The CAPM

Class 11
Financial Management, 15.414

Today

The CAPM

- Measuring risk
- Systematic vs. diversifiable risk
- The trade-off between risk and return

Reading

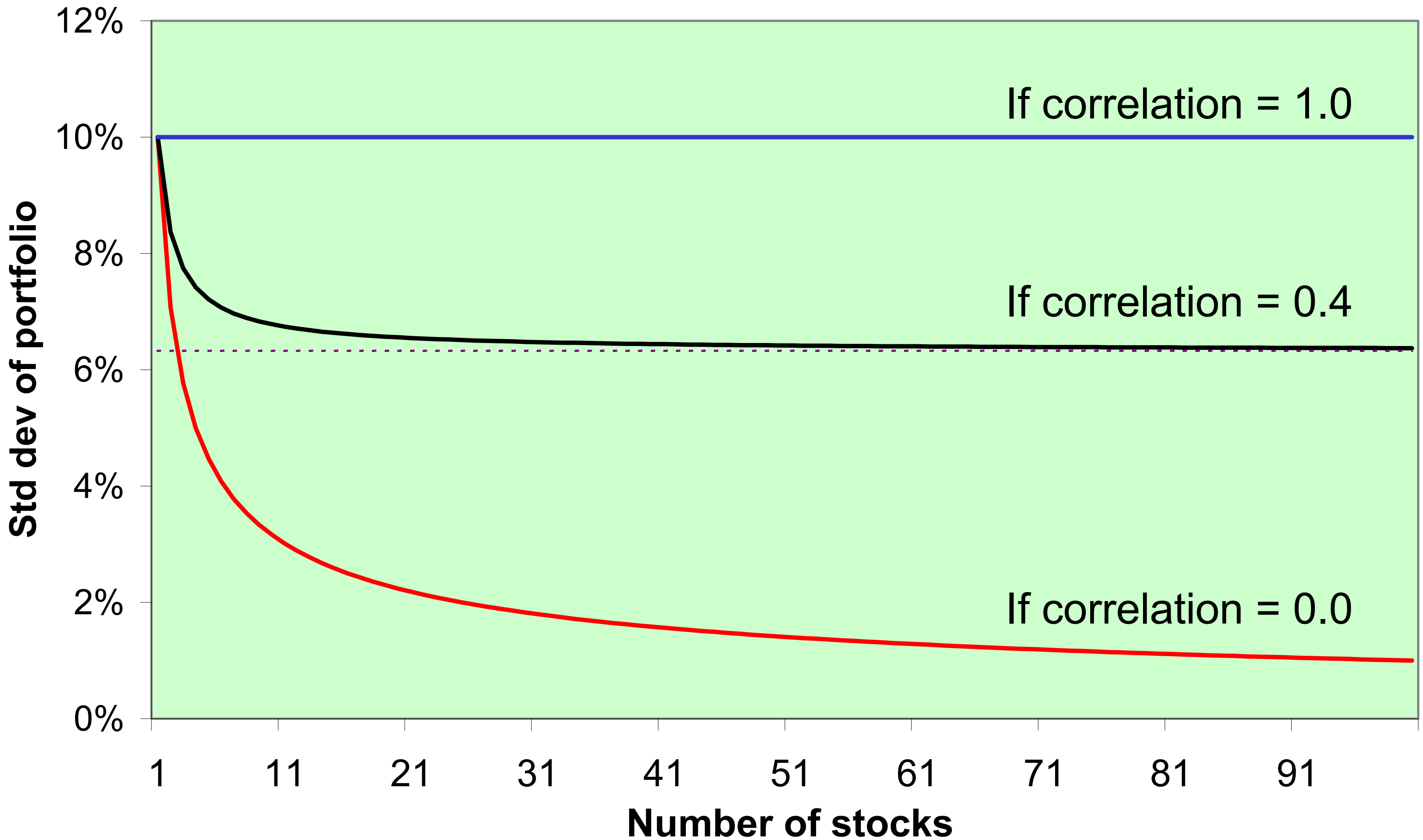
- Brealey and Myers, Chapter 8.2 – 8.5

Review

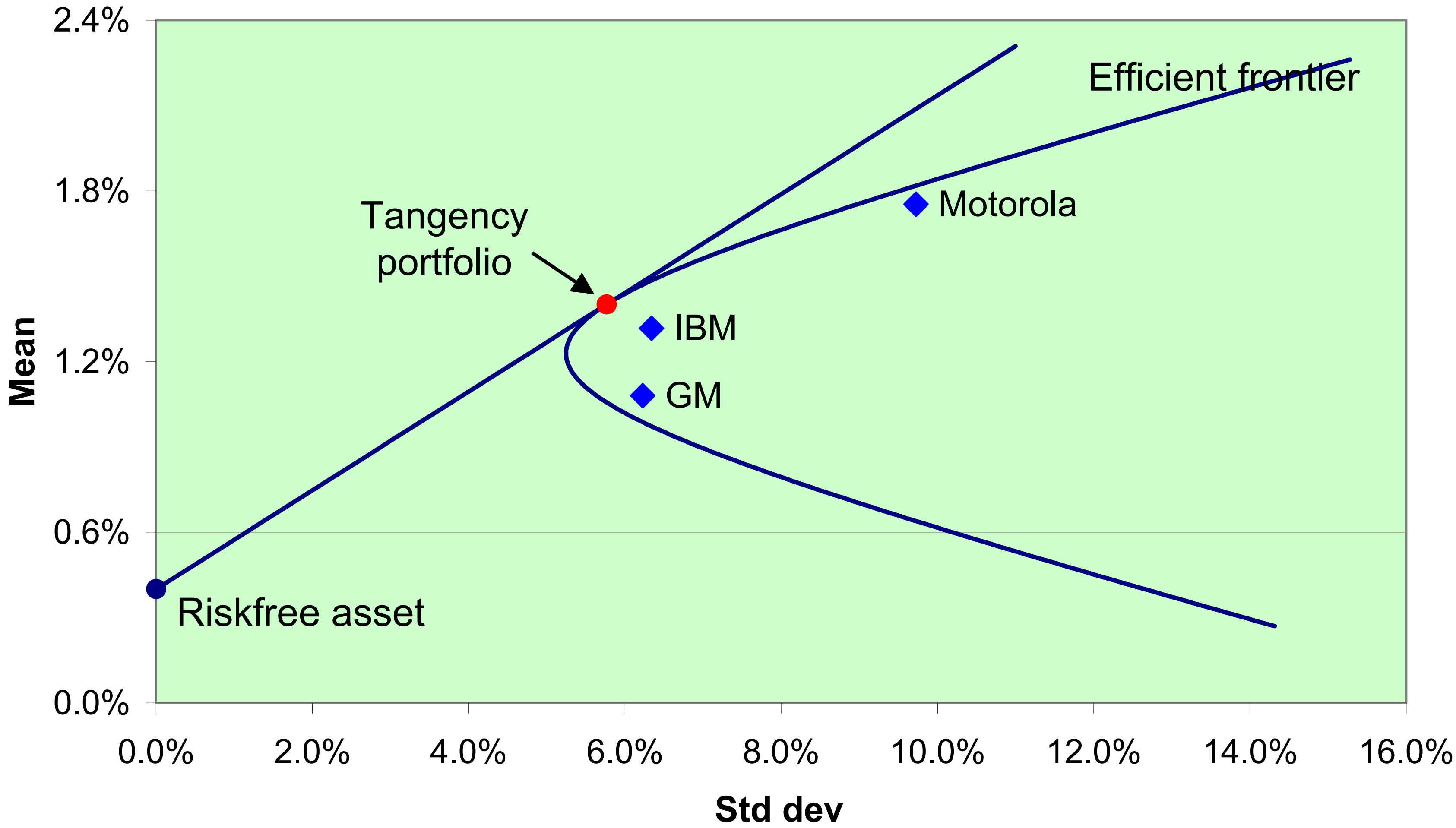
Diversification

- Diversification reduces risk, as long as stocks aren't perfectly correlated with each other.
- Portfolio variance depends primarily on the covariances among stocks, not the individual variances. Risk common to all firms cannot be diversified away.
- Investors should try to hold portfolios that maximize expected return for a given level of risk. The tangency portfolio is the best portfolio.

Diversification



Optimal portfolios



The CAPM

Capital Asset Pricing Model

- **Stock prices are affected by firm-specific and marketwide risks.** Investors care only about risk that is non-diversifiable.

- **A stock's non-diversifiable risk is measured by beta**, the slope when the stock is regressed on the market:

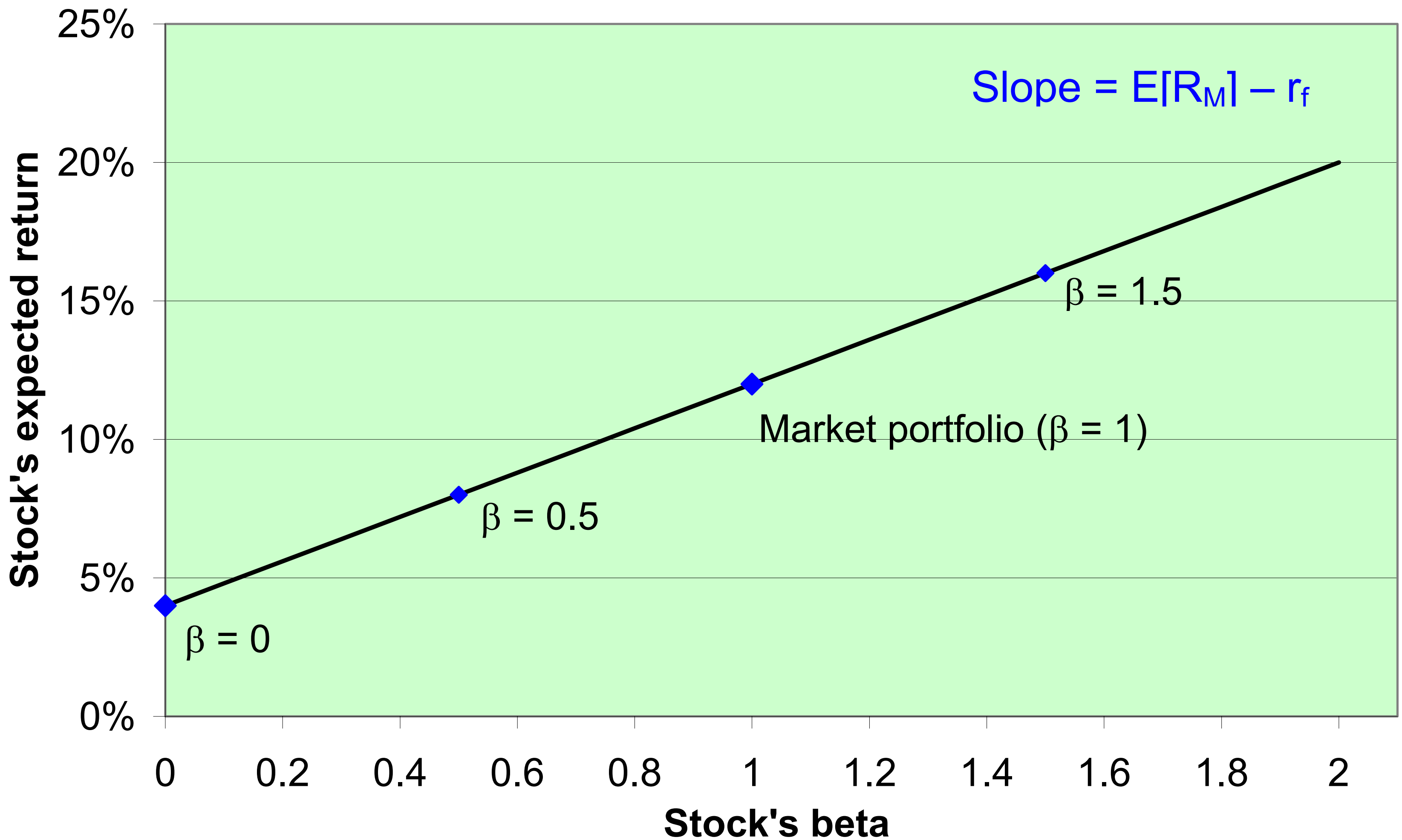
  $R_i = \alpha + \beta R_M + \varepsilon$

- **Expected, or required, returns are a linear function of betas:**

  $\mathbf{E[R_i] = r_f + \beta_i E[R_M - r_f]}$ Market risk premium

  For example, a stock with $\beta = 2$ is twice as risky as the market, so investors require twice the risk premium.

CAPM: Security Market Line



Beta

Regression slope

- **How sensitive is the stock to overall market movements?** How much does the stock go up or down when other stocks go up or down?

- $\mathbf{R_i = \alpha + \beta R_M + \varepsilon}$

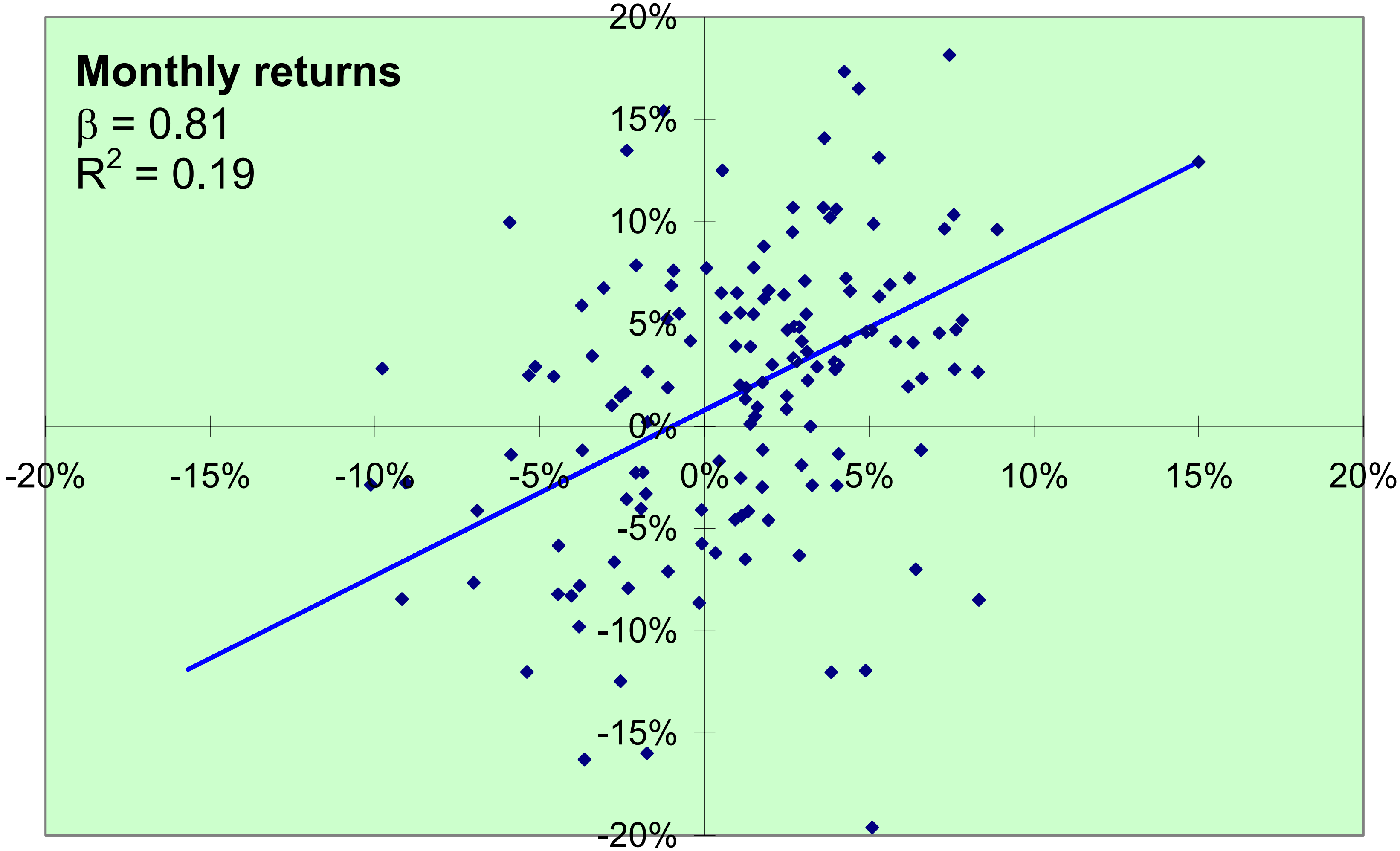
ε = firm-specific return
  (‘diversifiable,’ ‘idiosyncratic,’ or ‘unsystematic’ risk)

β = sensitivity to market returns
  (‘systematic,’ ‘non-diversifiable,’ or ‘macroeconomic’ risk)

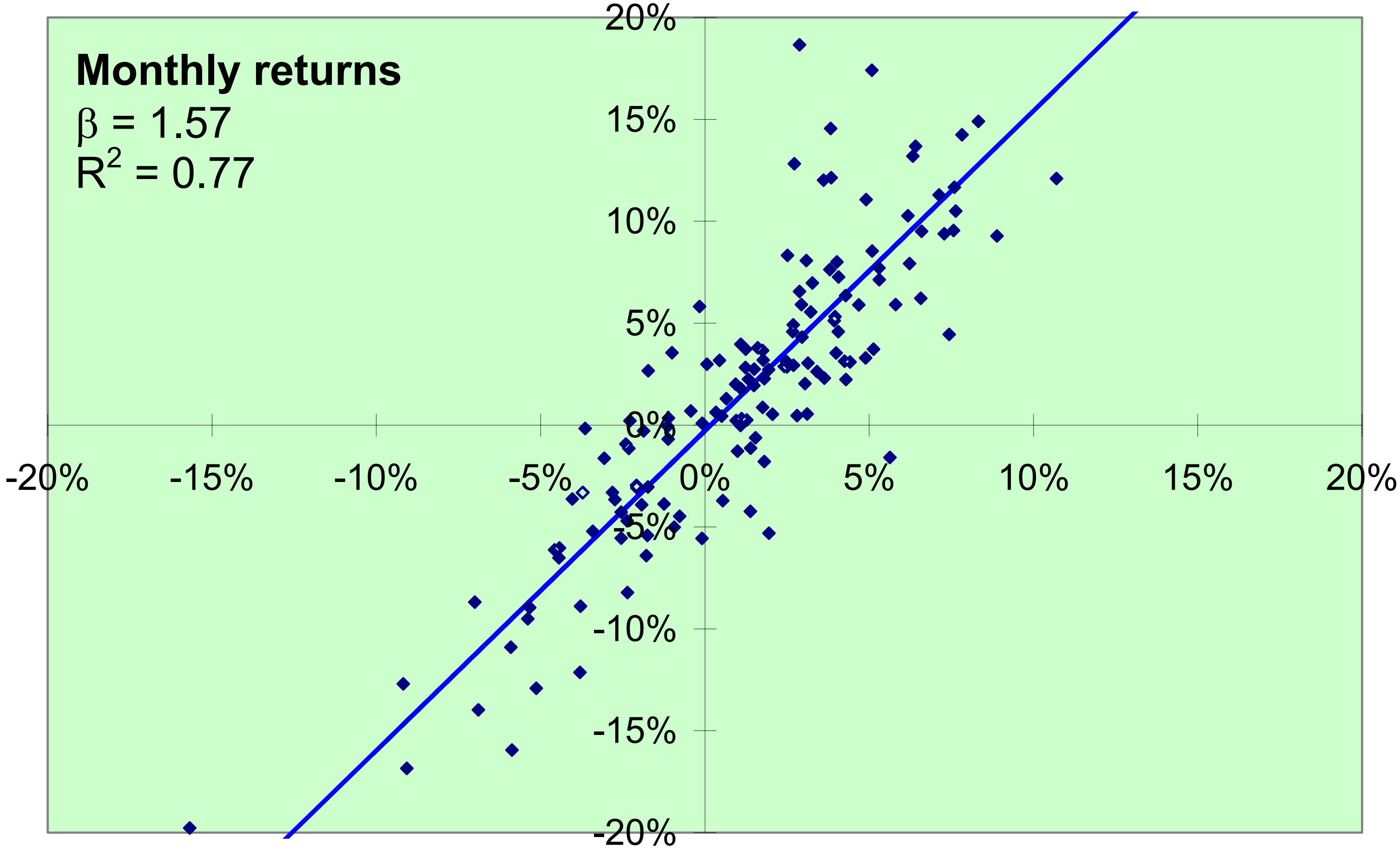
R^2 = explained variance
  (fraction of variance explained by market returns)

Regressions in Excel

Gillette vs. Total U.S. market return



NASDAQ vs. Total U.S. market return



Betas, 1960 – 2001

Size-sorted portfolios

1960 – 1979			1980 – 2001		
Decile	β	R^2	Decile	β	R^2
Smallest	1.58	0.60	Smallest	1.27	0.49
2	1.45	0.76	2	1.25	0.72
3	1.45	0.81	3	1.26	0.75
4	1.36	0.84	4	1.22	0.79
5	1.32	0.86	5	1.18	0.80
6	1.27	0.90	6	1.13	0.85
7	1.22	0.92	7	1.09	0.89
8	1.16	0.95	8	1.04	0.91
9	1.05	0.96	9	1.02	0.95
Largest	0.92	0.97	Largest	0.96	0.97

CAPM

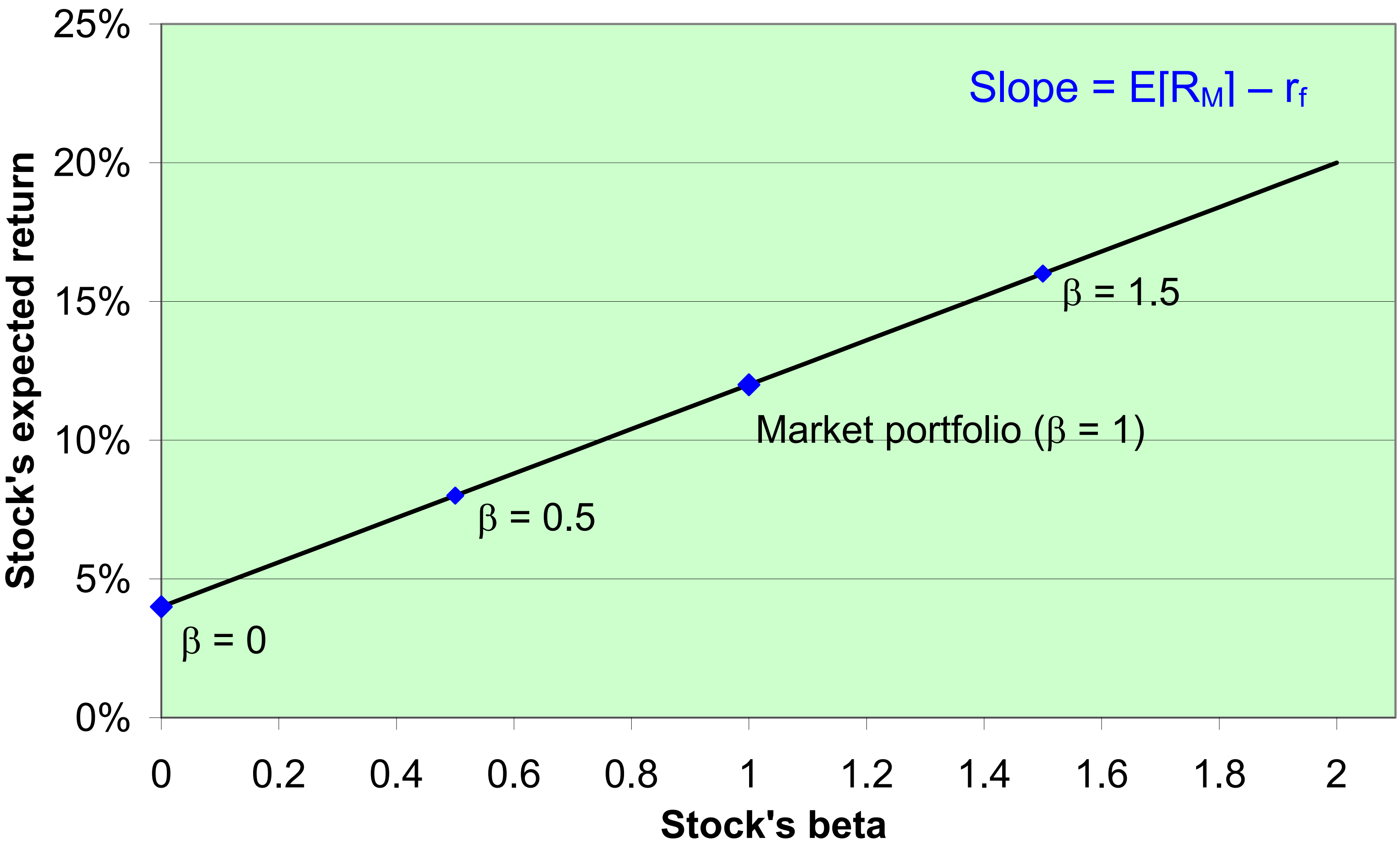
Key insight

For a diversified investor, beta measures a stock's contribution to portfolio risk. Beta, not variance, is the appropriate measure of risk.

The required return on a stock equals:

$$\mathbf{E[R_i] = r_f + \beta_i\, E[R_M - r_f]}$$

Security Market Line



Example 1

Using monthly returns from 1990 – 2001, you estimate that Microsoft has a beta of 1.49 (std err = 0.18) and Gillette has a beta of 0.81 (std err = 0.14). If these estimates are a reliable guide for their risks going forward, what rate of return is required for an investment in each stock?

- **$E[R_i] = r_f + \beta_i \, E[R_M - r_f]$**

  Tbill rate = 1.0%; market risk premium is around 4 – 6%.

- **Expected returns**

  Gillette: $E[R_{GS}] = 0.01 + (0.81 \times 0.06) = 5.86\%$

  Microsoft: $E[R_{MSFT}] = 0.01 + (1.49 \times 0.06) = 9.94\%$

Example 2

Over the past 40 years, the smallest decile of firms had an average monthly return of 1.33% and a beta of 1.40. The largest decile of firms had an average return of 0.90% and a beta of 0.94. Over the same time period, the riskfree rate averaged 0.43% and the market risk premium was 0.49%. Are the average returns consistent with the CAPM?

- **$E[R_i] = r_f + \beta_i E[R_M - r_f]$**

  Tbill rate = 0.43%; market risk premium is 0.49%.

- **How far are average returns from the CAPM security market line?**

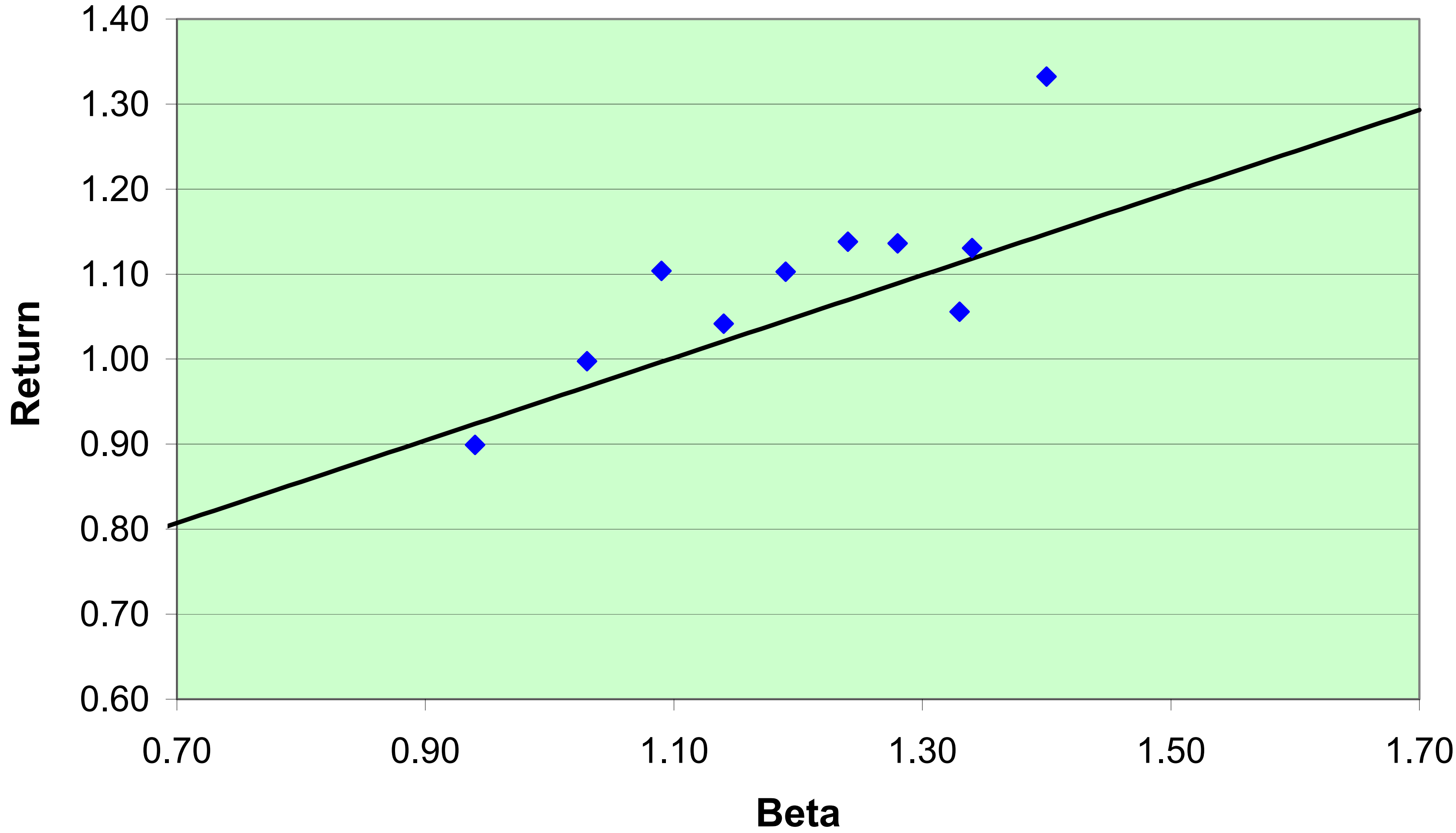
Size portfolios, 1960 – 2001

Average returns vs. CAPM

Decile	Avg return	CAPM β	$r_f + \beta_i E[R_M - r_f]$	Difference
Smallest	1.33	1.40	1.15	0.19
2	1.06	1.33	1.11	-0.06
3	1.13	1.34	1.12	0.01
4	1.14	1.28	1.09	0.05
5	1.14	1.24	1.07	0.07
6	1.10	1.19	1.04	0.06
7	1.04	1.14	1.02	0.02
8	1.10	1.09	0.99	0.11
9	1.00	1.03	0.97	0.03
Largest	0.90	0.94	0.93	-0.03

Difference = Avg. return – CAPM prediction

Size portfolios, 1960 – 2001



Example 3

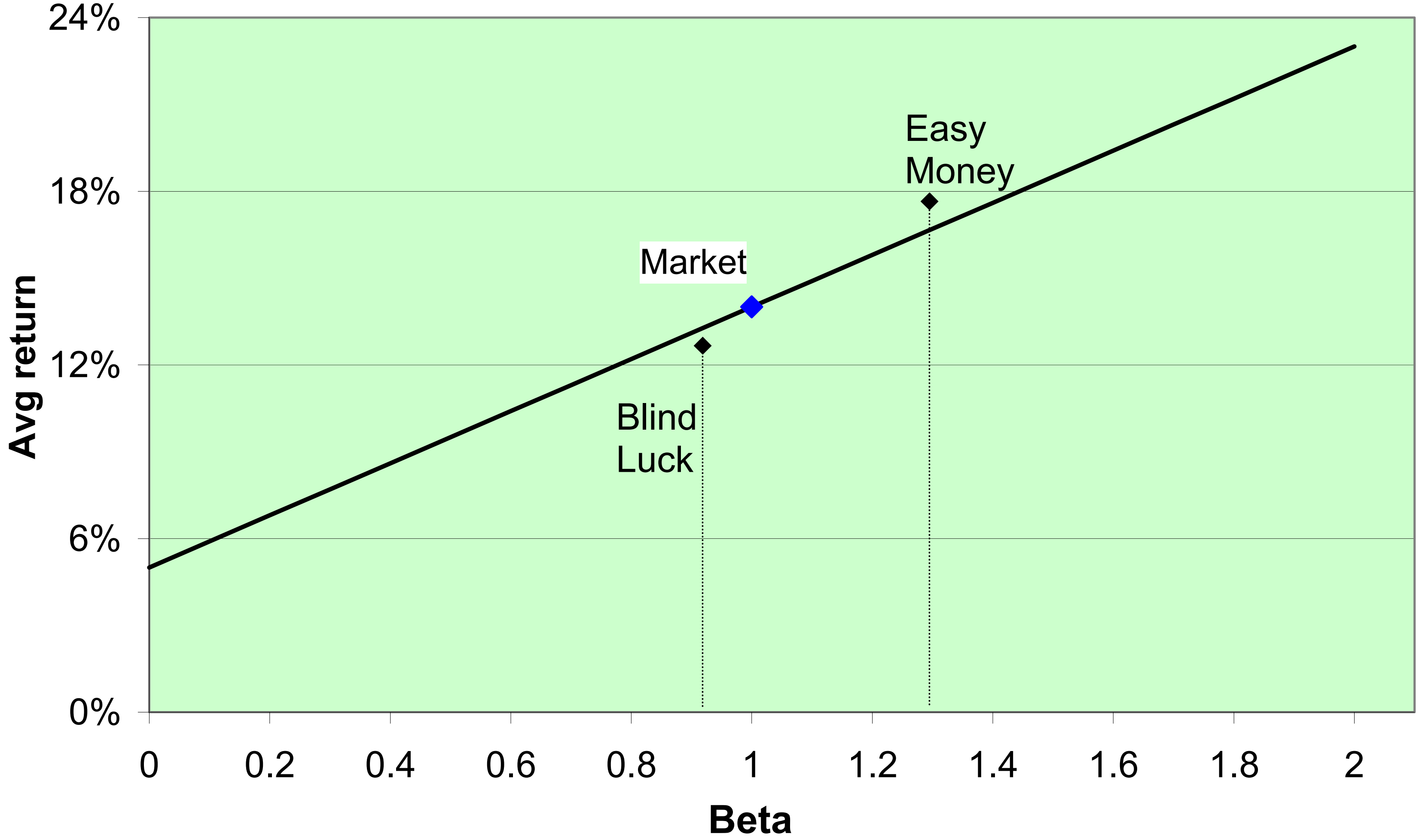
You are choosing between two mutual funds. Over the past 10 years, BlindLuck Value Fund had an average return of 12.8% and a β of 0.9. EasyMoney Growth Fund had a return of 17.9% and a β of 1.3. The market's average return over the same period was 14% and the Tbill rate was 5%.

Which fund is better?

Portfolio	Avg return	β	CAPM $r_f + \beta_i E[R_M - r_f]$	Dif
Market	14.0%	1.0		
BlindLuck	12.8	0.9	13.1	-0.30
EasyMoney	17.9	1.3	16.7	1.20

['Dif' is referred to as the fund's 'alpha']

Example 3


24%
18%
12%
6%
0%
Avg return
Easy
Money
Market
Blind
Luck
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Beta

CAPM

Applications

- **Measures and quantifies 'risk'**
  One stock or project is riskier than another stock or project if it has a higher β.

- **Valuation**
  The CAPM provides a way to estimate the firm's cost of capital (risk-adjusted discount rate).*

- **Evaluating a stock or mutual fund's risk-adjusted performance**
  The CAPM provides a benchmark.

* Graham and Harvey (2000) survey CFOs; 74% of firms use the CAPM to estimate the cost of capital.

Observation 1

Portfolios

A portfolio's beta is a weighted average of the betas of the individual stocks.

Stocks 1, …, N

Portfolio return: $R_P = w_1 R_1 + w_2 R_2 + \ldots + w_N R_N$

Individual stocks

$$\left.\begin{aligned} R_1 &= \alpha_1 + \beta_1 R_M + \varepsilon_1 \\ R_2 &= \alpha_2 + \beta_2 R_M + \varepsilon_2 \\ &\vdots \\ R_N &= \alpha_N + \beta_N R_M + \varepsilon_N \end{aligned}\right\}$$

Portfolio

$$R_P = \alpha_P + \beta_P R_M + \varepsilon_P$$

avg of $\beta_1, \ldots, \beta_N$

What happens to the residual variance when more stocks are added?

Observation 1

Example

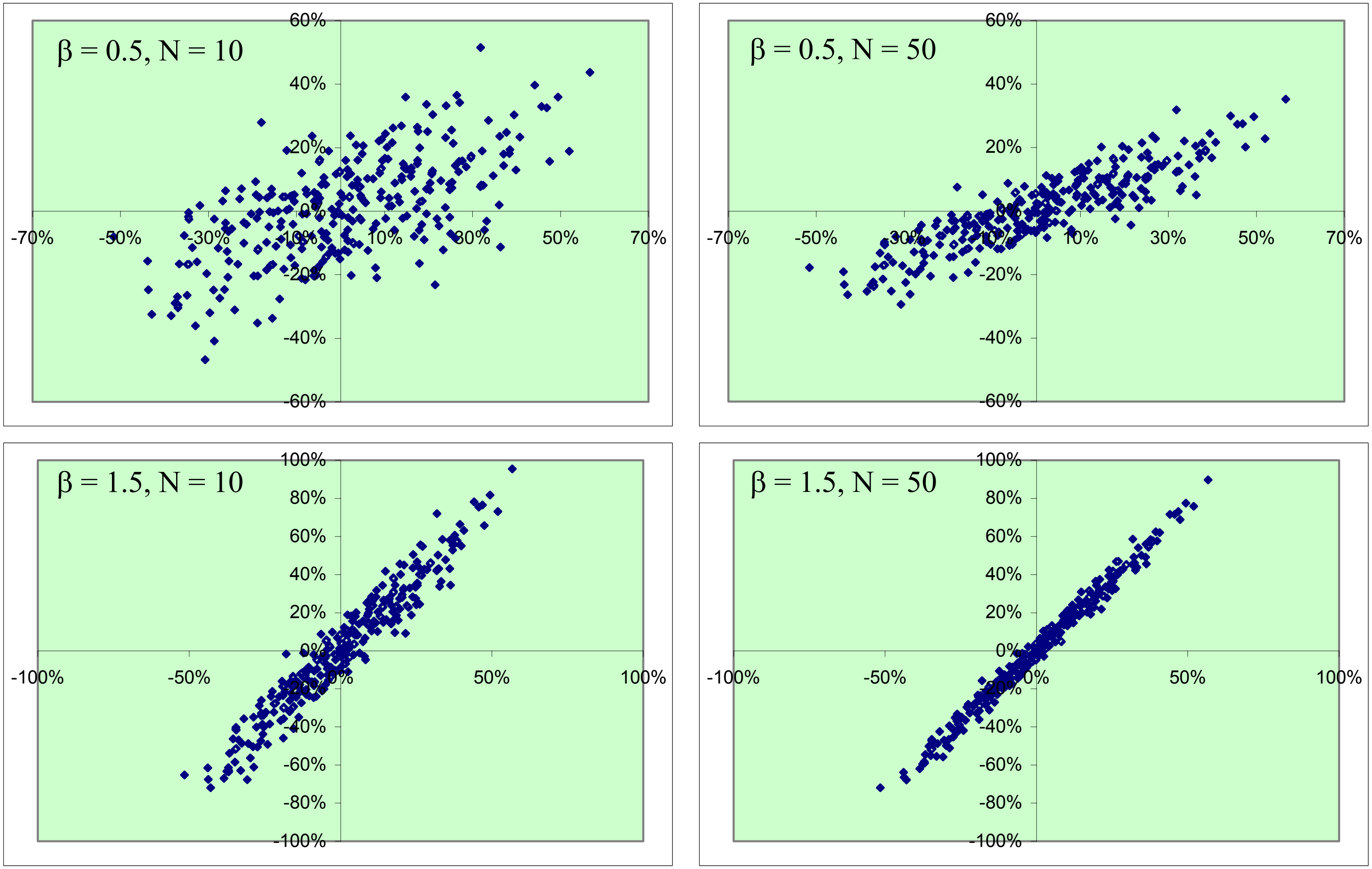
Two groups of stocks

Group 1: $\beta = 0.5$
Group 2: $\beta = 1.5$

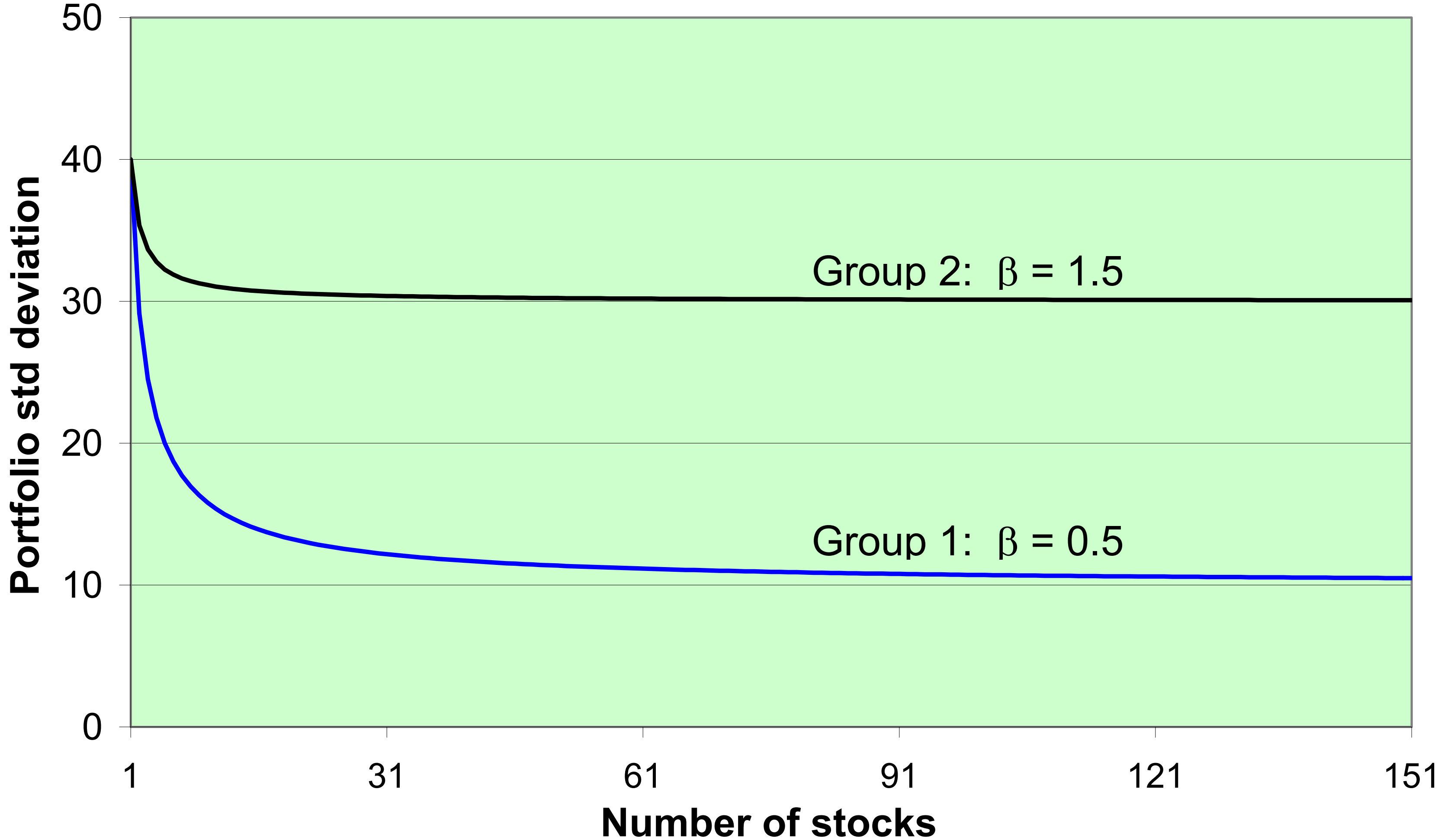
All stocks have a standard deviation of 40%. The market portfolio has standard deviation of 20%.

How does portfolio beta and residual risk change as the portfolio gets more and more stocks?

Hypothetical portfolios vs. market portfolio



Diversification



Observation 2

Total variance vs. beta risk

Two assets can have the same total variance, but much different β's. Investors should care only about systematic, beta, risk.

$$var(R_i) = \beta^2 \, var(R_M) + var(\varepsilon_i)$$

Which stock is riskier?

Stock 1: $std(R_1) = 0.40$, $\beta = 0.5$

Stock 2: $std(R_2) = 0.40$, $\beta = 1.5$

Observation 3

Assets can have negative risk!

A stock's β is less than 0 if the stock is negatively correlated with the market portfolio.
If the market goes down, it goes up.

Such a stock contributes negatively to portfolio risk.
The stock is better than riskfree!

Examples
Various derivative securities; return from a short sale of stock

Observation 4

Tangency portfolio

The CAPM implies that the market portfolio should be the tangency portfolio.
The market portfolio will have the highest risk-return trade-off (or Sharpe ratio) of any possible portfolio.

You cannot gain by stock-picking.
Competition among investors ensures that stock prices are efficient; the only way to earn a higher rate of return is to take more risk.

Portfolio advice
Buy an index fund (like Vangaurd 500)