sharpe Ratio} = \frac{r_p - r_f}{\sigma_p}$$



Efficient Frontier

Return

Low Risk

High Return

High Risk

High Return

Low Risk

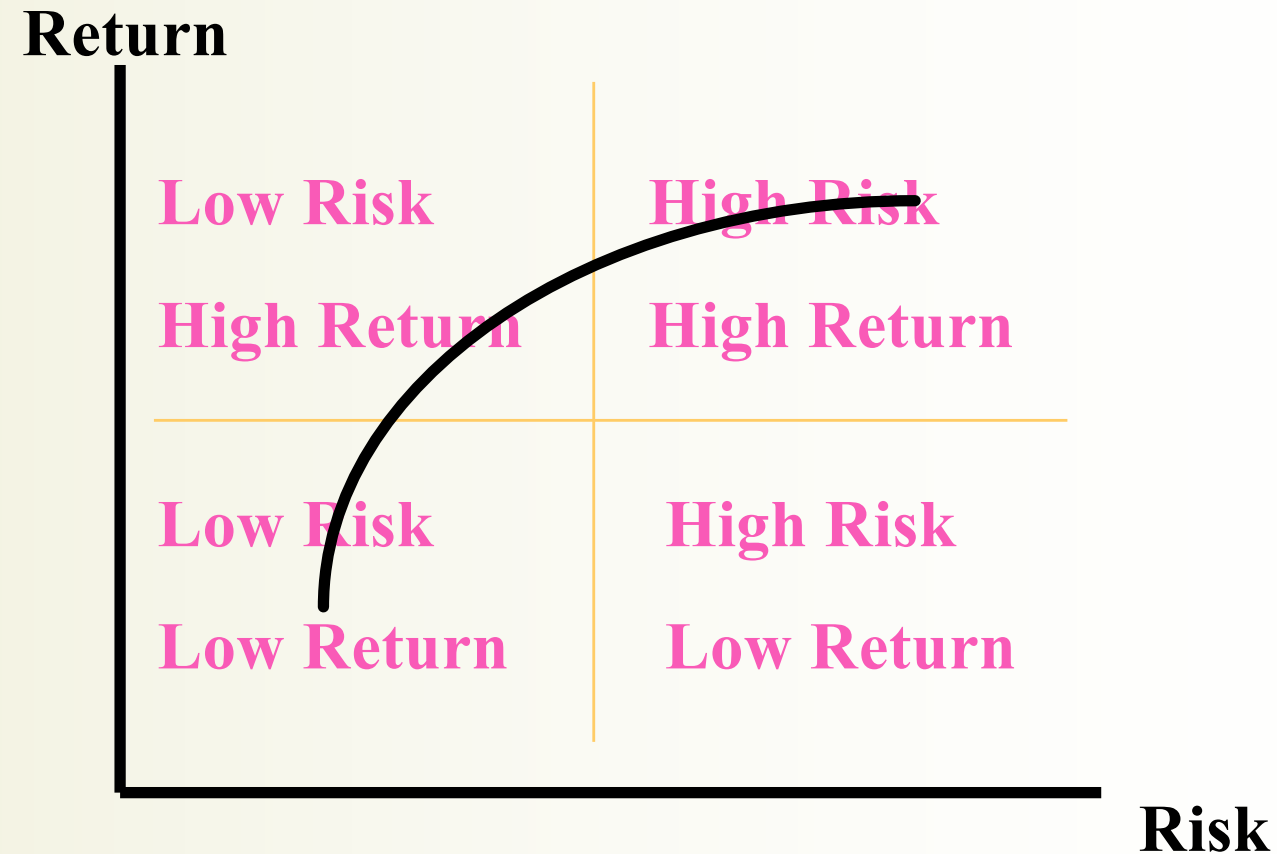
Low Return

High Risk

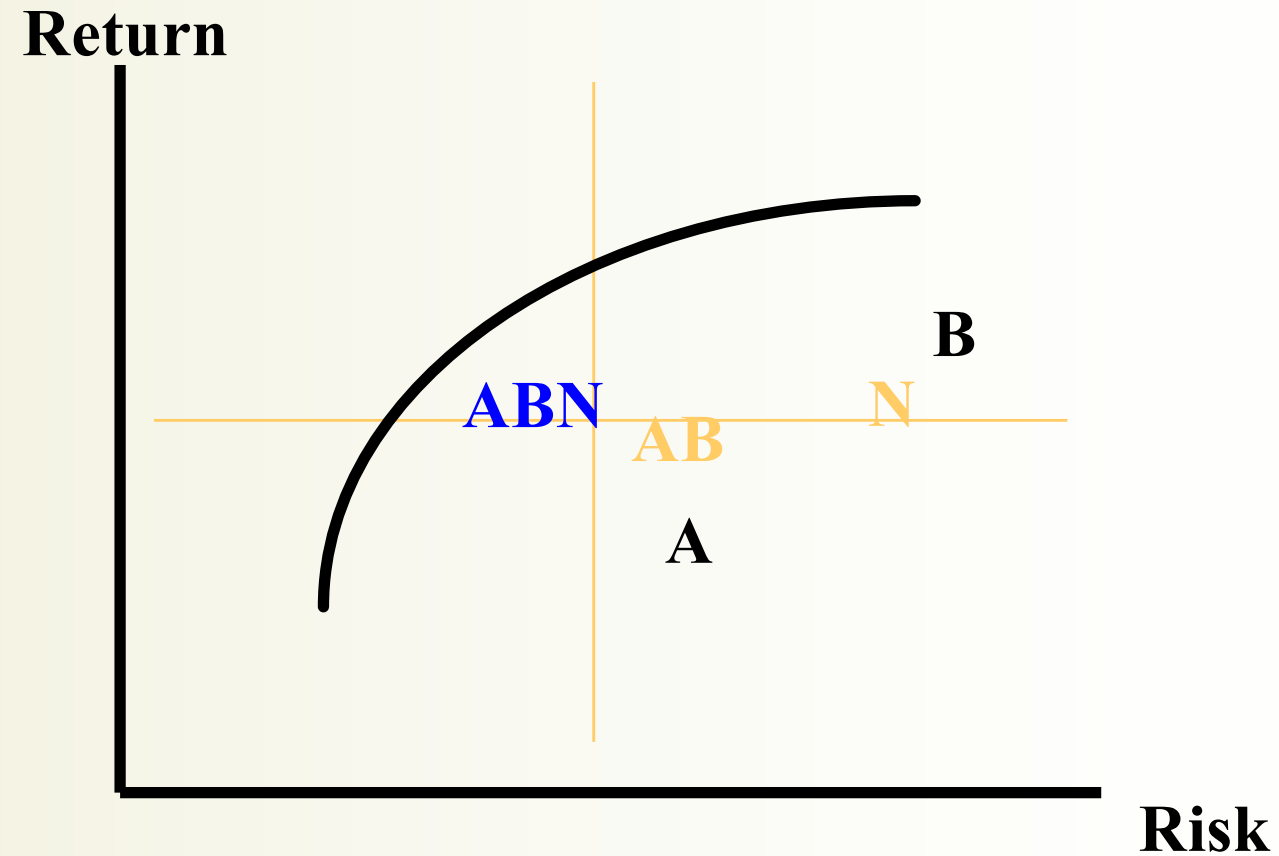
Low Return

Risk

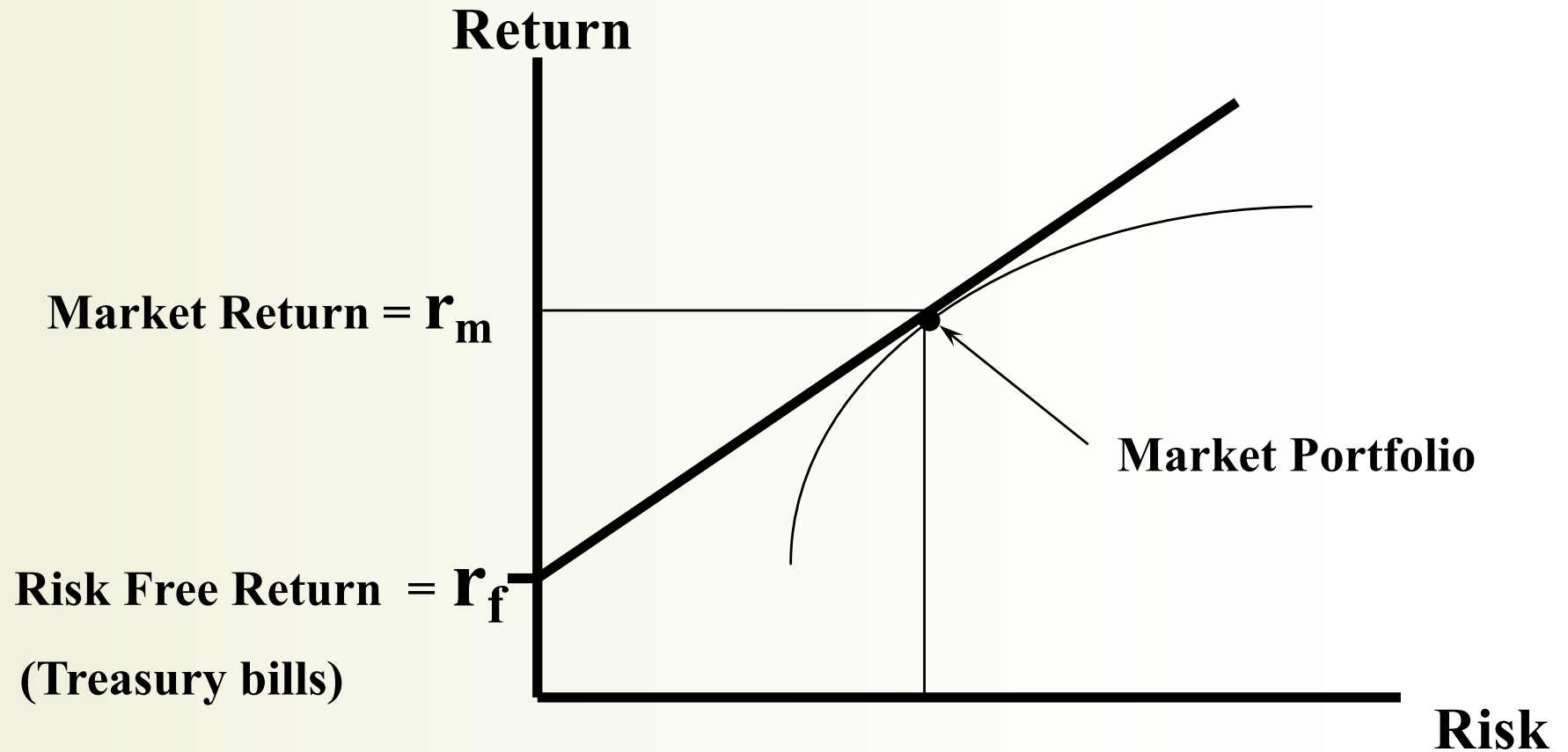
Efficient Frontier



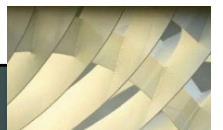
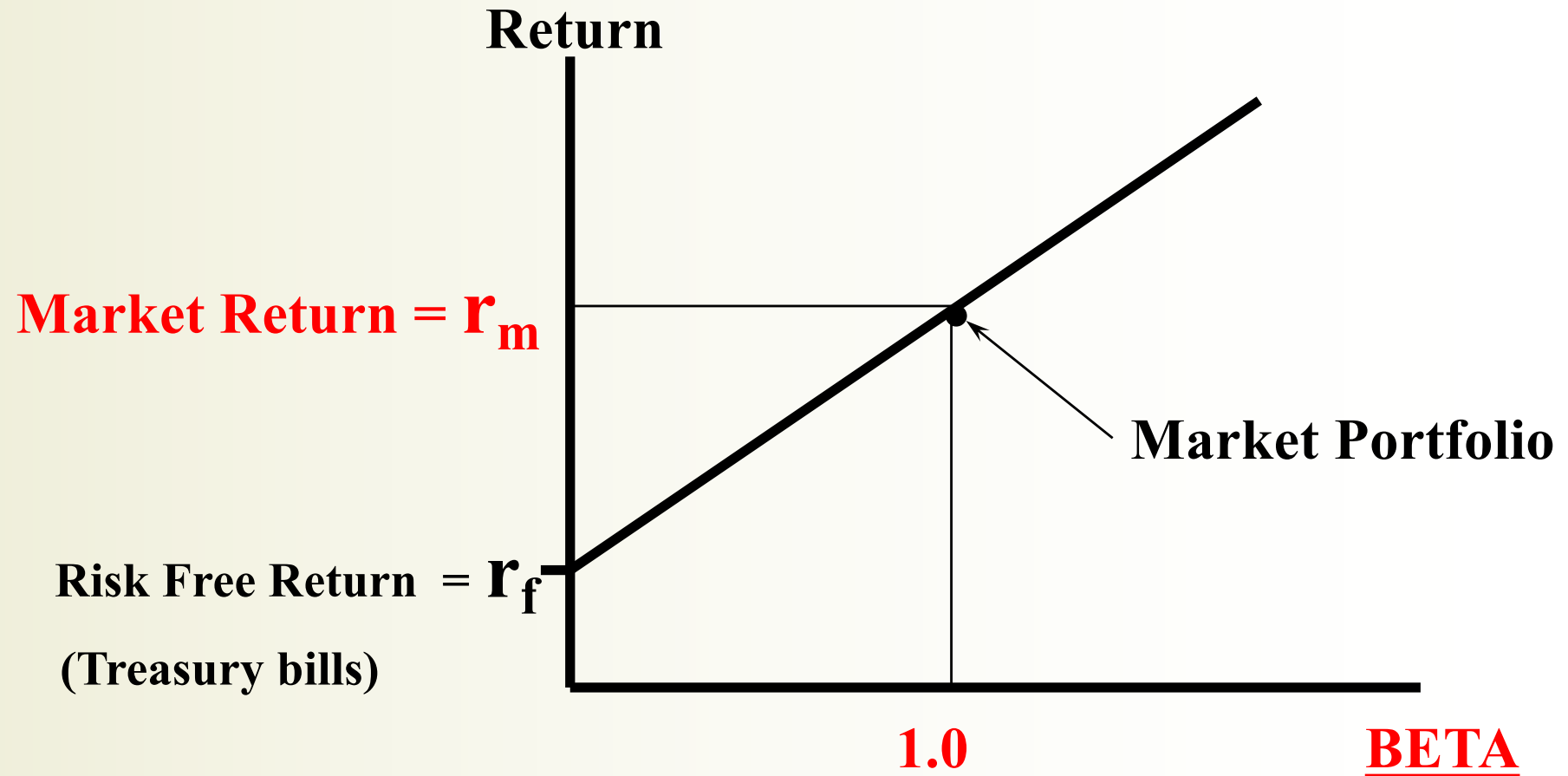
Efficient Frontier



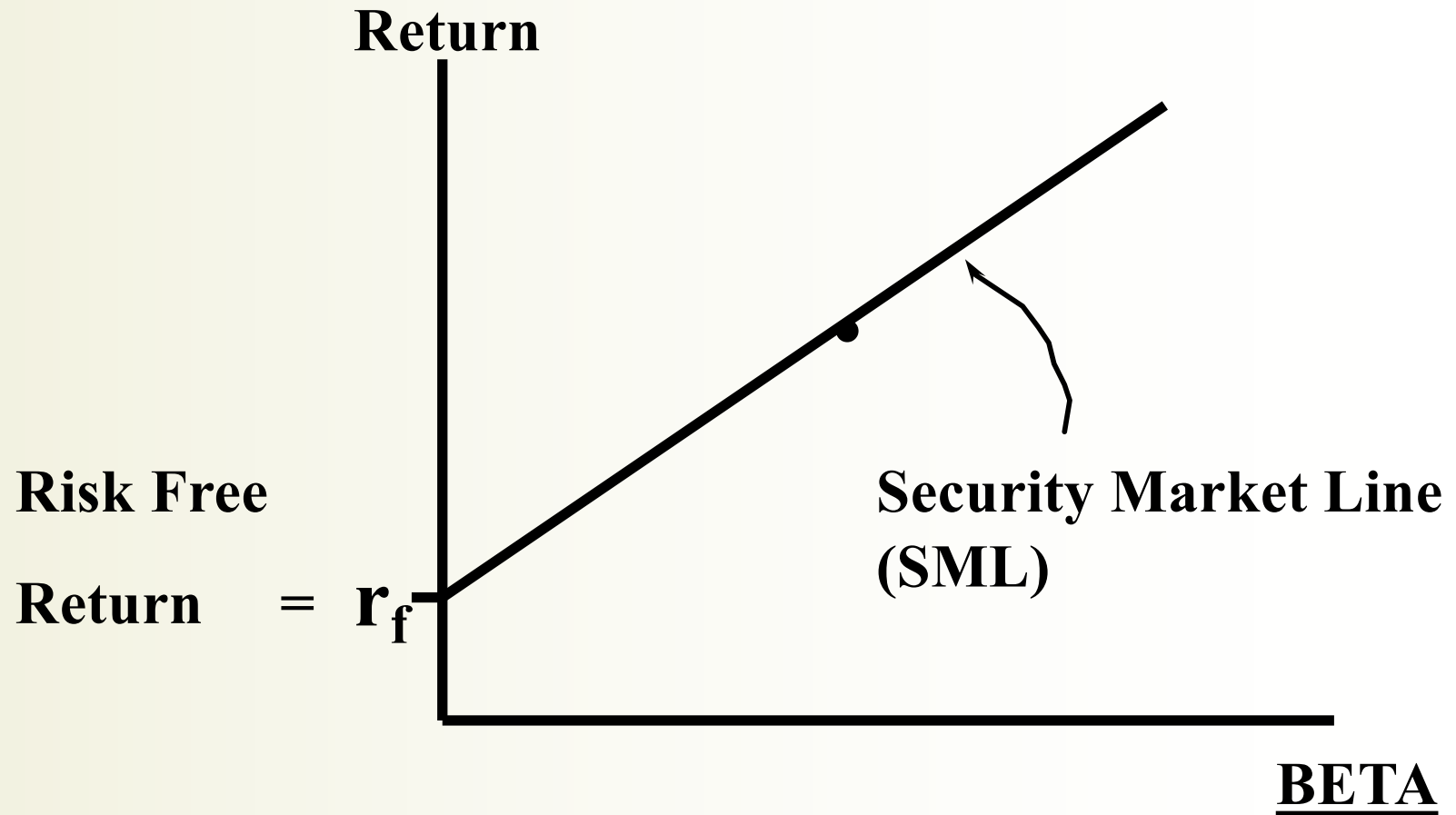
Security Market Line



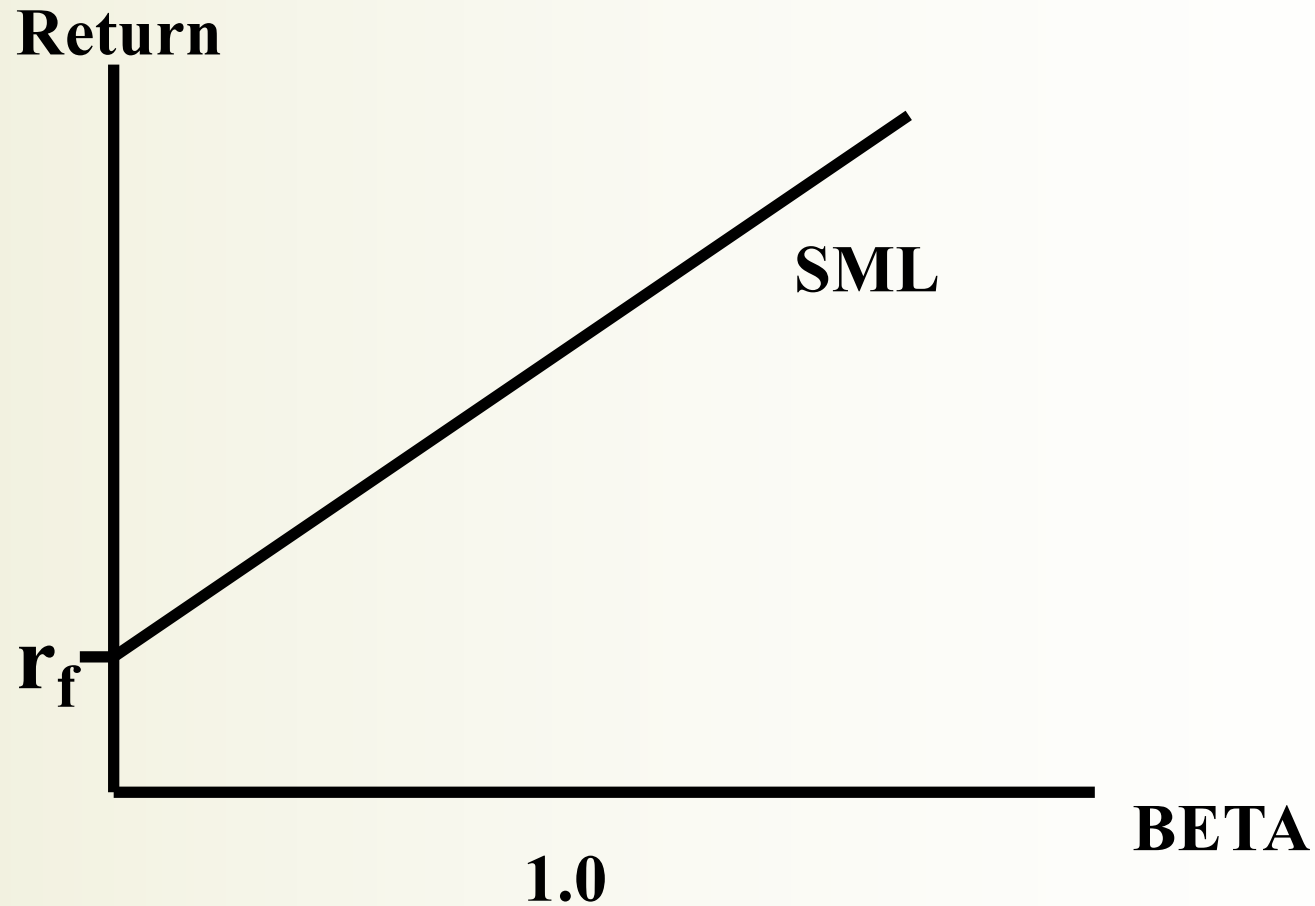
Security Market Line



Security Market Line



Security Market Line



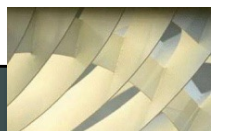
$$\text{SML Equation} = r_f + B (r_m - r_f)$$

Capital Asset Pricing Model

8-31

$$r = r_f + B(r_m - r_f)$$

CAPM



Expected Returns

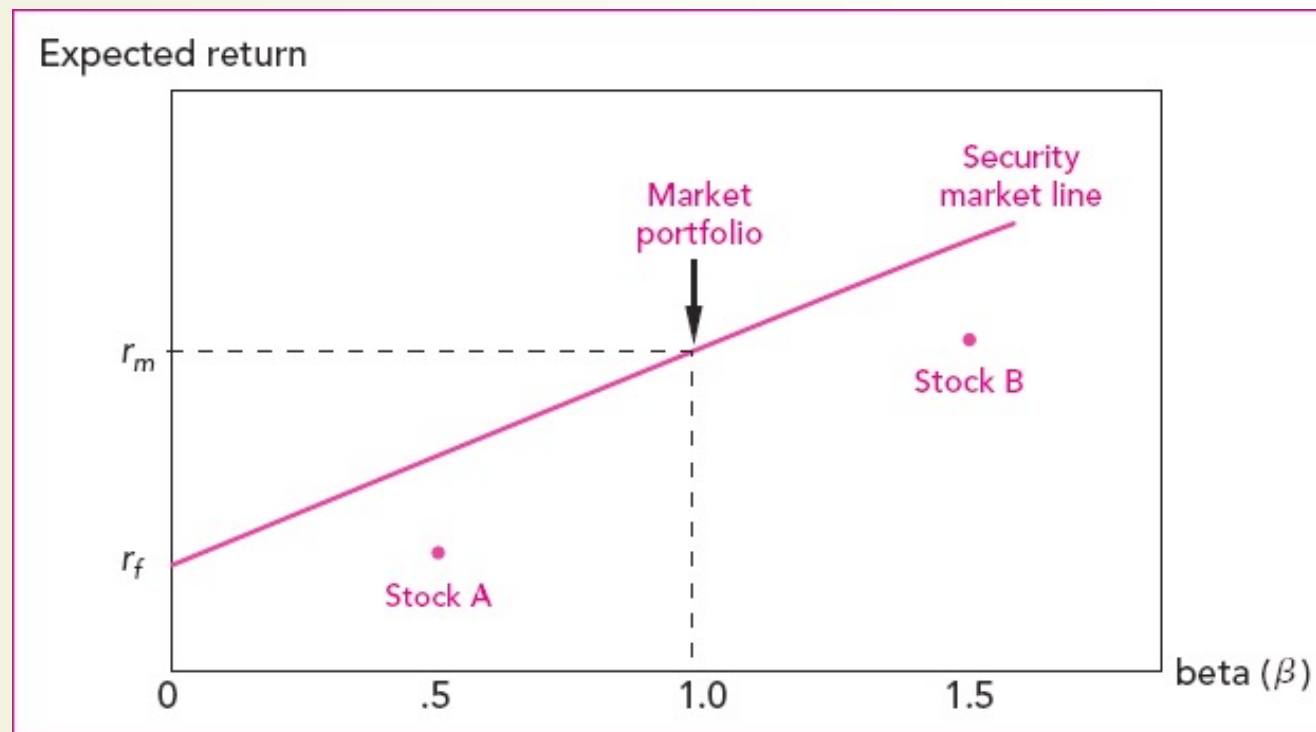
These estimates of the returns expected by investors in February 2009 were based on the capital asset pricing model. We assumed 0.2% for the interest rate r_f and 7% for the expected risk premium $r_m - r_f$.

TABLE 8.2		
Stock	Beta (β)	Expected Return $[r_f + \beta(r_m - r_f)]$
Amazon	2.16	15.4
Ford	1.75	12.6
Dell	1.41	10.2
Starbucks	1.16	8.4
Boeing	1.14	8.3
Disney	.96	7.0
Newmont	.63	4.7
ExxonMobil	.55	4.2
Johnson & Johnson	.50	3.8
Soup	.30	2.4



SML Equilibrium

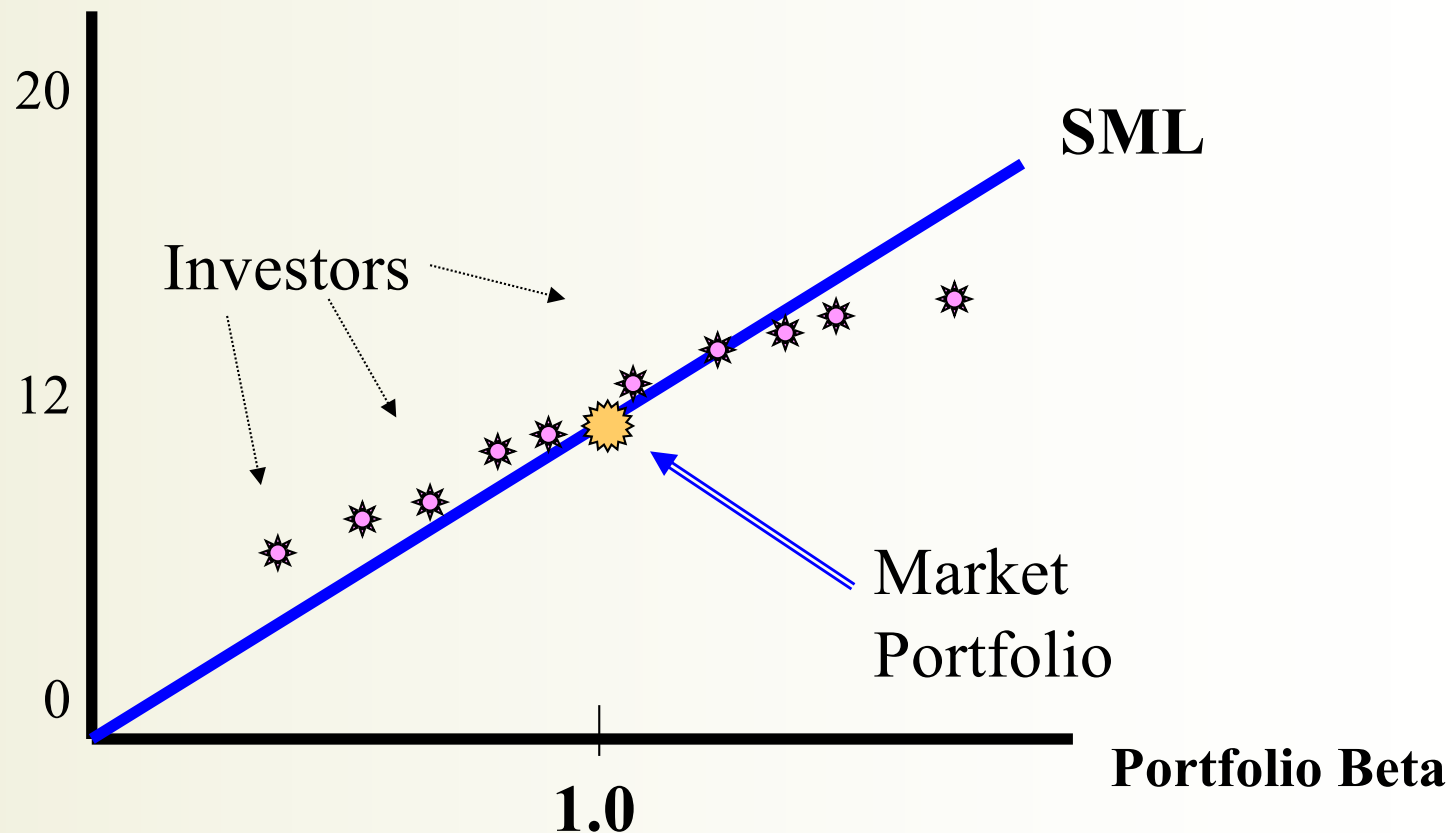
- In equilibrium no stock can lie below the security market line. For example, instead of buying stock A, investors would prefer to lend part of their money and put the balance in the market portfolio. And instead of buying stock B, they would prefer to borrow and invest in the market portfolio.



Testing the CAPM

Beta vs. Average Risk Premium

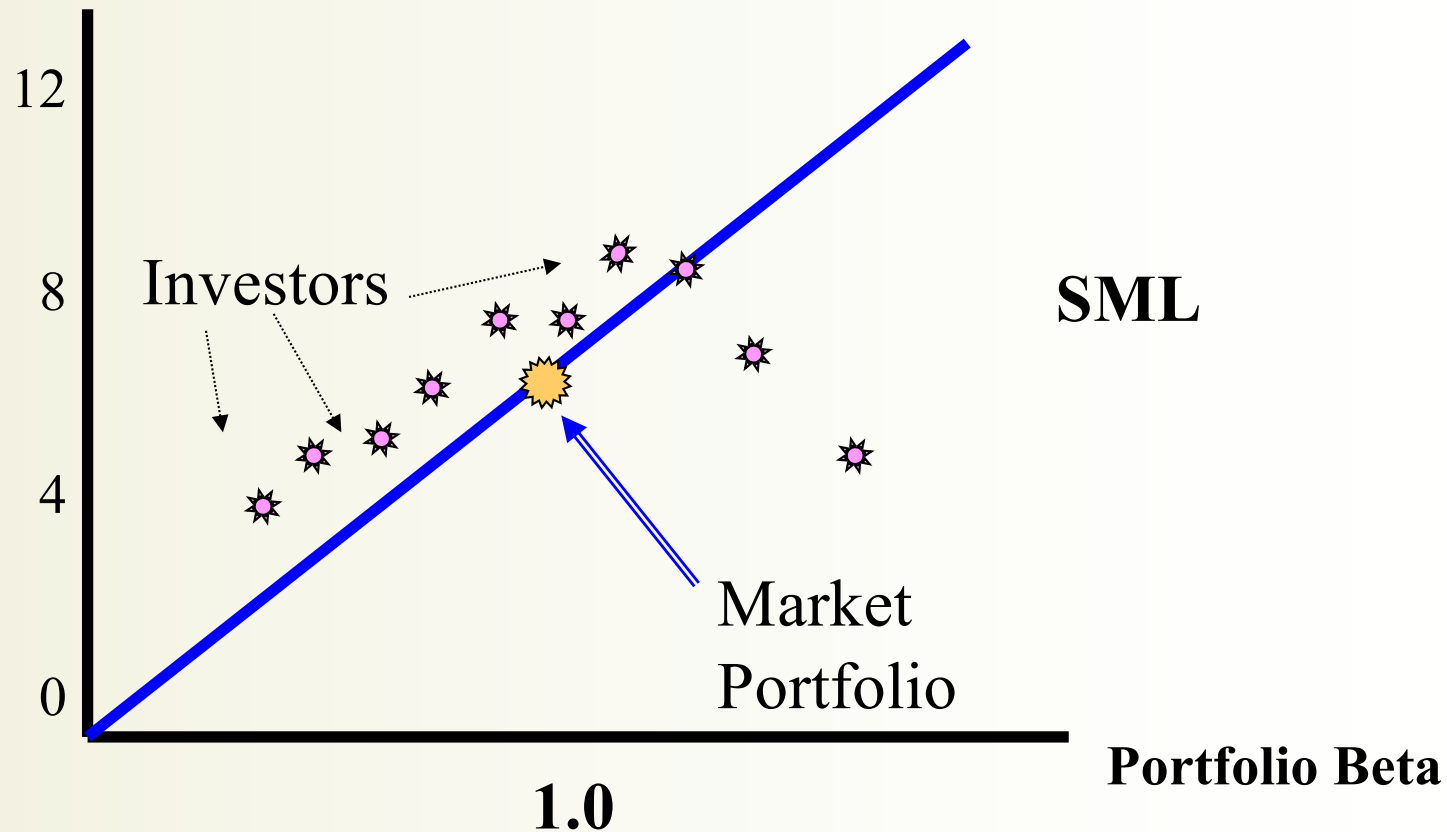
Average Risk Premium
1931-2008



Testing the CAPM

Beta vs. Average Risk Premium

Average Risk Premium
1966-2008

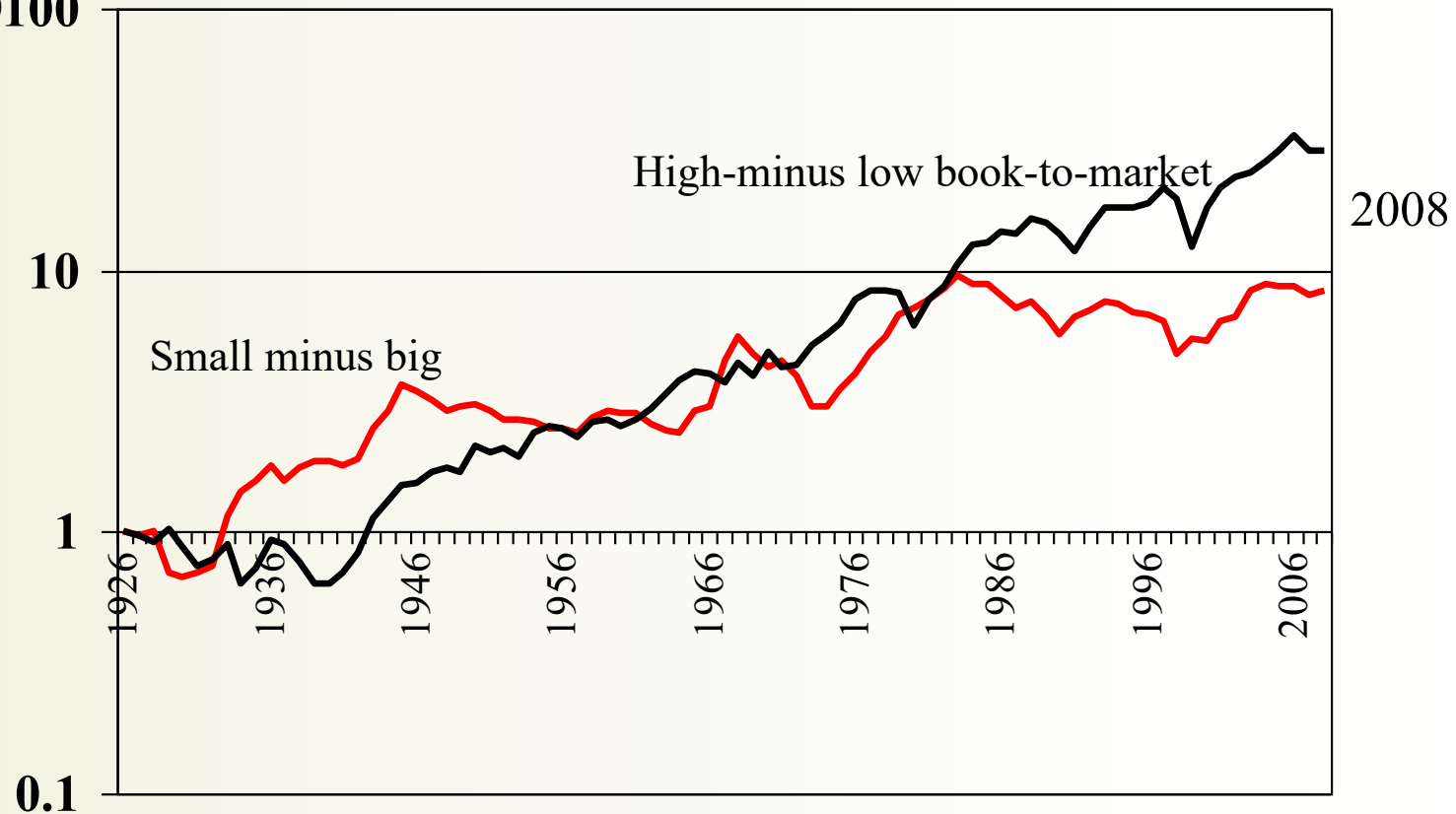


Testing the CAPM

Return vs. Book-to-Market

Dollars

(log scale)



http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

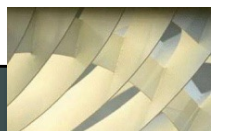


Arbitrage Pricing Theory

Alternative to CAPM

$$\text{Return} = a + b_1(r_{\text{factor1}}) + b_2(r_{\text{factor2}}) + b_3(r_{\text{factor3}}) + \dots + \text{noise}$$

$$\begin{aligned}\text{Expected Risk Premium} &= r - r_f \\ &= b_1(r_{\text{factor1}} - r_f) + b_2(r_{\text{factor2}} - r_f) + \dots\end{aligned}$$



Arbitrage Pricing Theory

Estimated risk premiums for taking on risk factors
(1978-1990)

Factor	Estimated Risk Premium ($r_{\text{factor}} - r_f$)
Yield spread	5.10%
Interest rate	-.61
Exchange rate	-.59
Real GNP	.49
Inflation	-.83
Mrket	6.36

Three Factor Model

Steps to Identify Factors

1. Identify a reasonably short list of macroeconomic factors that could affect stock returns
2. Estimate the expected risk premium on each of these factors (r factor 1 $- r_f$, etc.);
3. Measure the sensitivity of each stock to the factors (b_1 , b_2 , etc.).

Three Factor Model

TABLE 8.3 Estimates of expected equity returns for selected industries using the Fama-French three-factor model and the CAPM.

	Three-Factor Model			CAPM	
	Factor Sensitivities			Expected return*	Expected return**
	b_{market}	b_{size}	$b_{\text{book-to-market}}$		
Autos	1.51	.07	0.91	15.7	7.9
Banks	1.16	-.25	.7	11.1	6.2
Chemicals	1.02	-.07	.61	10.2	5.5
Computers	1.43	.22	-.87	6.5	12.8
Construction	1.40	.46	.98	16.6	7.6
Food	.53	-.15	.47	5.8	2.7
Oil and gas	0.85	-.13	0.54	8.5	4.3
Pharmaceuticals	0.50	-.32	-.13	1.9	4.3
Telecoms	1.05	-.29	-.16	5.7	7.3
Utilities	0.61	-.01	.77	8.4	2.4

The expected return equals the risk-free interest rate plus the factor sensitivities multiplied by the factor risk premia, that is, $r_f + (b_{\text{market}} \times 7) + (b_{\text{size}} \times 3.6) + (b_{\text{book-to-market}} \times 5.2)$

** Estimated as $r_f + \beta(r_m - r_f)$, that is $r_f + \beta \times 7$.

Web Resources

Click to access web sites
Internet connection required



<http://finance.yahoo.com>

www.duke.edu/~charvey

<http://mba.tuck.dartmouth.edu/pages/faculty/ken.french>

