CHAPTER 8

PORTFOLIO THEORY AND THE CAPITAL ASSET PRICING MODEL

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

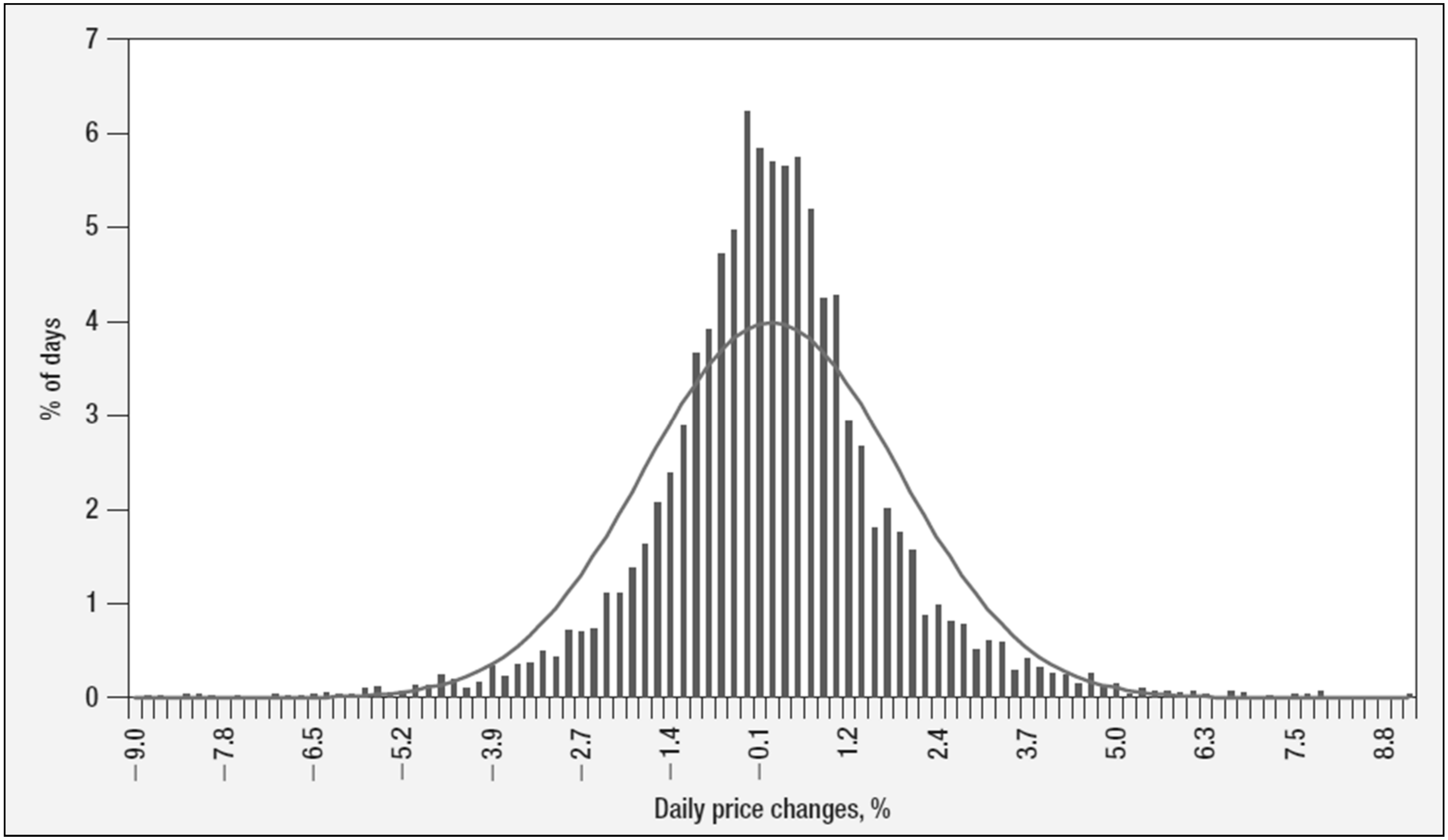
Markowitz Portfolio Theory

- 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

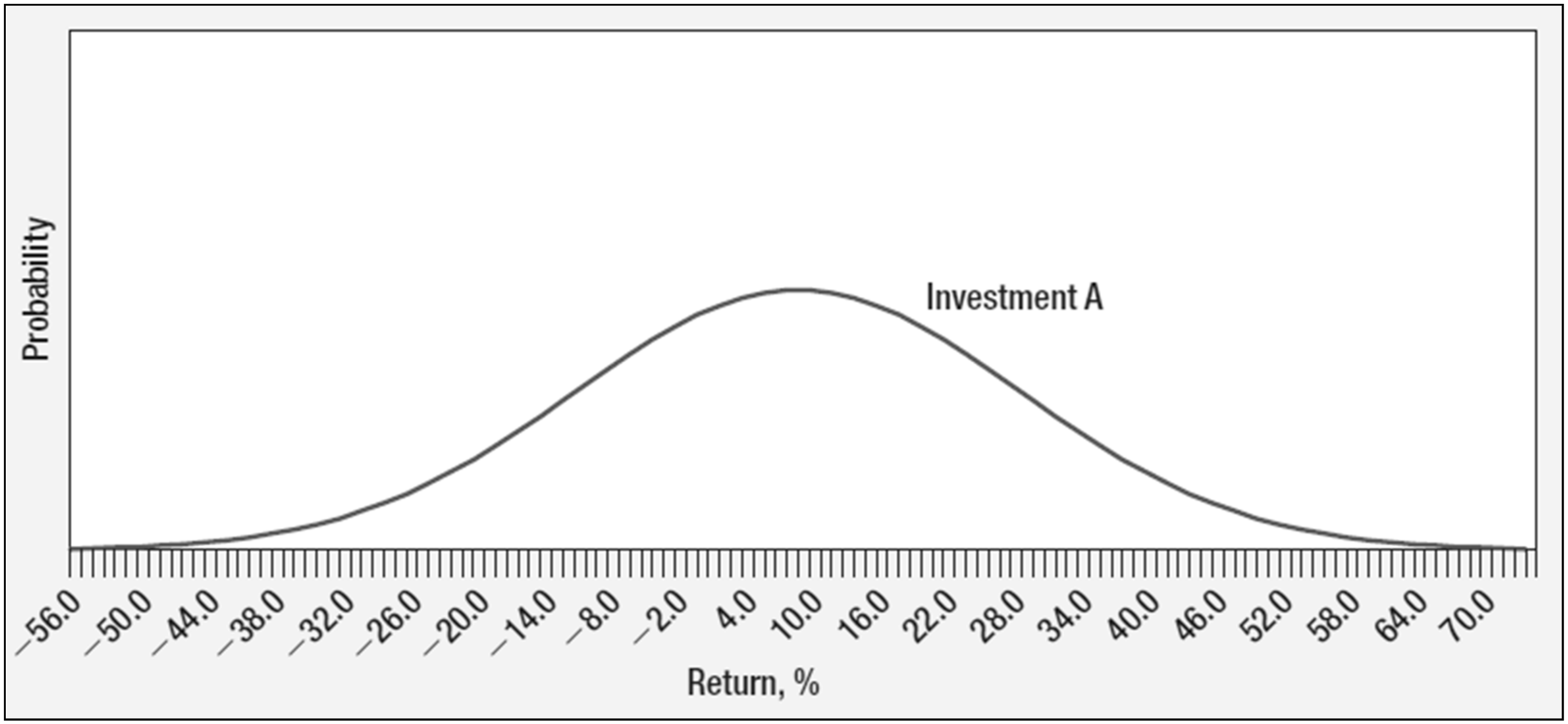
Price changes vs. Normal distribution

IBM - Daily % change 1994-2013



Markowitz Portfolio Theory

Standard Deviation vs. Expected Return



Markowitz Portfolio Theory

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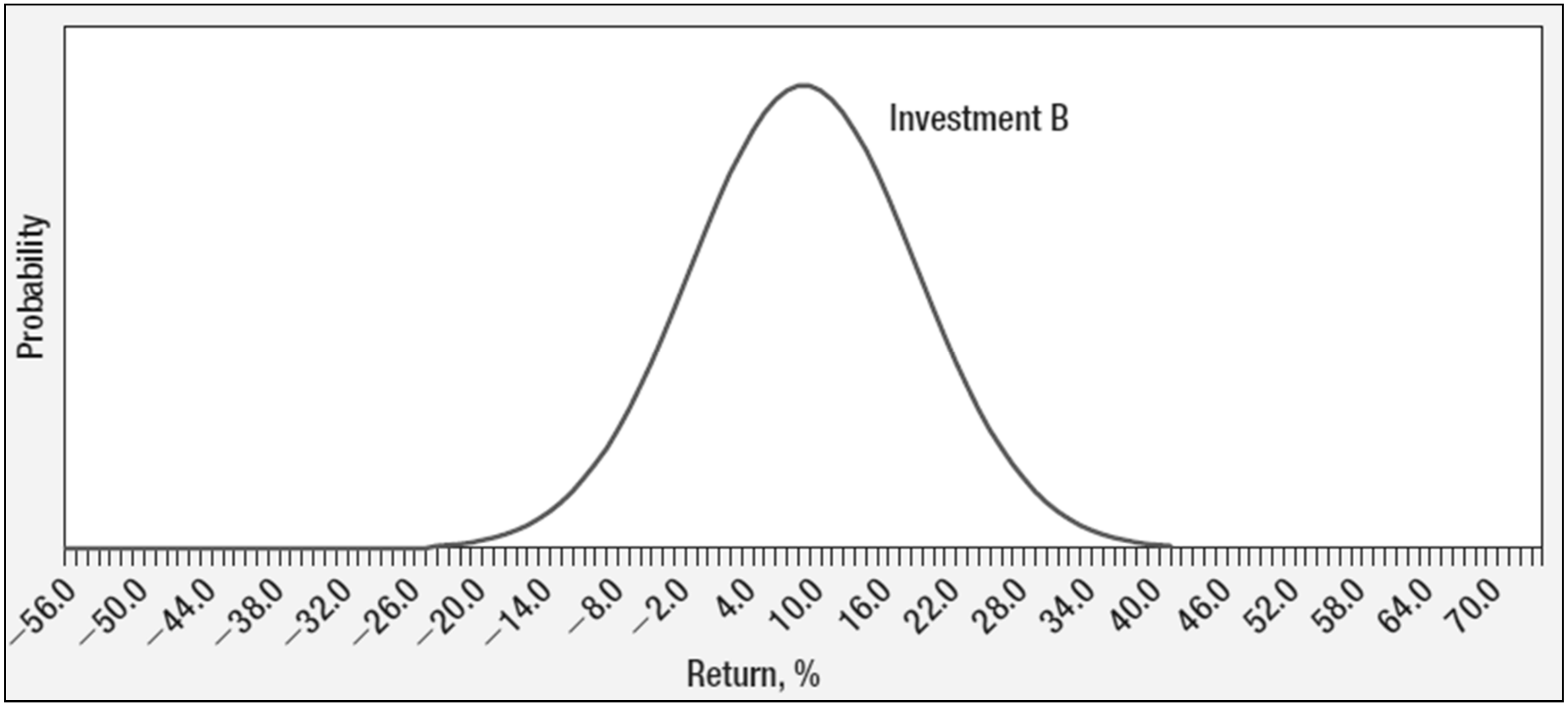
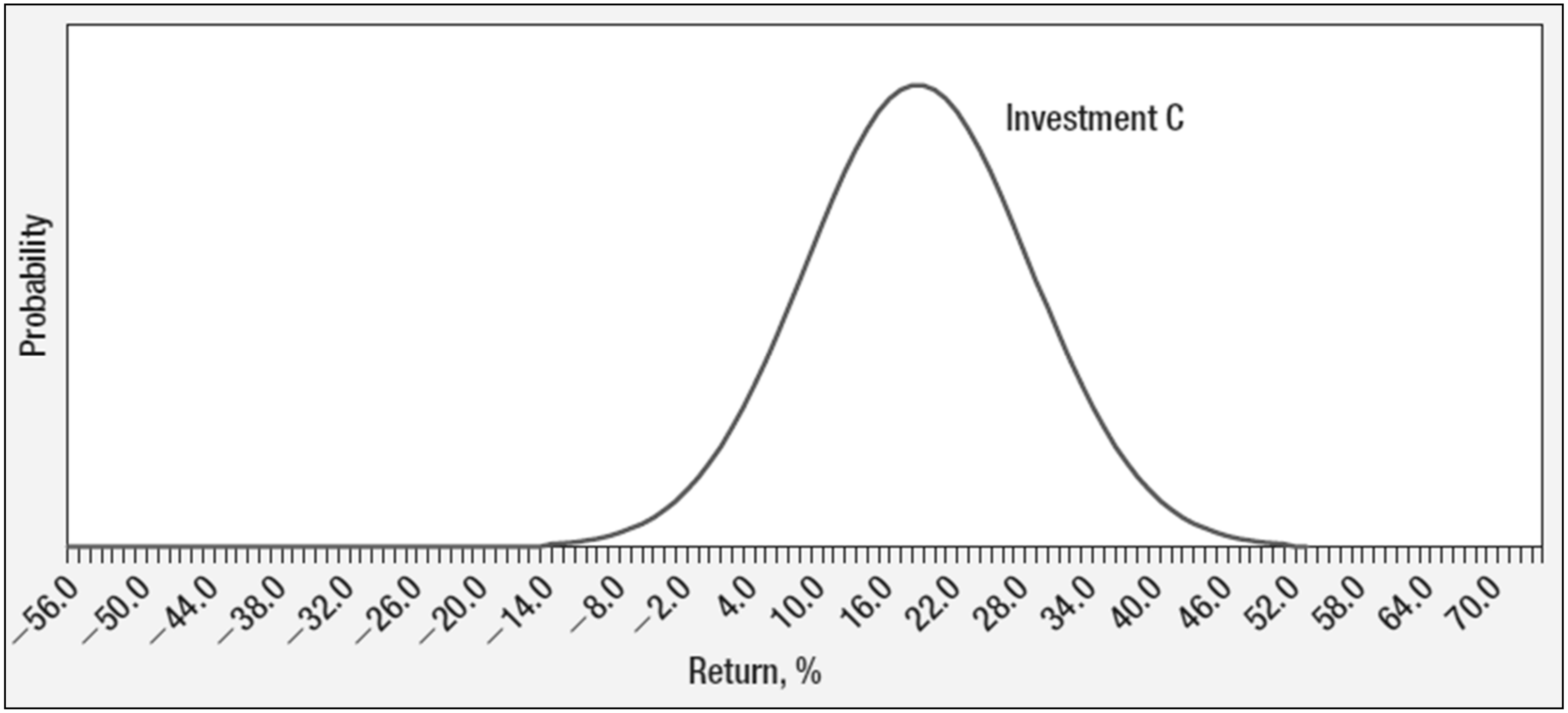


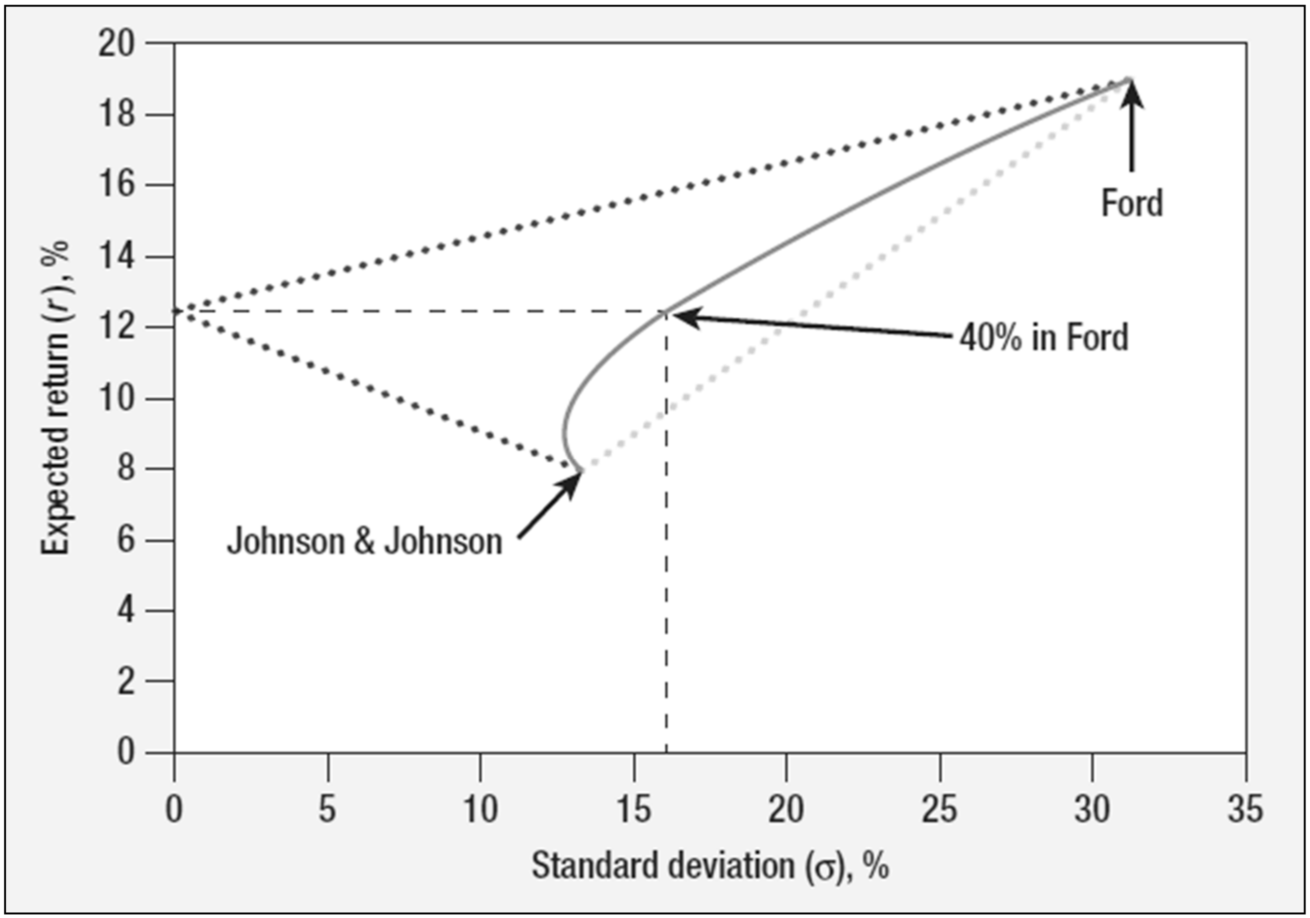
Markowitz Portfolio Theory

Standard Deviation vs. Expected Return



Markowitz Portfolio Theory

Expected returns and standard deviations vary given different weighted combinations of the stocks

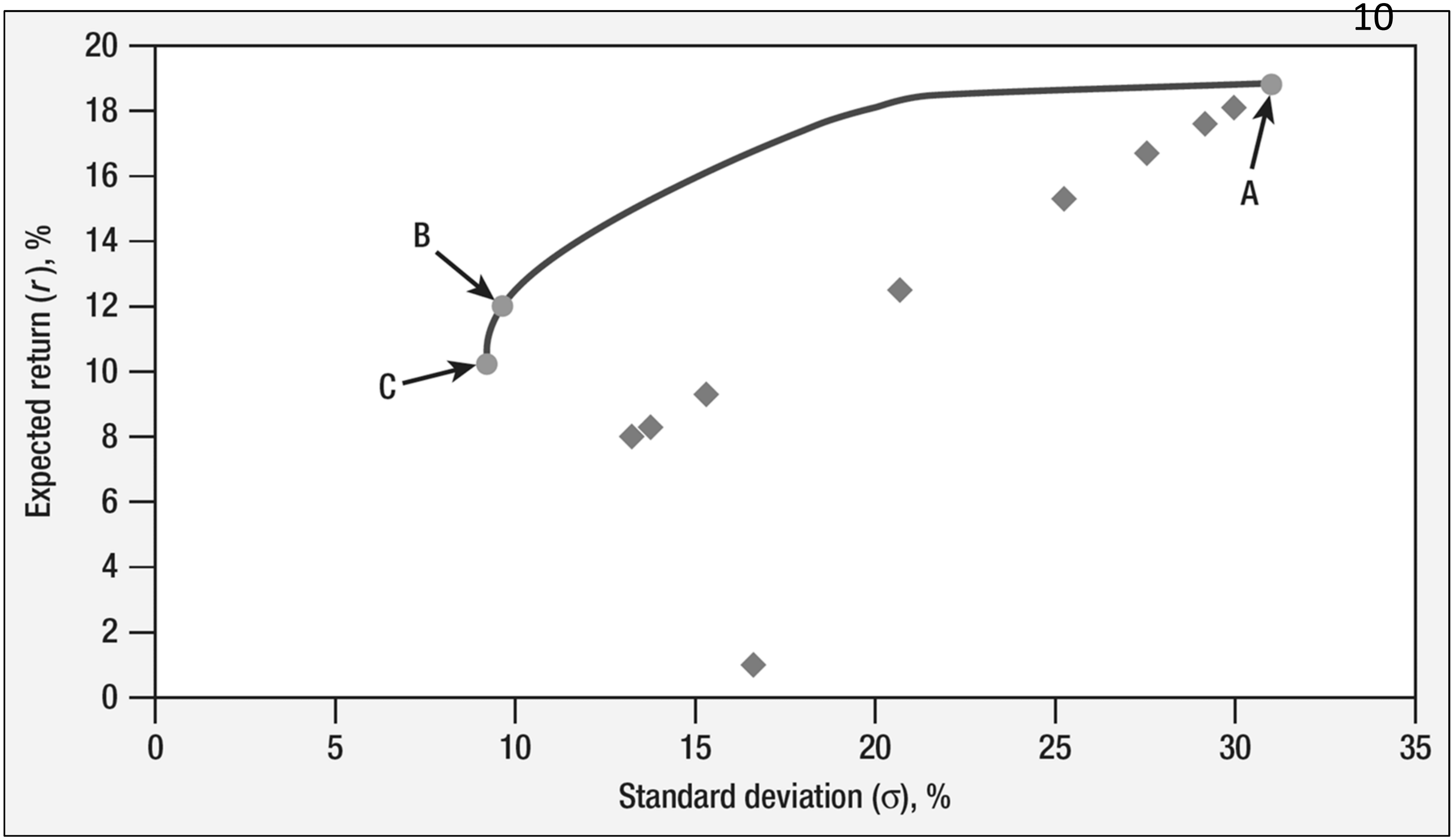


Efficient Frontier

	Expected Return (%)	Standard Deviation (%)	Three Efficient Portfolios—Percentages Allocated to Each Stock (%) A	B	C
Caterpillar	17.6	29.2	0	0	
Microsoft	12.5	20.7	13	11	
Consolidated Edison	8.3	13.8	27	22	
Newmont	18.1	30.0	11	18	
Apple	15.3	25.2	4	8	
Johnson & Johnson	8.0	13.2	10	0	
Campbell Soup	1.0	16.6	15	17	
Walmart	9.3	15.3	17	10	
Ford	18.8	31.0	2	9	100
Dow Chemical	16.7	27.5	3	5	
Expected portfolio return			10.61	12.84	18.8
Portfolio standard deviation			9.14	10.35	31.0

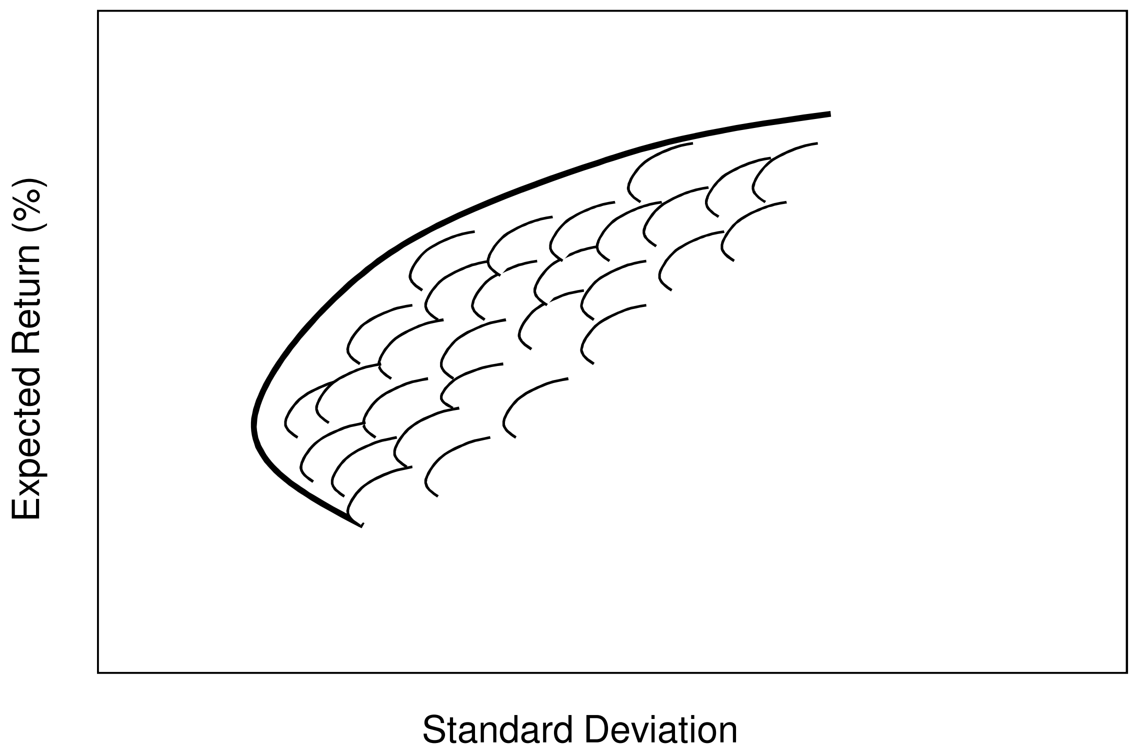
Efficient Frontier

Three efficient portfolios all from the same 10 stocks



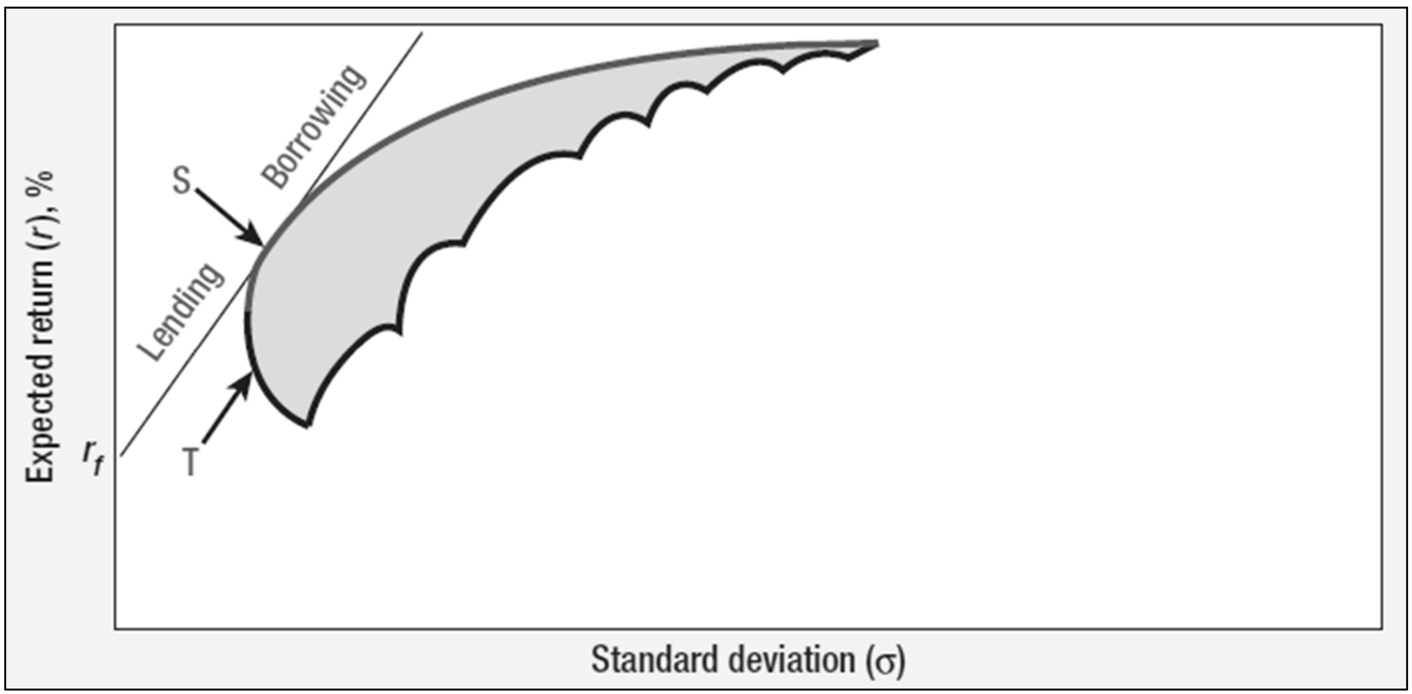
Efficient Frontier

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



Efficient Frontier

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



Efficient Frontier

Example Correlation coefficient = .19

Stocks	σ	% of Portfolio	Avg Return
JNJ	13.2	60%	15%
Ford	31.0	40%	21%

Standard deviation = weighted avg = 20.3%

Standard deviation = portfolio = 15.9 %

Return = weighted avg = portfolio = 12.3%

Efficient Frontier

Example Correlation coefficient = .4

Stocks	σ	% of Portfolio	Avg Return
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%

Additive standard deviation (common sense):

= .28 (60%) + .42 (40%) = 33.6% WRONG

Real standard deviation:

$$= \sqrt{x_1^2\sigma_1^2 + x_2^2\sigma_2^2 + 2(x_1x_2\rho_{12}\sigma_1\sigma_2)}$$

$$= \sqrt{.60^2 .28^2 + .40^2 .42^2 + 2(.6)(.4)(.4)(.28)(.42)}$$

$$= .281 \text{ or } 28.1\% \text{ CORRECT}$$

Efficient Frontier

Previous Example Correlation coefficient = .3

Stocks	σ	% of Portfolio	Avg Return
Portfolio	28.1	50%	17.4%
New Corp	30	50%	19%

NEW standard deviation = weighted avg = 31.80 %

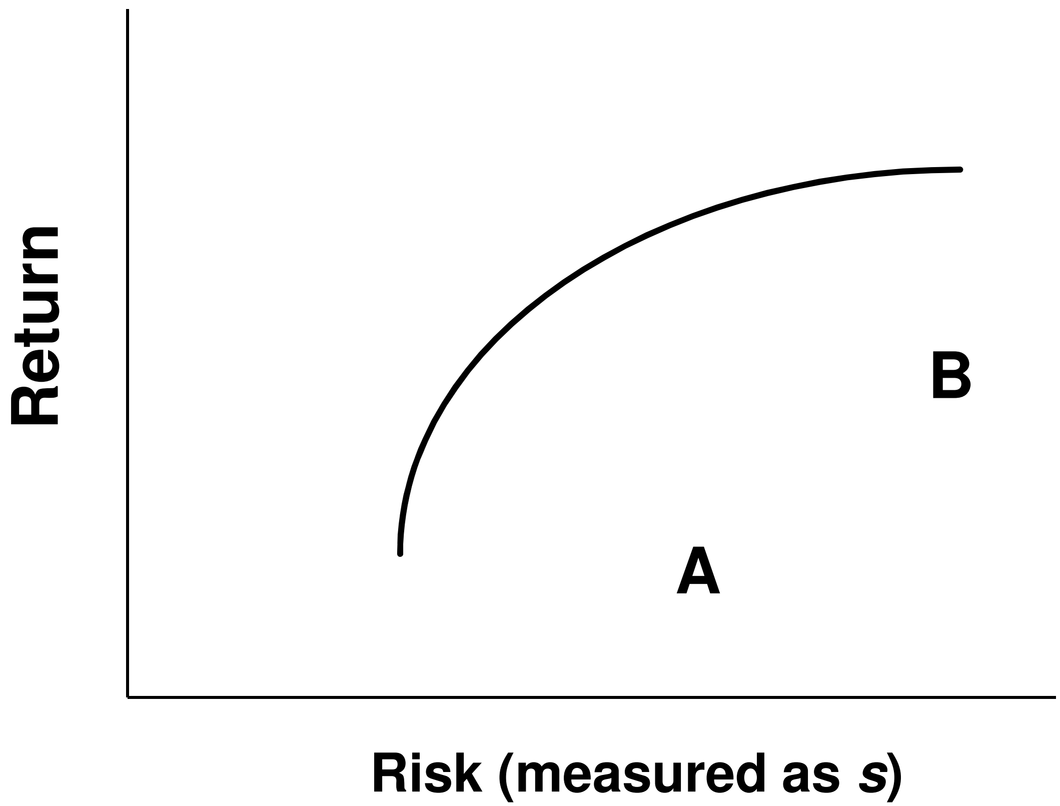
NEW standard deviation = portfolio = 23.43 %

NEW return = weighted avg = portfolio = 18.20%

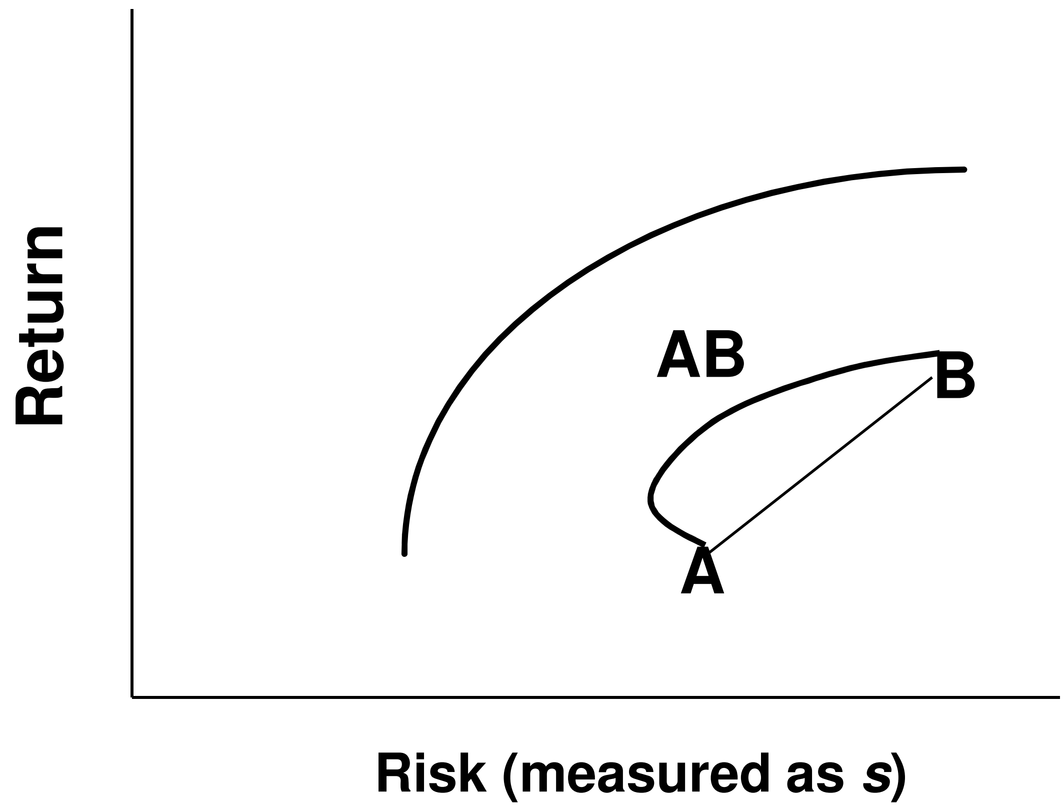
NOTE: Higher return & lower risk

How did we do that? DIVERSIFICATION

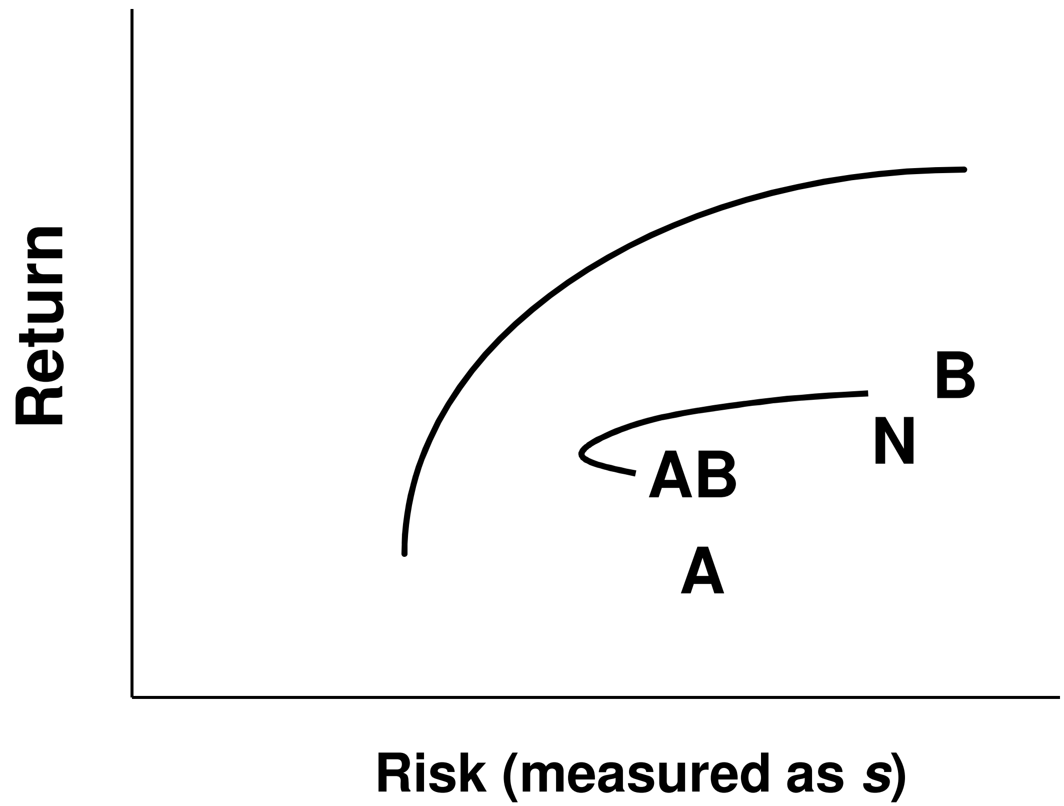
Efficient Frontier



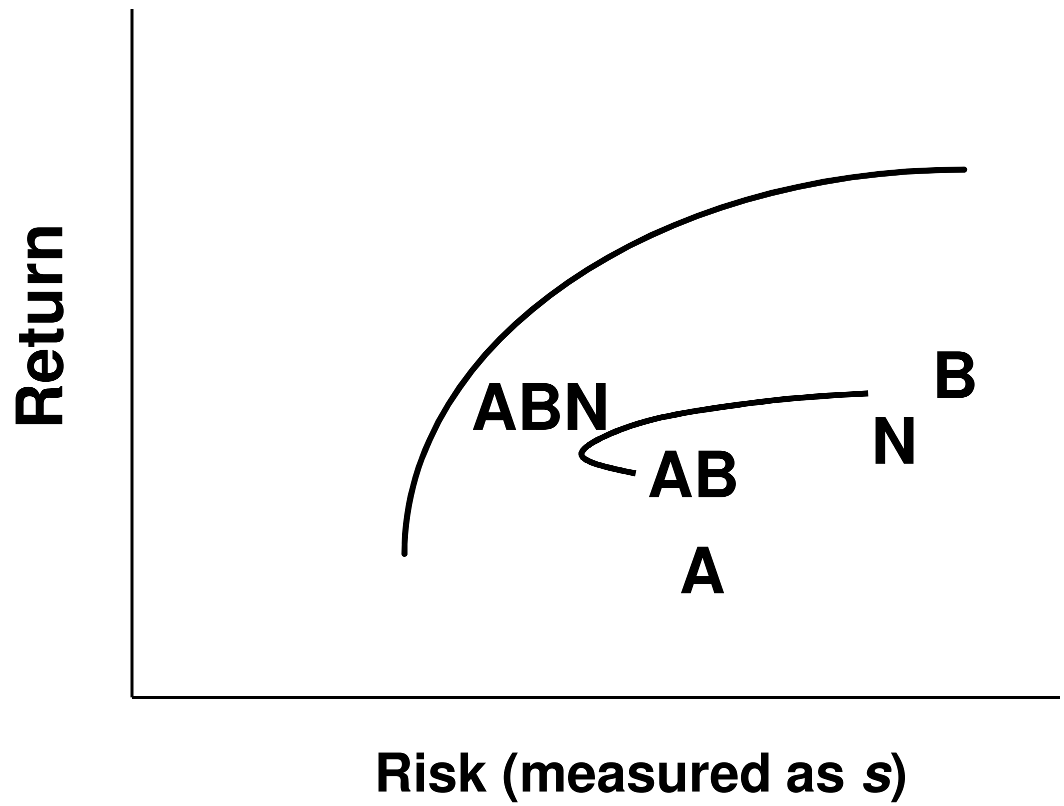
Efficient Frontier



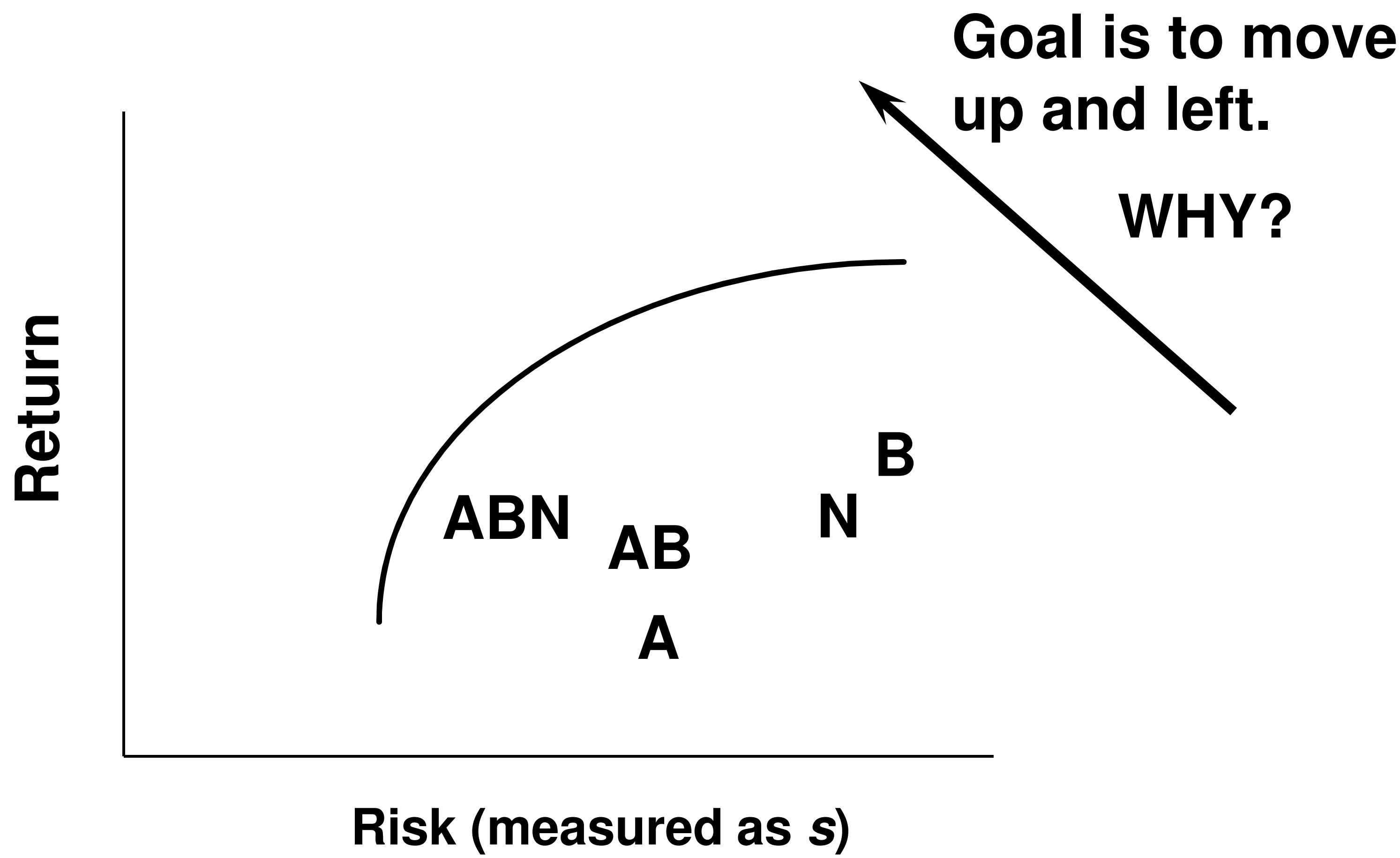
Efficient Frontier



Efficient Frontier



Efficient Frontier



Efficient Frontier

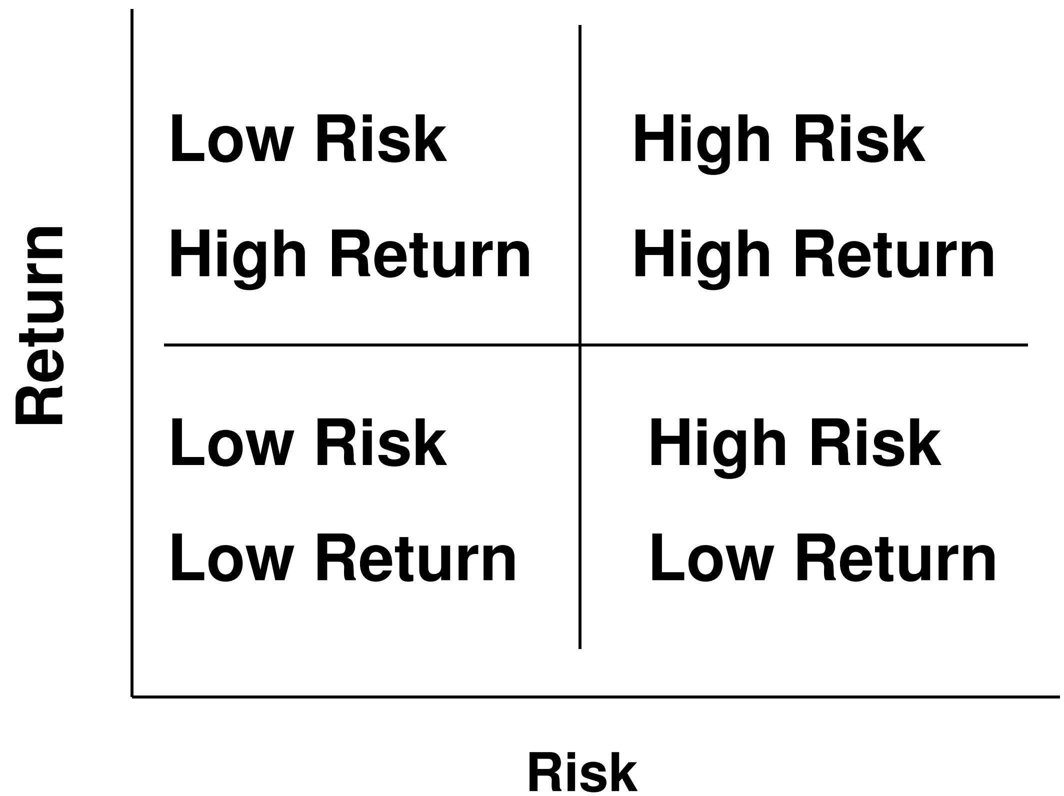
The ratio of the risk premium to the standard deviation is called the Sharpe ratio:

Goal is to move up and left.

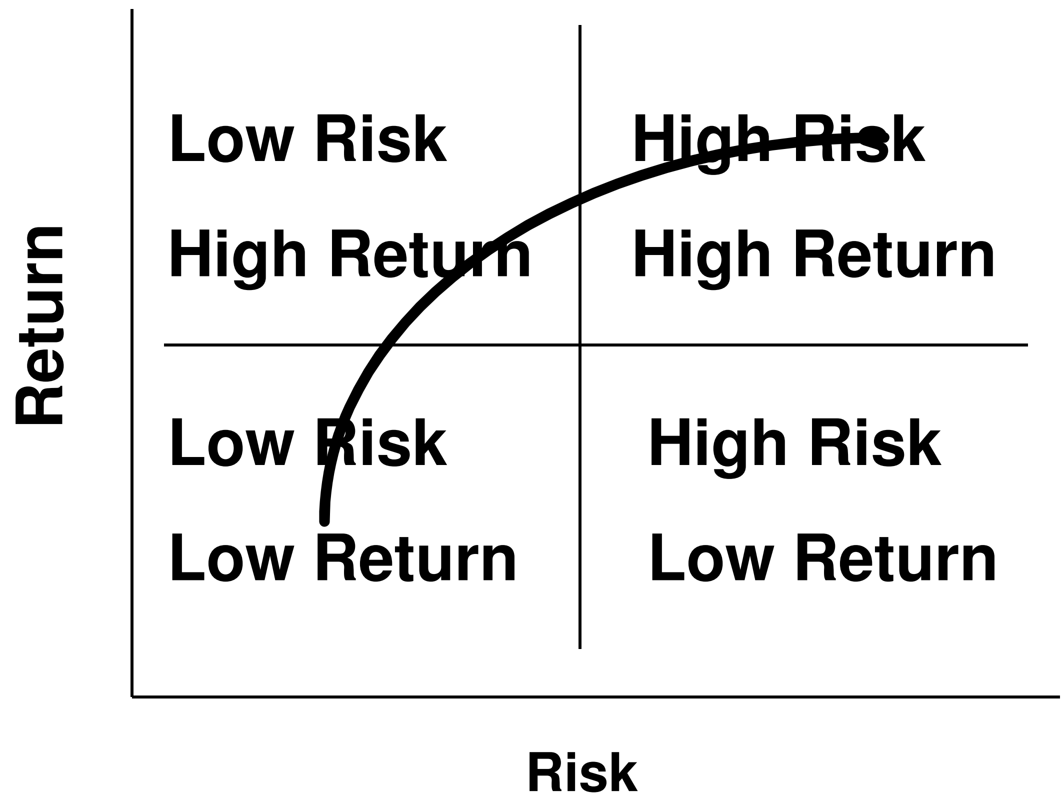
WHY?

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

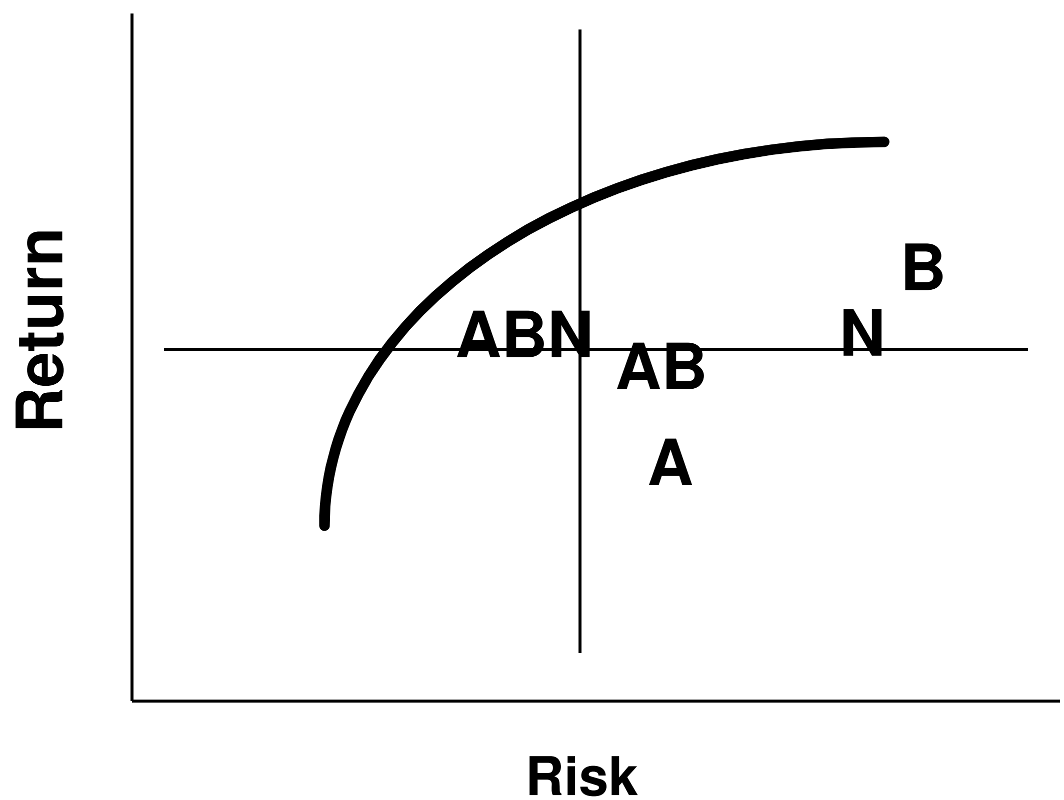
Efficient Frontier



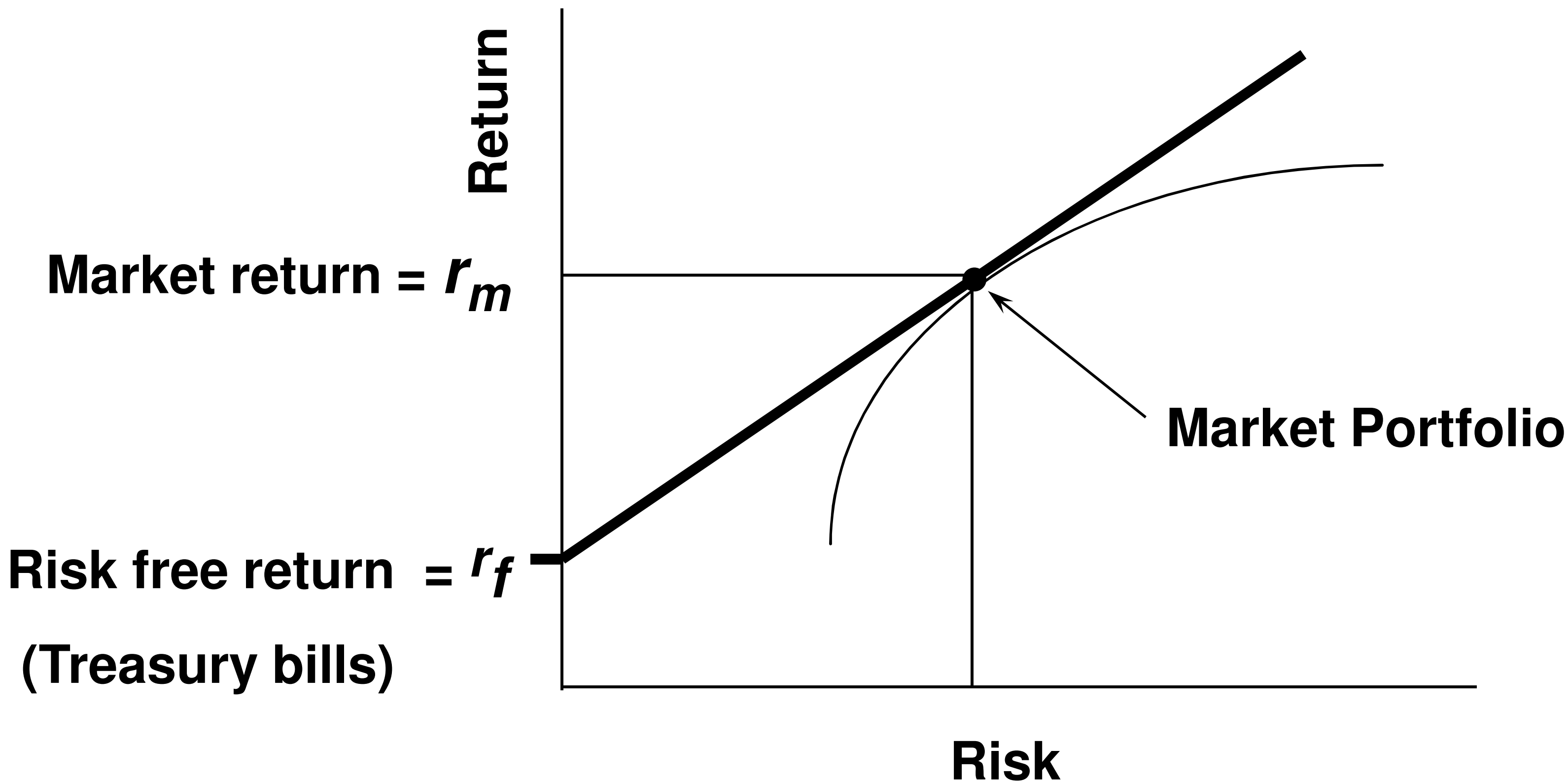
Efficient Frontier



Efficient Frontier



Security Market Line



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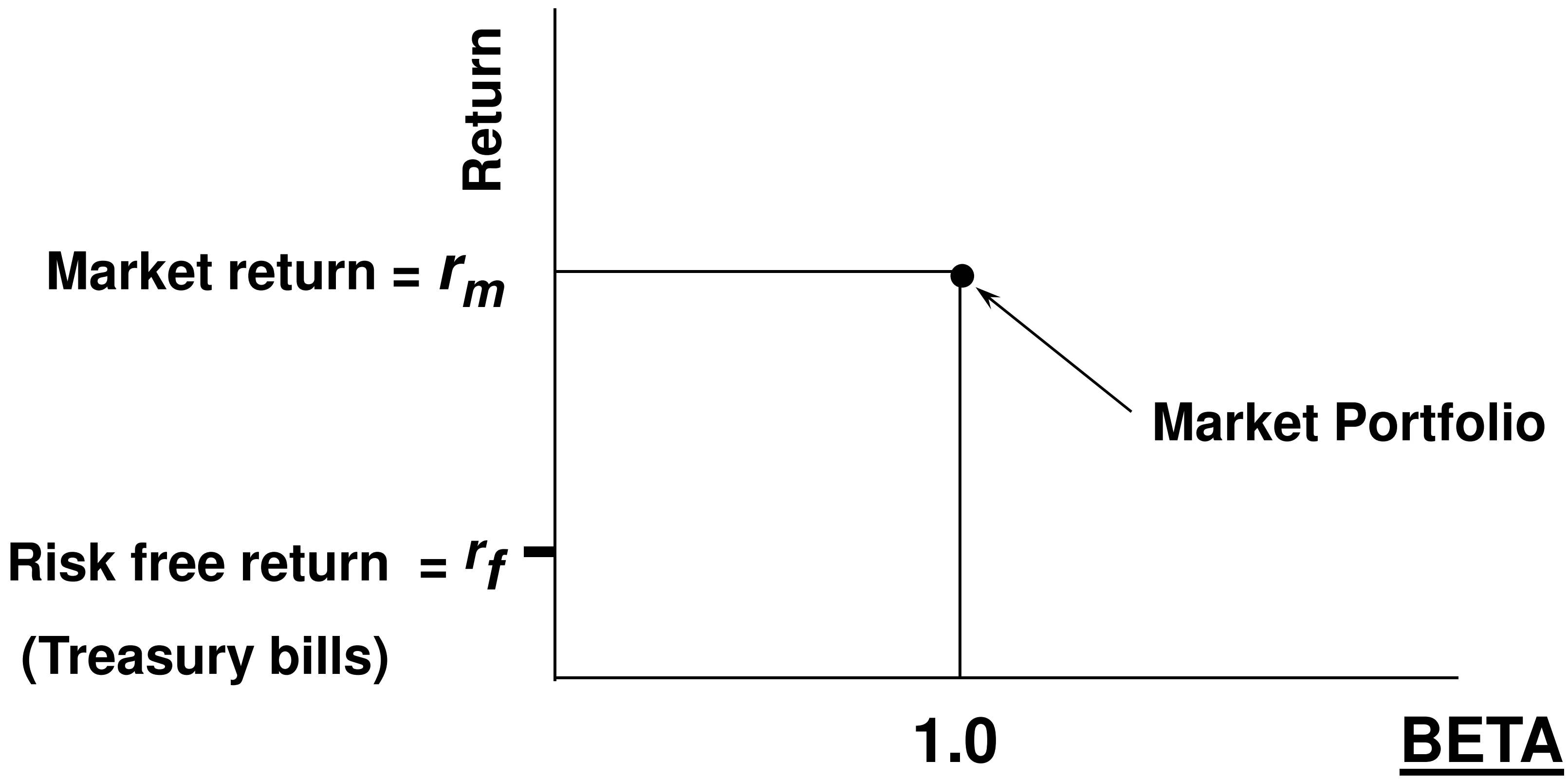

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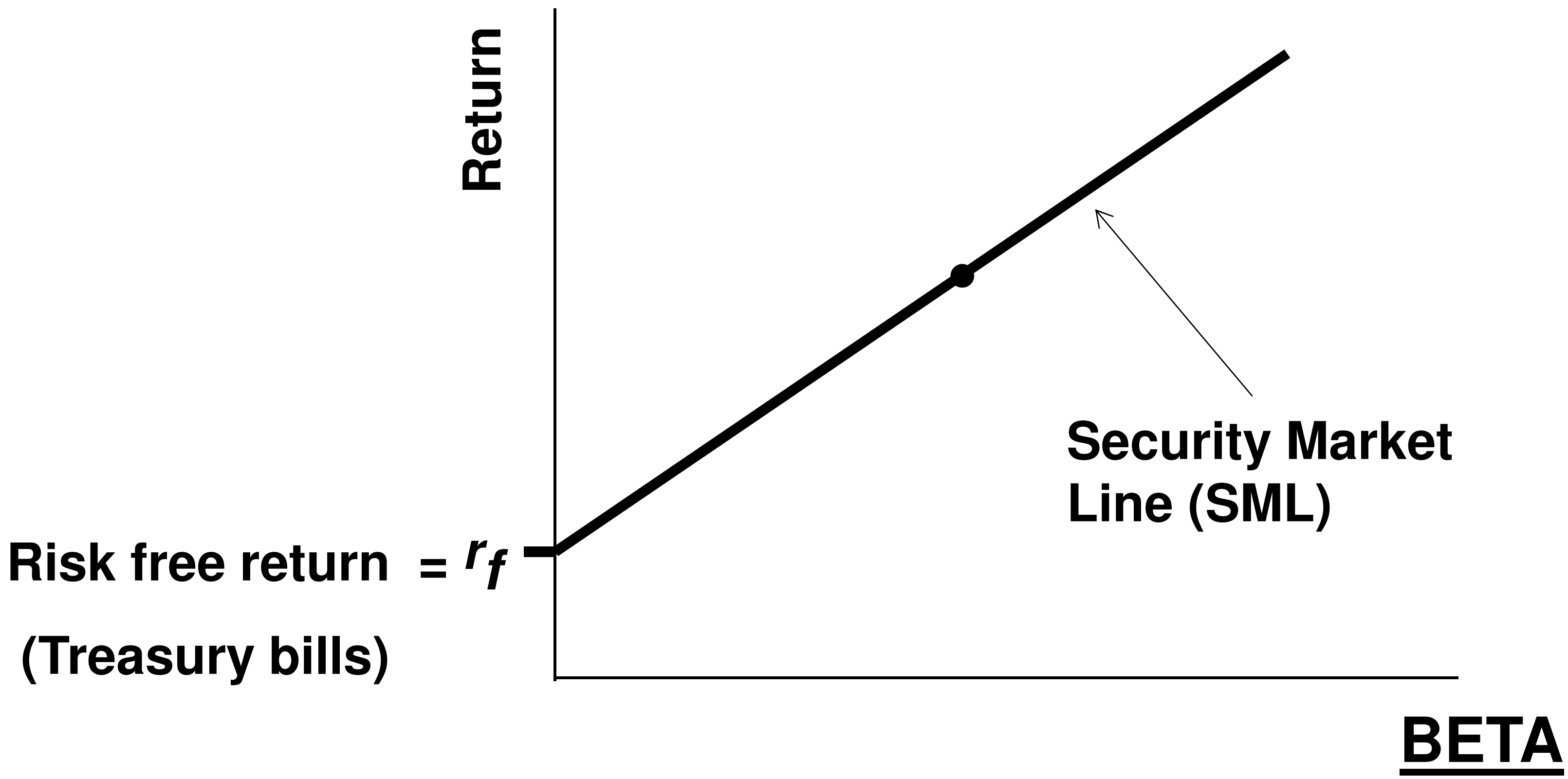

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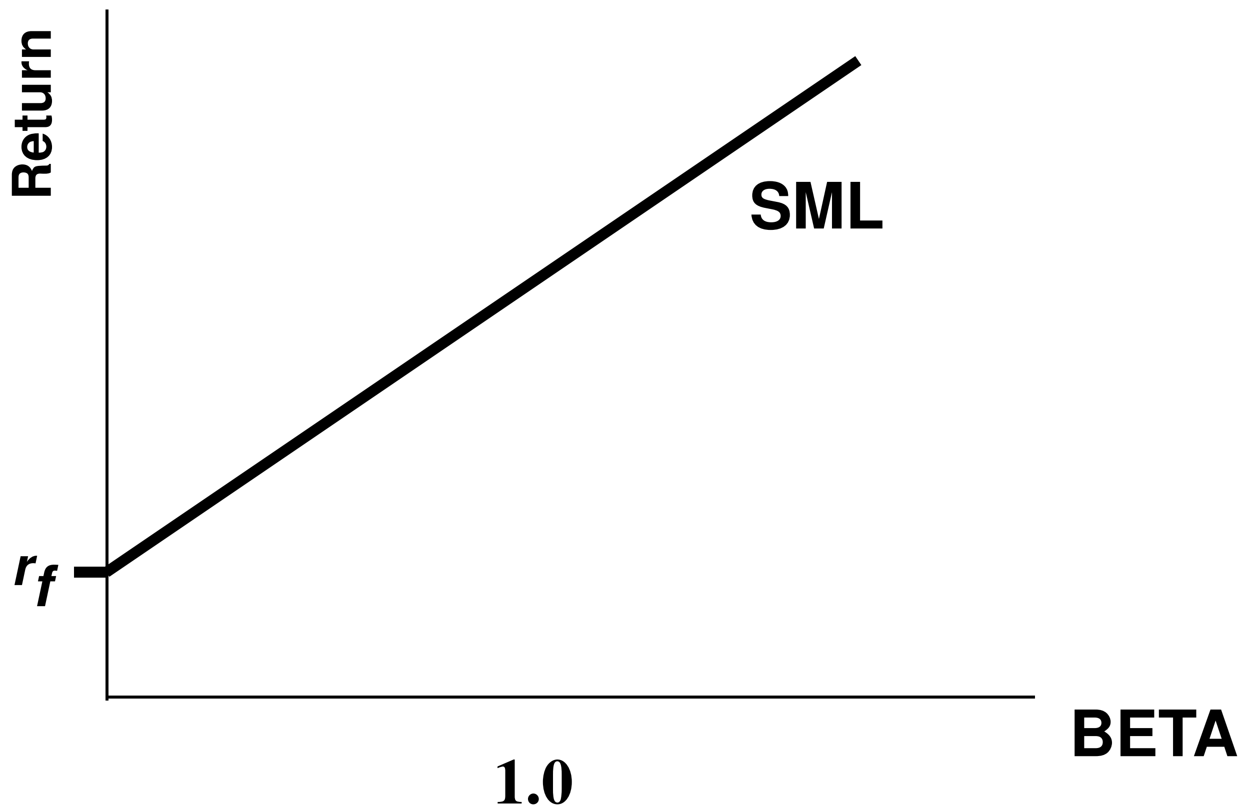


$$\text{SML Equation} = r_f + \beta(r_m - r_f)$$

Capital Asset Pricing Model

$$\boxed{r = r_f + \beta(r_m - r_f)}$$

CAPM

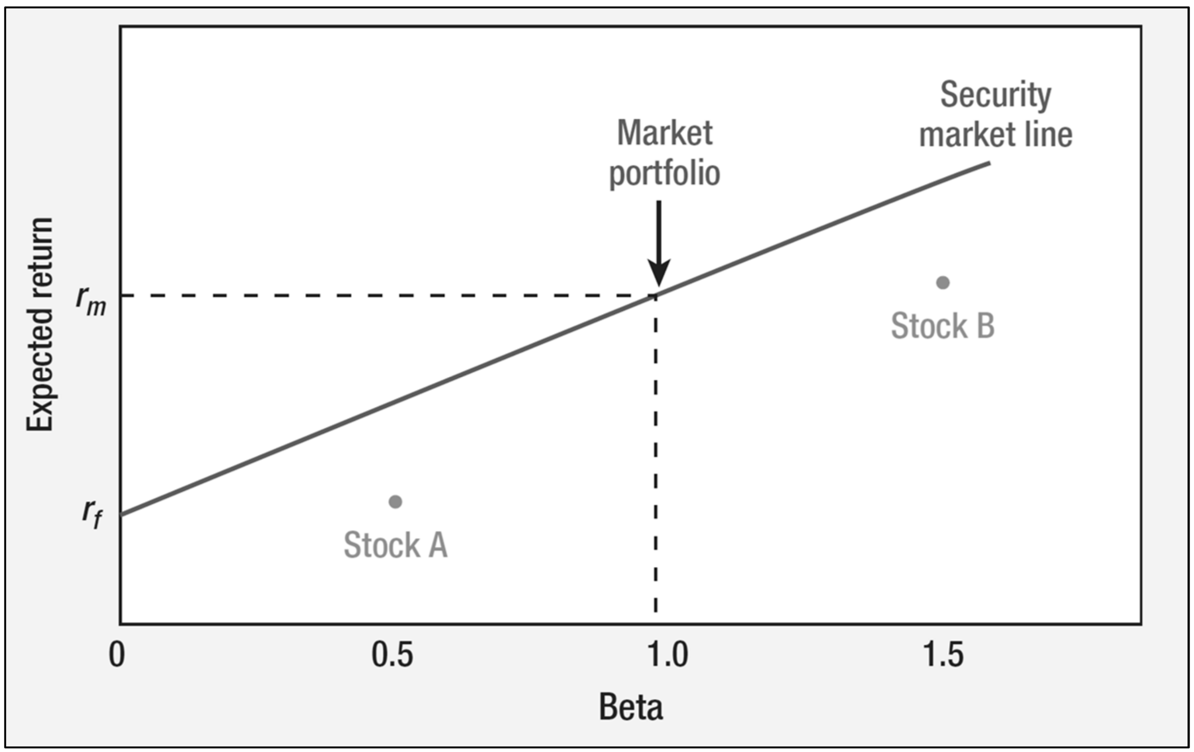
Expected Returns

These estimates of the returns expected by investors in November 2014 were based on the capital asset pricing model. We assumed 2% for the interest rate r_f and 7% for the expected risk premium $r_m - r_f$.

Stock	Beta (β)	Expected Return $r_f = \beta(r_m - r_f)$
Caterpillar	1.66	13.6
Dow Chemical	1.65	13.5
Ford	1.44	12.1
Microsoft	0.98	8.9
Apple	0.91	8.4
Johnson & Johnson	0.53	5.7
Walmart	0.45	5.2
Campbell Soup	0.39	4.7
Consolidated Edison	0.17	3.2
Newmont	0	2.0

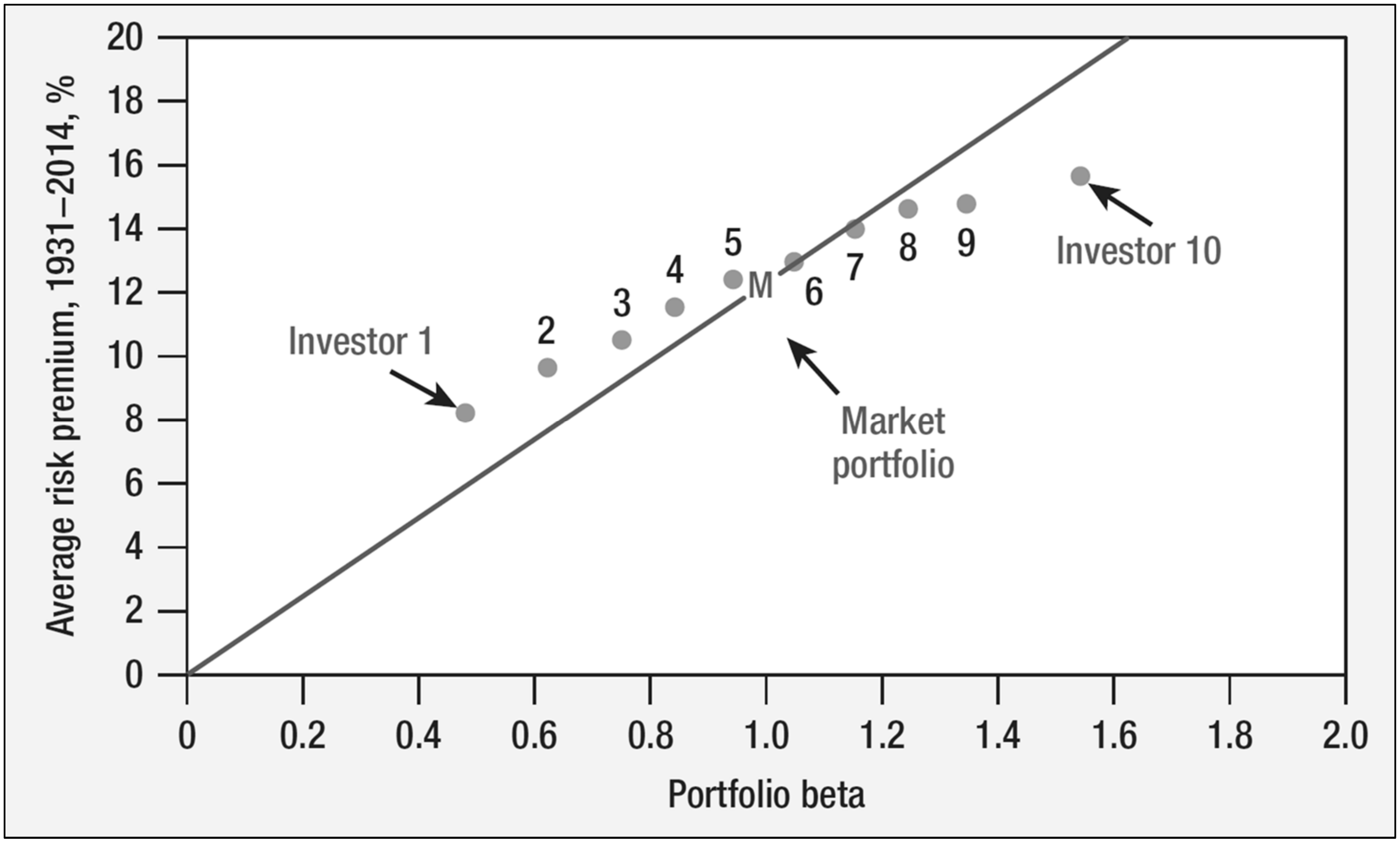
SML Equilibrium

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



Testing the CAPM

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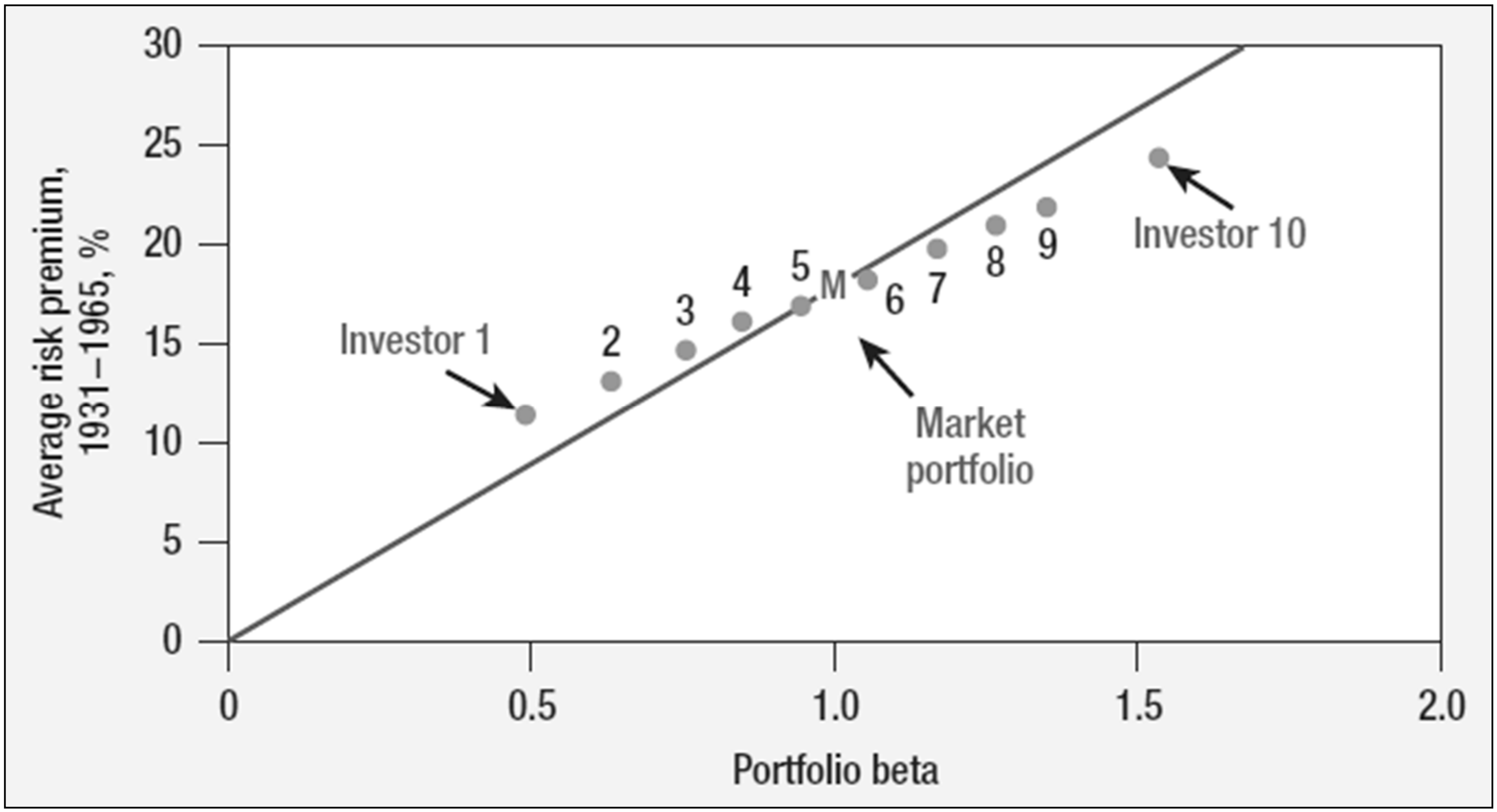
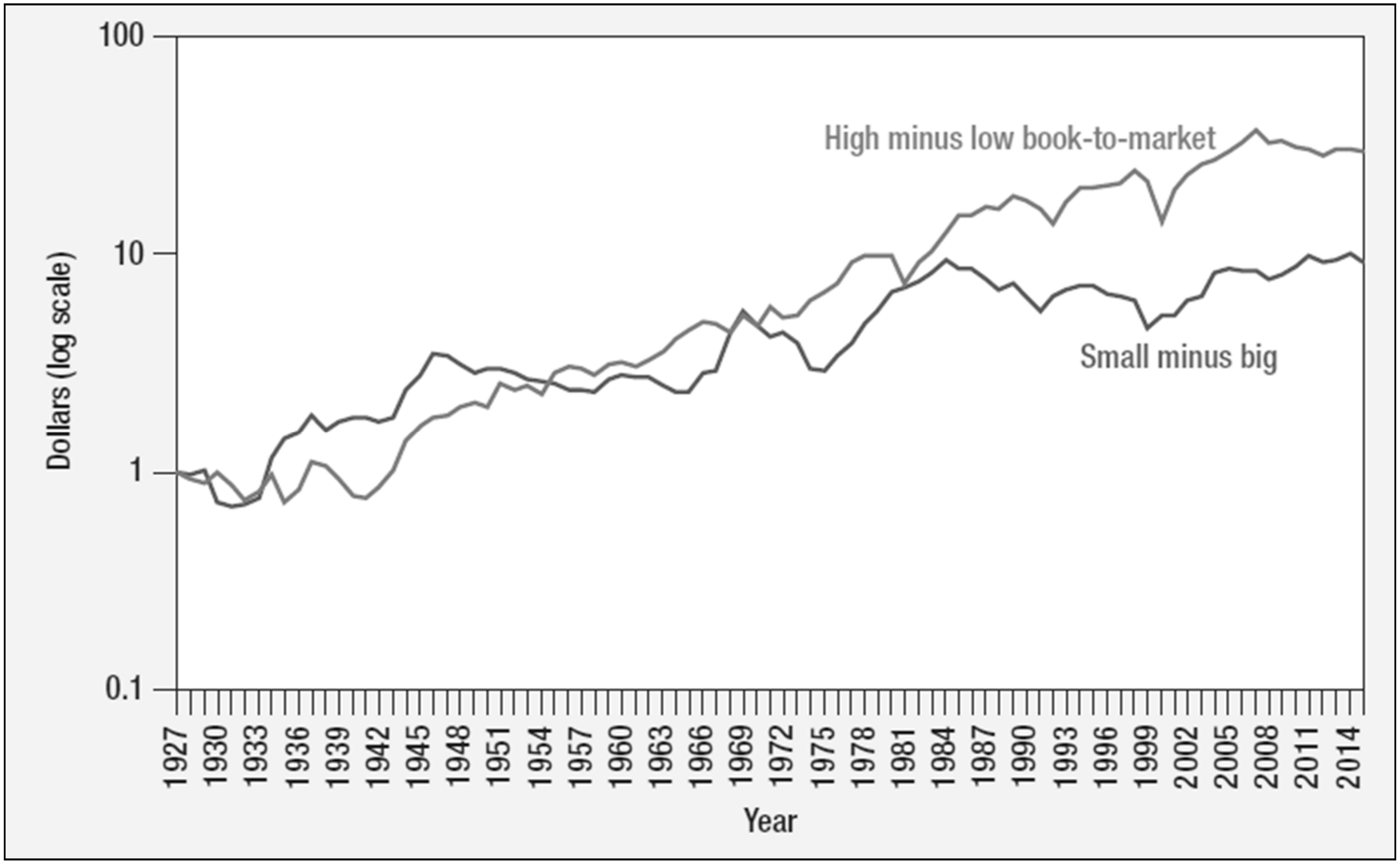


Testing the CAPM

Return vs. Book-to-Market



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

Arbitrage Pricing Theory

Alternative to CAPM

$$\boxed{\text{Return} = a + b_1(r_{\text{factor 1}}) + b_2(r_{\text{factor 2}}) + b_3(r_{\text{factor 3}}) + \ldots. + \text{noise}}$$

$$\begin{aligned}\text{Expected risk premium} &= r - r_f \\ &= b_1(r_{\text{factor 1}} - r_f) + b_2(r_{\text{factor 2}} - r_f) + \ldots\end{aligned}$$

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
Market	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 ($r_{\text{factor 1}} - r_{f,}$ etc.)
3. Measure the sensitivity of each stock to the factors (b_1, b_2, etc.)

Three Factor Model

	Three-Factor Model				CAPM
	Factor Sensitivities				
	b_{market}	b_{size}	$b_{book\text{-}to\text{-}market}$	Expected return[a]	Expected return[b]
Autos	1.37	0.62	–0.07	13.4%	12.7%
Banks	1.12	0.02	0.74	13.5	10.6
Chemicals	1.35	0.05	–0.19	10.7	11.3
Computers	1.17	–0.10	–0.33	8.3	9.7
Construction	1.13	0.82	0.57	15.5	12.1
Food	0.52	–0.15	0.00	5.1	5.4
Oil and gas	1.21	–0.20	0.02	9.9	10.1
Pharmaceuticals	0.77	–0.27	–0.31	5.0	4.9
Telecoms	0.87	–0.08	0.04	8.0	8.0
Utilities	0.48	–0.16	0.08	5.2	5.2