Intermediate Financial Management 13th edition Brigham Solutions Manual

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Chapter 2
Risk and Return: Part I
ANSWERS TO BEGINNING-OF-CHAPTER QUESTIONS

Our students have had an introductory finance course, and many have also taken a course on investments and/or capital markets. Therefore, they have seen the Chapter 2 material previously. However, we use the Beginning of Chapter (BOC) questions to review the chapter because our students need a refresher.

With students who have not had as much background, it is best to go through the chapter on a point-by-point basis, using the PowerPoint slides. With our students, this would involve repeating too much of the intro course. Therefore, we just discuss the questions, including the model for Question 6. Before the class, we tell our students that the chapter is a review and that we will call on them to discuss the BOC questions in class. We expect students to be able to give short, incomplete answers that demonstrate that they have read the chapter, and then we provide more complete answers as necessary to make sure the key points are covered.

Our students have mainly taken multiple-choice exams, so they are uncomfortable with essay tests. Also, we cover the chapters they were exposed to in the intro course rather quickly, so our assignments often cover a lot of pages. We explain that much of the material is a review, and that if they can answer the BOC questions (after the class discussion) they will do OK on the exams. We also tell them, partly for motivation and partly to reduce anxiety, that our exams will consist of 5 slightly modified BOC questions, of which they must answer 3. We also tell them that they can use a 4-page "cheat sheet," two sheets of paper, front and back. They can put anything they want on it—formulas, definitions, outlines of answers to the questions, or complete answers.

The better students write out answers to the questions before class, and then extend them after class and before the exams. This helps them focus and get better prepared. Writing out answers is a good way to study, and outlining answers to fit them on the cheat sheet (in really small font!) also helps them learn. We try to get students to think in an integrated manner, relating topics covered in different chapters to one another. Studying all of the BOC questions in a fairly compressed period before the exams helps in this regard. They tell us that they learn a great deal when preparing their cheat sheets.

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We initially expected really excellent exams, given that the students had the questions and could use cheat sheets. Some of the exams were indeed excellent, but we were surprised and disappointed at the poor quality of many of the midterm exams. Part of the problem is that our students were not used to taking essay exams. Also, they would have done better if they had taken the exam after we covered cases (in the second half of the semester), where we apply the text material to real-world cases. While both points are true, it's also true that some students are just better than others.

The students who received low exam grades often asked us what they did wrong. That's often a hard question to answer regarding an essay exam. What we ended up doing was make copies of the best 2 or 3 student answers to each exam question, and then when students came in to see why they did badly, we made them read the good answers before we talked with them. 95% of the time, they told us they understand why their grade was low, and they resolved to do better next time. Finally, since our students are all graduating seniors, we graded rather easily.

Answers

2-1 Stand-alone risk is the risk faced by an investor who holds just one asset, versus the risk inherent in a diversified portfolio.

Stand-alone risk is measured by the standard deviation (SD) of expected returns or the coefficient of variation (CV) of returns = SD/expected return.

A portfolio's risk is measured by the SD of its returns, and the risk of the individual stocks in the portfolio is measured by their beta coefficients. Note that unless returns on all stocks in a portfolio are perfectly positively correlated, the portfolio's SD will be less than the average of the SD's of the individual stocks. Diversification reduces risk.

In theory, investors should be concerned only with portfolio risk, but in practice many investors are not well diversified, hence are concerned with stand-alone risk. Managers or other employees who have large stockholdings in their companies are an example. They get stock (or options) as incentive compensation or else because they founded the company, and they are often constrained from selling to diversify. Note too that years ago brokerage costs and administrative hassle kept people from diversifying, but today mutual funds enable small investors to diversify efficiently. Also, the Enron and WorldCom debacles and their devastating effects on 401k plans heavily in those stocks illustrated the importance of diversification.

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2-2 Diversification can eliminate unsystematic risk, but market risk will remain. See Figure 2-6 for a picture of what happens as stocks are added to a portfolio. The graph shows that the risk of the portfolio as measured by its SD declines as more and more stocks are added. This is the situation if randomly selected stocks are added, but if stocks in the same industry are added, the benefits of diversification will be lessened.

Conventional wisdom says that 40 to 50 stocks from a number of different industries is sufficient to eliminate most unsystematic risk. Of course, the more stocks, the closer the portfolio will be to having zero unsystematic risk. Again, this assumes that stocks are randomly selected. Note, however, that the more stocks the portfolio contains, the greater the administrative costs. Mutual funds can help here.

Different diversified portfolios can have different amounts of risk. First, if the portfolio concentrates on a given industry or sector (as sector mutual funds do), then the portfolio will not be well diversified even if it contains 100 stocks. Second, the betas of the individual stocks affect the risk of the portfolio. If the stock with the highest beta in each industry is selected, then the portfolio may not have much unsystematic risk, but it will have a high beta and thus have a lot of market risk. **(Note: The market risk of a portfolio is measured by the beta of the portfolio, and that beta is a weighted average of the betas of the stocks in the portfolio.)**

2-3 a. Note: This question is covered in more detail in Chapter 8, but students should remember this material from their first finance course, so it is a review.

Expected: The rate of return someone expects to earn on a stock. It's typically measured as $D_1/P_0 + g$ for a constant growth stock.

Required: The minimum rate of return that an investor must expect on a stock to induce him or her to buy or hold the stock. It's typically measured as $r_s = r_{rf} + b(MRP)$, where MRP is the market risk premium or the risk premium required for an average stock.

Historical: The average rate of return earned on a stock during some past period. The historical return on an average large stock varied has varied widely during the last 20 years and of course, the bottom fell out of the market with the Global Economic Crisis in 2008 and 2009! Historical stock returns are highly variable!

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b. Are the 3 types of return equal? 1) Expected = required?. The answer is, "maybe." For the market to be in equilibrium, the expected and required rate of return as seen by "the marginal investor" must be equal for any given stock and therefore for the entire market. If the expected return exceeded the required return, then investors would buy, pushing the price up and the expected return down, and thus produce an equilibrium. Note, though, that any individual investor may believe that a given stock's expected and required returns differ, so individuals may think there are bargains to be bought or dogs to be sold. Also, new information is constantly hitting the market and changing the opinions of marginal investors, and this leads to swings in the market. New technology is causing new information to be disseminated ever more rapidly, and that is leading to more rapid and violent market swings.

2) Historical = expected and/or required? There is no reason whatever to think that the historical rate of return for any given year for either one stock or for all stocks on average will be equal to the expected and/or required rate of return. Rational people don't expect abnormally good or bad performance to continue. On the other hand, people do argue that investors expect to earn returns in the future that approximate average past returns. For example, if stocks returned 9% on average in the past (from 1926 to 2018, which is as far back as good data exist), then they may expect to earn about 9% on stocks in the future. Note, though, that this is a controversial issue—the period 1926-2018 covers a lot of very different economic environments, and investors may not expect the future to replicate the past. Certainly investors didn't expect future returns to equal distant past returns during the height of the 1999 bull market or to lose money as they did in 2008.

2-4 To be **risk averse** means to dislike risk. Most investors are risk averse. Therefore, if Securities A and B both have an expected return of say 10%, but Security A has less risk than B, then most investors will prefer A. As a result, A's price will be bid up, and B's price bid down, and in the resulting equilibrium A's expected rate of return will be below that of B. Of course, A's required rate of return will also be less than B's, and in equilibrium the expected and required returns will be equal.

One issue here is the type of risk investors are averse to—unsystematic, market, or both? According to CAPM theory, only market risk as measured by beta is relevant and thus only market risk requires a premium. However, empirical tests indicate that investors also require a premium for bearing unsystematic risk as measured by the stock's SD.

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2-5 CAPM = Capital Asset Pricing Model. The CAPM establishes a metric for measuring the market risk of a stock (beta), and it specifies the relationship between risk as measured by beta and the required rate of return on a stock. Its principal developers (Sharpe and Markowitz) won the Nobel Prize in 1990 for their work.

The key assumptions are spelled out in Chapter 3, but they include the following: (1) all investors focus on a single holding period, (2) investors can lend or borrow unlimited amounts at the risk-free rate, (3) there are no brokerage costs, and (4) there are no taxes. The assumptions are not realistic, so the CAPM may be incorrect. Empirical tests have neither confirmed nor refuted the CAPM with any degree of confidence, so it may or may not provide a valid formula for measuring the required rate of return.

The SML, or Security Market Line, specifies the relationship between risk as measured by beta and the required rate of return, $r_s = r_{rf} + b(MRP)$. MRP = Expected rate of return on the market – Risk-free rate = $r_m - r_{fr}$.

The data requirements are beta, the risk-free rate, and the rate of return expected on the market. Betas are easy to get (by calculating them or from some source such as Value Line or Yahoo!, but a beta shows how volatile a stock was in the past, not how volatile it will be in the future. Therefore, historical betas may not reflect investors' perceptions about a stock's future risk, which is what's relevant. The risk-free rate is based on either T-bonds or T-bills; these rates are easy to get, but it is not clear which should be used, and there can be a big difference between bill and bond rates, depending on the shape of the yield curve. Finally, it is difficult to determine the rate of return investors expect on an average stock. Some argue that investors expect to earn the same average return in the future that they earned in the past, hence use historical MRPs, but as noted above, that may not reflect investors' true expectations.

The bottom line is that we cannot be sure that the CAPM-derived estimate of the required rate of return is actually correct.

2-6 a. Given historical returns on X, Y, and the Market, we could calculate betas for X and Y. Then, given r_{rf} and the MRP, we could use the SML equation to calculate X and Y's required rates of return. We could then compare these required returns with the given expected returns to determine if X and Y are bargains, bad deals, or in equilibrium.

We assumed a set of data and then used an Excel model to calculate betas for X and Y, and the SML required returns for these stocks. Note that in our Excel model (ch02-M) we also show, for the market, how to calculate the total return based on stock price changes plus dividends. $b_x = 0.69$; $b_y = 1.66$ and $r_x = 10.7\%$; $r_y = 14.6\%$. Since Y has the higher beta, it has the higher required return.

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In our examples, the returns all fall on the trend line. Thus, the two stocks have essentially no diversifiable, unsystematic risk—all of their risk is market risk. If these were real companies, they might have the indicated trend lines and betas, but the points would be scattered about the trend line. See Figure 3-8 in Chapter 3, where data for General Electric are plotted. Although the situation for our Stocks X and Y would never occur for individual stocks, it would occur (approximately) for index funds, if Stock X were an index fund that held stocks with betas that averaged 0.69 and Stock Y were an index fund with b = 1.66 stocks.

b. Here we drop Year 1 and add Year 6, then calculate new betas and r's. For Stock X, the beta and required return would be reasonably stable. However, Y's beta would fall, given its sharp decline in a year when the market rose. In our Excel model, Y's beta falls from 1.66 to 0.19, and its required return as calculated with the SML falls to 8.8%.

The results for Y make little sense. The stock fell sharply because investors became worried about its future prospects, which means that it fell **because it became riskier**. Yet its beta fell. As a riskier stock, its required return should rise, yet the calculated return fell from 14.6% to 8.8%, which is only a little above the riskless rate.

The problem is that Y's low return tilted the regression line down—the point for Year 6 is in the lower right quadrant of the Excel graph. The low R^2 and the large standard error as seen in the Excel regression make it clear that the beta, and thus the calculated required return, are not to be trusted.

Note that in April 2001, the same month that PG&E declared bankruptcy, its beta as reported by Finance.Yahoo was only 0.05, so our hypothetical Stock Y did what the real PG&E actually did. The moral of the story is that the CAPM, like other cost of capital estimating techniques, can be dangerous if used without care and judgment.

One final point on all this: The utilities are regulated, and regulators estimate their cost of capital and use it as a basis for setting electric rates. If the estimated cost of capital is low, then the companies are only allowed to earn a low rate of return on their invested capital. At times, utilities like PG&E become more risky, have resulting low betas, and are then in danger of having some squirrelly finance "expert" argue that they should be allowed to earn an improper CAPM rate of return. In the industrial sector, a badly trained financial analyst with a dumb supervisor could make the same mistake, estimate the cost of capital to be below the true cost, and cause the company to make investments that should not be made.

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2-7 a. If technical trading rules could generate abnormal profits for an investor, then the market would not even be weak form efficient. Finance researchers believe that markets are at least weak form efficient because there are tens of thousands of analysts poring over past returns, prices, volumes and other technical characteristics of stock prices, and if any rules were consistently profitable, many of these analysts would discover this fact and their trading would drive out the profitability of the strategy. In addition, most studies find that technical trading rules do not generate abnormal profits. If technical analysis does not generate abnormal profits, then the market is weak form efficient.

b. If fundamental analysis cannot generate abnormal profits, then the market is said to be semi-strong form efficient.

c. If insider trading cannot generate abnormal profits, then the market is said to be strong form efficient. Strong form efficiency means that the stock market's prices impound *all* information about the stock, no matter how well kept the secret is.

d. Internet chat rooms, close friends connected with the company and close friends not connected with the company all provide non-public information. If a trader cannot make an abnormal profit from trading on this information, then the market is strong form efficient. If a trader can make abnormal profits from this information, then the market is not strong form efficient; it may or may not be semi-strong form or weak form efficient, depending on whether abnormal profits can be made from other strategies.

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ANSWERS TO END-OF-CHAPTER QUESTIONS

2-1 a. Stand-alone risk is only a part of total risk and pertains to the risk an investor takes by holding only one asset. Risk is the chance that some unfavorable event will occur. For instance, the risk of an asset is essentially the chance that the asset's cash flows will be unfavorable or less than expected. A probability distribution is a listing, chart or graph of all possible outcomes, such as expected rates of return, with a probability assigned to each outcome. When in graph form, the tighter the probability distribution, the less uncertain the outcome.

b. The expected rate of return ($\hat{r}$) is the expected value of a probability distribution of expected returns.

c. A continuous probability distribution contains an infinite number of outcomes and is graphed from $-\infty$ and $+\infty$.

d. The standard deviation (σ) is a statistical measure of the variability of a set of observations. The variance (σ^2) of the probability distribution is the sum of the squared deviations about the expected value adjusted for deviation.

e. A risk averse investor dislikes risk and requires a higher rate of return as an inducement to buy riskier securities. A realized return is the actual return an investor receives on their investment. It can be quite different than their expected return.

f. A risk premium is the difference between the rate of return on a risk-free asset and the expected return on Stock i which has higher risk. The market risk premium is the difference between the expected return on the market and the risk-free rate.

g. CAPM is a model based upon the proposition that any stock's required rate of return is equal to the risk free rate of return plus a risk premium reflecting only the risk remaining after diversification.

h. The expected return on a portfolio. $\hat{r}_p$, is simply the weighted-average expected return of the individual stocks in the portfolio, with the weights being the fraction of total portfolio value invested in each stock. The market portfolio is a portfolio consisting of all stocks.

i. Correlation is the tendency of two variables to move together. A correlation coefficient (ρ) of +1.0 means that the two variables move up and down in perfect synchronization, while a coefficient of -1.0 means the variables always move in opposite directions. A correlation coefficient of zero suggests that the two variables are not related to one another; that is, they are independent.

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j. Market risk is that part of a security's total risk that cannot be eliminated by diversification. It is measured by the beta coefficient. Diversifiable risk is also known as company specific risk, that part of a security's total risk associated with random events not affecting the market as a whole. This risk can be eliminated by proper diversification. The relevant risk of a stock is its contribution to the riskiness of a well-diversified portfolio.

k. The beta coefficient is a measure of a stock's market risk, A stock with a beta greater than 1 has stock returns that tend to be higher than the market when the market is up but tend to be below the market when the market is down. The opposite is true for a stock with a beta less than 1..

l. The security market line (SML) represents in a graphical form, the relationship between the risk of an asset as measured by its beta and the required rates of return for individual securities. The SML equation is essentially the CAPM, $r_i = r_{RF} + b_i(RP_M)$. It can also be written in terms of the required market return: $r_i = r_{RF} + b_i(r_M - r_{RF})$.

m. The slope of the SML equation is $(r_M - r_{RF})$, the market risk premium. The slope of the SML reflects the degree of risk aversion in the economy. The greater the average investors aversion to risk, then the steeper the slope, the higher the risk premium for all stocks, and the higher the required return.

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n. Equilibrium is the condition under which the expected return on a security is just equal to its required return, $\hat{r} = r$, and the market price is equal to the intrinsic value. The Efficient Markets Hypothesis (EMH) states (1) that stocks are always in equilibrium and (2) that it is impossible for an investor to consistently "beat the market." In essence, the theory holds that the price of a stock will adjust almost immediately in response to any new developments. In other words, the EMH assumes that all important information regarding a stock is reflected in the price of that stock. Financial theorists generally define three forms of market efficiency: weak-form, semistrong-form, and strong-form.

Weak-form efficiency assumes that all information contained in past price movements is fully reflected in current market prices. Thus, information about recent trends in a stock's price is of no use in selecting a stock. Semistrong-form efficiency states that current market prices reflect all publicly available information. Therefore, the only way to gain abnormal returns on a stock is to possess inside information about the company's stock. Strong-form efficiency assumes that all information pertaining to a stock, whether public or inside information, is reflected in current market prices. Thus, no investors would be able to earn abnormal returns in the stock market.

o. The Fama-French 3-factor model has one factor for the excess market return (the market return minus the risk free rate), a second factor for size (defined as the return on a portfolio of small firms minus the return on a portfolio of big firms), and a third factor for the book-to-market effect (defined as the return on a portfolio of firms with a high book-to-market ratio minus the return on a portfolio of firms with a low book-to-market ratio).

p. Most people don't behave rationally in all aspects of their personal lives, and behavioral finance assumes that investors have the same types of psychological behaviors in their financial lives as in their personal lives.

Anchoring bias is the human tendency to "anchor" too closely on recent events when predicting future events. Herding is the tendency of investors to follow the crowd. When combined with overconfidence, anchoring and herding can contribute to market bubbles.

2-2 a. The probability distribution for complete certainty is a vertical line.

b. The probability distribution for total uncertainty is the X axis from $-\infty$ to $+\infty$.

2-3 Security A is less risky if held in a diversified portfolio because of its lower beta and negative correlation with other stocks. In a single-asset portfolio, Security A would be more risky because $\sigma_A > \sigma_B$ and $CV_A > CV_B$.

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2-4 The risk premium on a high beta stock would increase more.

$$RP_j = \text{Risk Premium for Stock j} = (r_M - r_{RF})b_j.$$

If risk aversion increases, the slope of the SML will increase, and so will the market risk premium ($r_M - r_{RF}$). The product ($r_M - r_{RF}$)b_j is the risk premium of the jth stock. If b_j is low (say, 0.5), then the product will be small; RP_j will increase by only half the increase in RP_M. However, if b_j is large (say, 2.0), then its risk premium will rise by twice the increase in RP_M.

2-5 According to the Security Market Line (SML) equation, an increase in beta will increase a company's expected return by an amount equal to the market risk premium times the change in beta. For example, assume that the risk-free rate is 6 percent, and the market risk premium is 5 percent. If the company's beta doubles from 0.8 to 1.6 its expected return increases from 10 percent to 14 percent. Therefore, in general, a company's expected return will not double when its beta doubles.

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2-1

	Investment	Beta
	$20,000	0.7
	35,000	1.3
Total	$55,000	

($20,000/$55,000)(0.7) + ($35,000/$55,000)(1.3) = 1.08.

2-2 $r_{RF} = 4\%$; $r_M = 12\%$; $b = 0.8$; $r_s = ?$

$$\begin{aligned} r_s &= r_{RF} + (r_M - r_{RF})b \\ &= 4\% + (12\% - 4\%)0.8 \\ &= 10.4\%. \end{aligned}$$

2-3 $r_{RF} = 5\%$; $RP_M = 7\%$; $r_M = ?$

$r_M = 5\% + (7\%)1 = 12\% = r_s$ when $b = 1.0$.

r_s when $b = 1.7 = ?$

$r_s = 5\% + 7\%(1.7) = 16.9\%$.

2-4 Predicted return $= a_i + b_i(\bar{r}_{M,t}) + c_i(\bar{r}_{SMB,t}) + d_i(\bar{r}_{HML,t})$
$= 0.0\% + 1.2(10\%) + (-0.4)(3.2\%) + 1.3(4.8\%)$
$= 16.96\%$

2-5 $\hat{r} = (0.1)(-50\%) + (0.2)(-5\%) + (0.4)(16\%) + (0.2)(25\%) + (0.1)(60\%)$
$= 11.40\%$.

$$\begin{aligned} \sigma^2 = {} & (-50\% - 11.40\%)^2(0.1) + (-5\% - 11.40\%)^2(0.2) + (16\% - 11.40\%)^2(0.4) \\ & + (25\% - 11.40\%)^2(0.2) + (60\% - 11.40\%)^2(0.1) \end{aligned}$$

$\sigma^2 = 0.071244$; $\sigma = 26.69\%$.

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2-6 a. $\hat{r}_m = (0.3)(15\%) + (0.4)(9\%) + (0.3)(18\%) = 13.5\%.$

$\hat{r}_j = (0.3)(20\%) + (0.4)(5\%) + (0.3)(12\%) = 11.6\%.$

b. $\sigma_M = [(0.3)(15\% - 13.5\%)^2 + (0.4)(9\% - 13.5\%)^2 + (0.3)(18\% - 13.5\%)^2]^{1/2}$
$= \sqrt{14.85\%} = 3.85\%.$

$\sigma_J = [(0.3)(20\% - 11.6\%)^2 + (0.4)(5\% - 11.6\%)^2 + (0.3)(12\% - 11.6\%)^2]^{1/2}$
$= \sqrt{38.64\%} = 6.22\%.$

2-7 a. $r_A = r_{RF} + (r_M - r_{RF})b_A$
$12\% = 5\% + (10\% - 5\%)b_A$
$12\% = 5\% + 5\%(b_A)$
$7\% = 5\%(b_A)$
$1.4 = b_A.$

b. $r_A = 5\% + 5\%(b_A)$
$r_A = 5\% + 5\%(2)$
$r_A = 15\%.$

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2-8 a. $r_i = r_{RF} + (r_M - r_{RF})b_i = 5\% + (12\% - 5\%)1.4 = 14.8\%$.

b. 1. r_{RF} increases to 6%:

r_M increases by 1 percentage point, from 12% to 13%.

$r_i = r_{RF} + (r_M - r_{RF})b_i = 6\% + (12\% - 5\%)1.4 = 15.8\%$.

2. r_{RF} decreases to 4%:

r_M decreases by 1%, from 12% to 11%.

$r_i = r_{RF} + (r_M - r_{RF})b_i = 4\% + (12\% - 5\%)1.4 = 13.8\%$.

c. 1. r_M increases to 14%:

$r_i = r_{RF} + (r_M - r_{RF})b_i = 5\% + (14\% - 5\%)1.4 = 17.6\%$.

2. r_M decreases to 11%:

$r_i = r_{RF} + (r_M - r_{RF})b_i = 5\% + (11\% - 5\%)1.4 = 13.4\%$.

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2-9 Old portfolio beta = $\frac{\$70,000}{\$75,000}(b) + \frac{\$5,000}{\$75,000}(0.8)$

$1.2 = 0.9333b + 0.0533$
$1.1467 = 0.9333b$
$1.229 = b.$

New portfolio beta = 0.9333(1.229) + 0.0667(1.6) = 1.25.

Alternative Solutions:

1. Old portfolio beta = 1.2 = $(0.0667)b_1 + (0.0667)b_2 + ... + (0.0667)b_{20}$

   $1.2 = (\Sigma b_i)(0.0667)$
   $\Sigma b_i = 1.2/0.0667 = 18.0.$

   New portfolio beta = (18.0 - 0.8 + 1.6)(0.0667) = 1.253 = 1.25.

2. Σb_i excluding the stock with the beta equal to 0.8 is 18.0 - 0.8 = 17.2, so the beta of the portfolio excluding this stock is b = 17.2/14 = 1.2286. The beta of the new portfolio is:

   1.2286(0.9333) + 1.6(0.0667) = 1.1575 = 1.253.

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2-10 Portfolio beta = $\frac{\$400,000}{\$4,000,000}(1.50) + \frac{\$600,000}{\$4,000,000}(-0.50)$

$+ \frac{\$1,000,000}{\$4,000,000}(1.25) + \frac{\$2,000,000}{\$4,000,000}(0.75)$

$= 0.1)(1.5) + (0.15)(-0.50) + (0.25)(1.25) + (0.5)(0.75)$

$= 0.15 - 0.075 + 0.3125 + 0.375 = 0.7625.$

$r_p = r_{RF} + (r_M - r_{RF})(b_p) = 6\% + (14\% - 6\%)(0.7625) = 12.1\%.$

Alternative solution: First compute the return for each stock using the CAPM equation $[r_{RF} + (r_M - r_{RF})b]$, and then compute the weighted average of these returns.

$r_{RF} = 6\%$ and $r_M - r_{RF} = 8\%$.

Stock	Investment	Beta	$r = r_{RF} + (r_M - r_{RF})b$	Weight
A	$ 400,000	1.50	18%	0.10
B	600,000	(0.50)	2	0.15
C	1,000,000	1.25	16	0.25
D	2,000,000	0.75	12	0.50
Total	$4,000,000			1.00

$r_p = 18\%(0.10) + 2\%(0.15) + 16\%(0.25) + 12\%(0.50) = 12.1\%.$

2-11 First, calculate the beta of what remains after selling the stock:

$b_p = 1.1 = (\$100,000/\$2,000,000)0.9 + (\$1,900,000/\$2,000,000)b_R$

$1.1 = 0.045 + (0.95)b_R$

$b_R = 1.1105.$

$b_N = (0.95)1.1105 + (0.05)1.4 = 1.125.$

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2-12 We know that $b_R = 1.50$, $b_S = 0.75$, $r_M = 13\%$, $r_{RF} = 7\%$.

$r_i = r_{RF} + (r_M - r_{RF})b_i = 7\% + (13\% - 7\%)b_i$.

$r_R = 7\% + 6\%(1.50) = 16.0\%$
$r_S = 7\% + 6\%(0.75) = \underline{11.5}$
$\underline{\underline{4.5}}\%$

2-13 The answers to a, b, and c are given below:

		$\bar{r}_A$	$\bar{r}_B$	Portfolio
	2014	(20.00%)	(5.00%)	(12.50%)
	2015	42.00	15.00	28.50
	2016	20.00	(13.00)	3.50
	2017	(8.00)	50.00	21.00
	2018	25.00	12.00	18.50
Mean		11.80	11.80	11.80
Std Dev		25.28	24.32	16.34

d. A risk-averse investor would choose the portfolio over either Stock A or Stock B alone, since the portfolio offers the same expected return but with less risk. This result occurs because returns on A and B are not perfectly positively correlated ($\rho_{AB} = -0.13$).

2-14 a. $b_X = 1.3471$; $b_Y = 0.6508$. These can be calculated with a spreadsheet.

b. $r_X = 6\% + (5\%)1.3471 = 12.7355\%$.
$r_Y = 6\% + (5\%)0.6508 = 9.2540\%$.

c. $b_p = 0.8(1.3471) + 0.2(0.6508) = 1.2078$.
$r_p = 6\% + (5\%)1.2078 = 12.04\%$.
Alternatively,
$r_p = 0.8(12.7355\%) + 0.2(9.254\%) = 12.04\%$.

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SOLUTION TO SPREADSHEET PROBLEM

2-15 The detailed solution for the spreadsheet problem is available in the file ***Ch02-P15 Build a Model Solution.xlsx*** on the textbook's Web site.

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MINI CASE

Assume that you recently graduated and landed a job as a financial planner with Cicero Services, an investment advisory company. Your first client recently inherited some assets and has asked you to evaluate them. The client owns a bond portfolio with $1 million invested in zero coupon Treasury bonds that mature in 10 years. The client also has $2 million invested in the stock of Blandy, Inc., a company that produces meat-and-potatoes frozen dinners. Blandy's slogan is "Solid food for shaky times."

Unfortunately, Congress and the president are engaged in an acrimonious dispute over the budget and the debt ceiling. The outcome of the dispute, which will not be resolved until the end of the year, will have a big impact on interest rates one year from now. Your first task is to determine the risk of the client's bond portfolio. After consulting with the economists at your firm, you have specified five possible scenarios for the resolution of the dispute at the end of the year. For each scenario, you have estimated the probability of the scenario occurring and the impact on interest rates and bond prices if the scenario occurs. Given this information, you have calculated the rate of return on 10-year zero coupon Treasury bonds for each scenario. The probabilities and returns are shown below:

Scenario	Probability of Scenario	Return on a 10-Year Zero Coupon Treasury Bond During the Next Year
Worst Case	0.10	−14%
Poor Case	0.20	−4%
Most Likely	0.40	6%
Good Case	0.20	16%
Best Case	0.10	26%
	1.00	

You have also gathered historical returns for the past 10 years for Blandy, Gourmange Corporation (a producer of gourmet specialty foods), and the stock market.

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	Historical Stock Returns		
Year	Market	Blandy	Gourmange
1	30%	26%	47%
2	7	15	−54
3	18	−14	15
4	−22	−15	7
5	−14	2	−28
6	10	−18	40
7	26	42	17
8	−10	30	−23
9	−3	−32	−4
10	38	28	75
Average return:	8.0%	?	9.2%
Standard deviation:	20.1%	?	38.6%
Correlation with the market:	1.00	?	0.678
Beta:	1.00	?	1.30

The risk-free rate is 4% and the market risk premium is 5%.

a. What are investment returns? What is the return on an investment that costs $1,000 and is sold after 1 year for $1,060?

Answer: Investment return measures the financial results of an investment. They may be expressed in either dollar terms or percentage terms.

The dollar return is $1,60 - $1,000 = $60. The percentage return is $60/$1,000 = 0.06 = 6%.

b. Graph the probability distribution for the bond returns based on the 5 scenarios. What might the graph of the probability distribution look like if there were an infinite number of scenarios (i.e., if it were a continuous distribution and not a discrete distribution)?

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Answer: Here is the probability distribution for the five possible outcomes:

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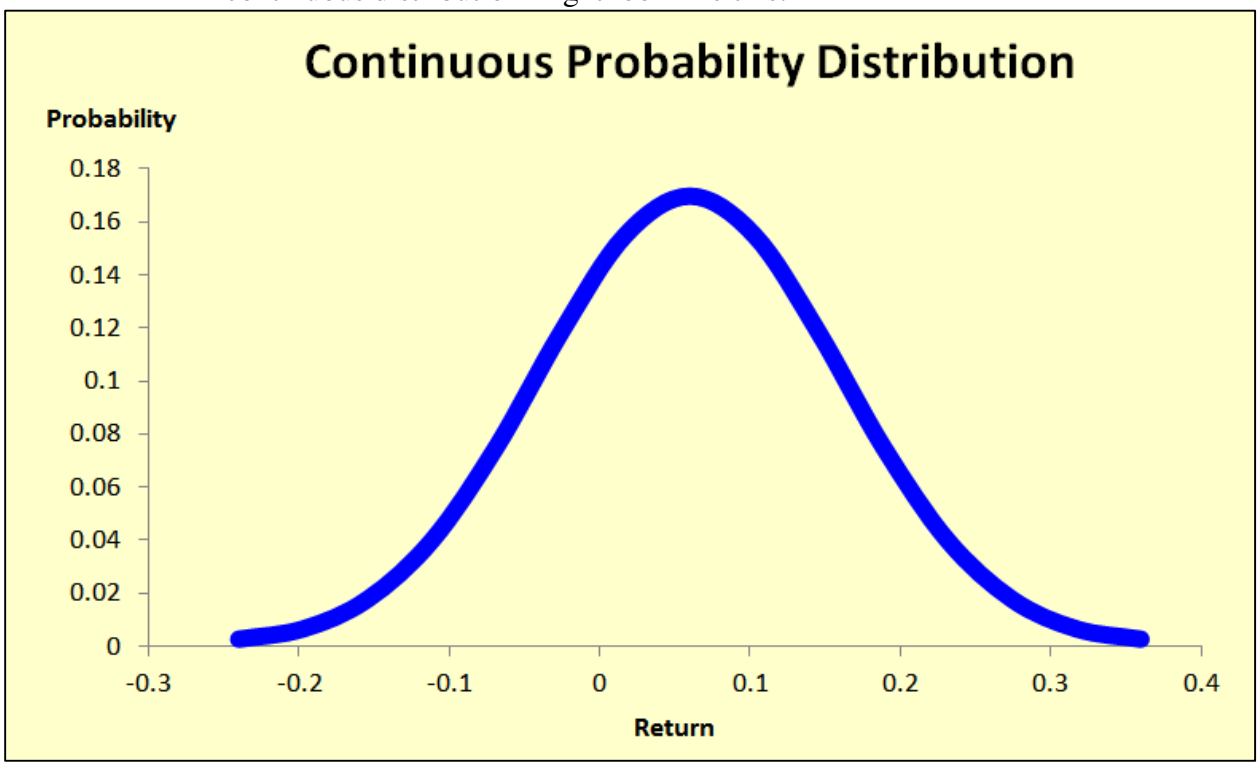
A continuous distribution might look like this:



c.	**Use the scenario data to calculate the expected rate of return for the 10-year zero coupon Treasury bonds during the next year.**

Answer: The expected rate of return, $\hat{r}$, is expressed as follows:

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

Here p_i is the probability of occurrence of the ith state, r_i is the estimated rate of return for that state, and n is the number of states. Here is the calculation:

$$\begin{aligned}\hat{r} &= 0.1(-14.0\%) + 0.2(-4.0\%) + 0.4(6.0\%) + 0.2(16.0\%) + \quad 0.1(26.0\%) \\ &= 6.0\%.\end{aligned}$$

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d.	**What is stand-alone risk? Use the scenario data to calculate the standard deviation of the bond's return for the next year.**

Answer: Stand-alone risk is the risk of an asset if it is held by itself and not as a part of a portfolio. Standard deviation measures the dispersion of possible outcomes, and for a single asset, the stand-alone risk is measured by standard deviation.

The variance and standard deviation are calculated as follows:

$$\sigma^2 = \sum_{i=1}^{n} p_i (r_i - \hat{r}_i)^2$$

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

$$\sigma^2 = [(0.1)(-0.14 - 0.06)^2 + (0.2)(-0.04 - 0.06)^2 + (0.4)(0.06 - 0.06)^2 + (0.2)(0.16 - 0.06)^2 + (0.1)(0.26 - 0.06)^2]$$

$$\sigma^2 = 0.0120$$

$$\sigma = \sqrt{\sigma^2} \quad \sqrt{0.0120} = 0.1095 = 10.95\%.$$

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e.	**Your client has decided that the risk of the bond portfolio is acceptable and wishes to leave it as it is. Now your client has asked you to use historical returns to estimate the standard deviation of Blandy's stock returns. (Note: Many analysts use 4 to 5 years of monthly returns to estimate risk and many use 52 weeks of weekly returns; some even use a year or less of daily returns. For the sake of simplicity, use Blandy's 10 annual returns.)**

Answer: The formulas are shown below:

$$\bar{r}_{Avg} = \frac{\sum_{t=1}^{T} \bar{r}_t}{T}$$

$$\text{Estimated } \sigma = S = \sqrt{\frac{\sum_{t=1}^{T} (\bar{r}_t - \bar{r}_{Avg})^2}{T-1}}$$

Using Excel, the past average returns and standard deviations are:

	Market	Blandy	Gourmange
Average return:	8.0%	6.4%	9.2%
Standard deviation of returns:	20.1%	25.2%	38.6%

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f.	**Your client is shocked at how much risk Blandy stock has and would like to reduce the level of risk. You suggest that the client sell 25% of the Blandy stock and create a portfolio with 75% Blandy stock and 25% in the high-risk Gourmange stock. How do you suppose the client will react to replacing some of the Blandy stock with high-risk stock? Show the client what the proposed portfolio return would have been in each of year of the sample. Then calculate the average return and standard deviation using the portfolio's annual returns. How does the risk of this two-stock portfolio compare with the risk of the individual stocks if they were held in isolation?**

Answer: To find historical returns on the portfolio, we first find each annual return for the portfolio using the portfolio weights and the annual stock returns:

The percentage of a portfolio's value that is invested in Stock i is denoted by the "weight" w_i. Notice that the sum of all the weights must equal 1. With n stocks in the portfolio, its return each year will be:

$$\bar{r}_p = w_1\bar{r}_1 + w_2\bar{r}_2 + \cdots + w_n\bar{r}_n$$
$$= \sum_{i=1}^{n} w_i\bar{r}_i$$

The portfolio return each year will be:

$$\bar{r}_{P,t} = w_{Blandy}\left(\bar{r}_{Blandy,t}\right) + w_{Gour.}\left(\bar{r}_{Gour.,t}\right)$$
$$\bar{r}_{P,t} = 0.75\left(\bar{r}_{Blandy,t}\right) + 0.25\left(\bar{r}_{Gour.,t}\right)$$

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Following is a table showing the portfolio's return in each year. It also shows the average return and standard deviation during the past 10 years.

	Stock Returns		
Year	Blandy	Gourmange	Portfolio
1	26%	47%	31.3%
2	15%	-54%	-2.3%
3	-14%	15%	-6.8%
4	-15%	7%	-9.5%
5	2%	-28%	-5.5%
6	-18%	40%	-3.5%
7	42%	17%	35.8%
8	30%	-23%	16.8%
9	-32%	-4%	-25.0%
10	28%	75%	39.8%
Average return:	6.4%	9.2%	7.1%
Standard deviation of returns:	25.2%	38.6%	22.2%

Notice that the portfolio risk is actually less than the standard deviations of the stocks making up the portfolio.

The average portfolio return during the past 10 years can be calculated as average return of the 10 yearly returns. But there is another way—the average portfolio return over a number of periods is also equal to the weighted average of the stock's average returns:

$$\bar{r}_{Avg,p} = \sum_{i=1}^{n} w_i \bar{r}_{Avg,i}$$

This method is used below:

$$\bar{r}_{Avg,p} = 0.75(6.4\%) + 0.25(9.2\%) = 7.1\%$$

Note, however, that the only way to calculate the standard deviation of historical returns for a portfolio is to first calculate the portfolio's annual historical returns and then calculate its standard deviation. **A portfolio's historical standard deviation is not the weighted average of the individual stocks' standard deviations!** (The only exception occurs when there is zero correlation among the portfolio's stocks, which would be extremely rare.)

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g.	**Explain correlation to your client. Calculate the estimated correlation between Blandy and Gourmange. Does this explain why the portfolio standard deviation was less than Blandy's standard deviation?**

Answer: Loosely speaking, the correlation (ρ) coefficient measures the tendency of two variables to move together. The formula, shown below, is complicated, but it is easy to use Excel to calculate the correlation.

$$\text{Estimated } \rho_{i,j} = R = \frac{\sum_{t=1}^{T}(\bar{r}_{i,t} - \bar{r}_{i,Avg})(\bar{r}_{j,t} - \bar{r}_{j,Avg})}{\sqrt{\left[\sum_{t=1}^{T}(\bar{r}_{i,t} - \bar{r}_{i,Avg})^2\right]\left[\sum_{t=1}^{T}(\bar{r}_{j,t} - \bar{r}_{j,Avg})^2\right]}}$$

Using Excel, the correlation between Blandy (B) and Gourmange (G) is:

$$\text{Est. } \rho_{B,G} = 0.11$$

A correlation coefficient of +1 means that the stocks always move together; a correlation coefficient of −1 means that the stocks always move oppositely to one another. A correlation coefficient of 0 means that there is no relationship between the stocks' movements. The correlation coefficient of 0.11 means that sometime when Blandy is up, Gourmange is down, and vice versa. This makes the total risk of the portfolio less than the risk of holding either stock by itself.

h.	**Suppose an investor starts with a portfolio consisting of one randomly selected stock. As more and more randomly selected stocks are added to the portfolio, what happens to the portfolio's risk?**

Answer: The standard deviation gets smaller as more stocks are combined in the portfolio, while r_p (the portfolio's return) remains constant. Thus, by adding stocks to your portfolio, which initially started as a 1-stock portfolio, risk has been reduced.

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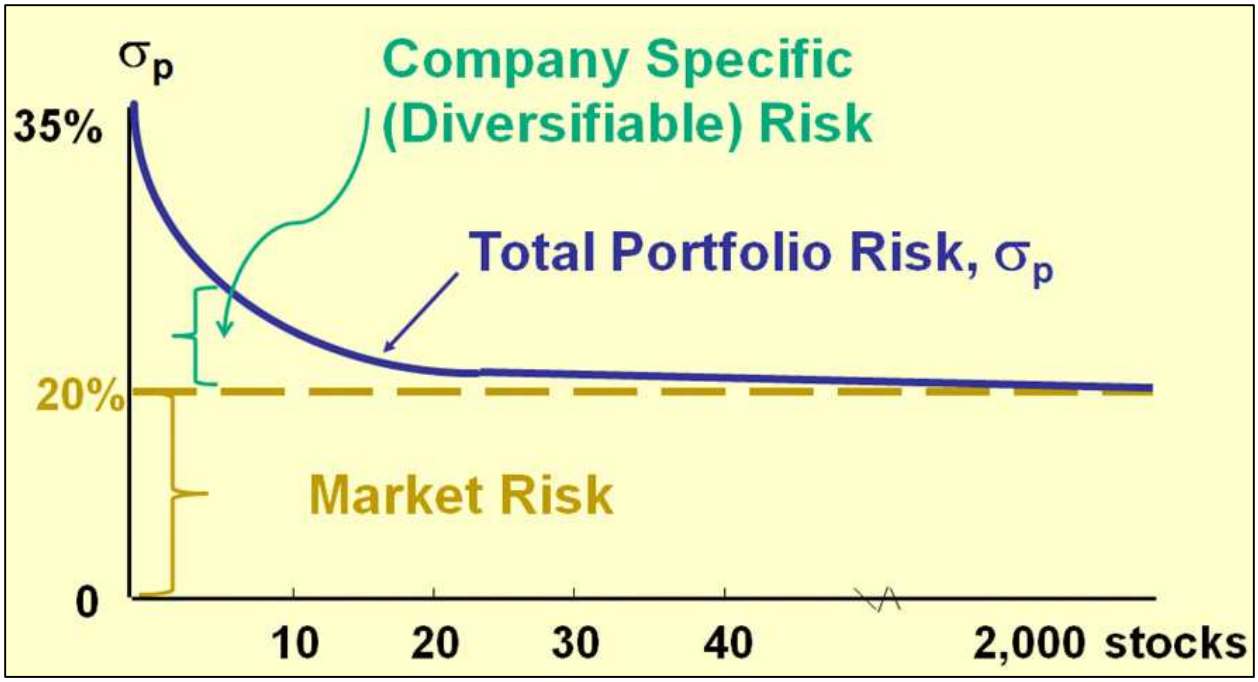

In the real world, stocks are positively correlated with one another--if the economy does well, so do stocks in general, and vice versa. Correlation coefficients between stocks generally range from +0.5 to +0.7. The average correlation between stocks is about 0.35. A single stock selected at random would on average have a standard deviation of about 35 percent. As additional stocks are added to the portfolio, the portfolio's standard deviation decreases because the added stocks are not perfectly positively correlated. However, as more and more stocks are added, each new stock has less of a risk-reducing impact, and eventually adding additional stocks has virtually no effect on the portfolio's risk as measured by σ. In fact, σ stabilizes at about 20 percent when 40 or more randomly selected stocks are added. Thus, by combining stocks into well-diversified portfolios, investors can eliminate almost one-half the riskiness of holding individual stocks. (Note: it is not completely costless to diversify, so even the largest institutional investors hold less than all stocks. Even index funds generally hold a smaller portfolio which is highly correlated with an index such as the S&P 500 rather than hold all the stocks in the index.)

The implication is clear: <u>investors should hold well-diversified portfolios of stocks rather than individual stocks.</u> (In fact, individuals can hold diversified portfolios through mutual fund investments.) By doing so, they can eliminate about half of the riskiness inherent in individual stocks.

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i.	**1.**	**Should portfolio effects influence how investors think about the risk of individual stocks?**

Answer: Portfolio diversification does affect investors' views of risk. A stock's stand-alone risk as measured by its σ or CV, may be important to an undiversified investor, but it is not relevant to a well-diversified investor. A rational, risk-averse investor is more interested in the impact that the stock has on the riskiness of his or her portfolio than on the stock's stand-alone risk. Stand-alone risk is composed of diversifiable risk, which can be eliminated by holding the stock in a well-diversified portfolio, and the risk that remains is called market risk because it is present even when the entire market portfolio is held.

i.	**2.**	**If you decided to hold a one-stock portfolio and consequently were exposed to more risk than diversified investors, could you expect to be compensated for all of your risk; that is, could you earn a risk premium on that part of your risk that you could have eliminated by diversifying?**

Answer: If you hold a one-stock portfolio, you will be exposed to a high degree of risk, but you won't be compensated for it. If the return were high enough to compensate you for your high risk, it would be a bargain for more rational, diversified investors. They would start buying it, and these buy orders would drive the price up and the return down. Thus, you simply could not find stocks in the market with returns high enough to compensate you for the stock's diversifiable risk.

j.	**According to the Capital Asset Pricing Model, what measures the amount of risk that an individual stock contributes to a well-diversified portfolio? Define this measurement.**

Answer: Market risk, which is relevant for stocks held in well-diversified portfolios, is defined as the contribution of a security to the overall risk of the portfolio. It is measured by a stock's beta coefficient. The beta of Stock i, denoted by b_i, is calculated as:

$$b_i = \left(\frac{\sigma_i}{\sigma_M}\right)\rho_{iM}$$

A stock's beta can also be estimated by running a regression with the stock's returns on the y axis and the market portfolio's returns on the x axis. The slope of the regression line gives the same result as the formula shown above.

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k.	**What is the Security Market Line (SML)? How is beta related to a stock's required rate of return?**

Answer: Here is the SML equation:

$$r_i = r_{Rf} + RP_M\, b_i.$$
$$r_i = r_{Rf} + (r_M - r_{Rf})b_i.$$

The SML asserts that because investing in stocks is risky, an investor must expect to get at least the risk-free rate of return plus a premium to reflect the additional risk of the stock. The premium is for a stock begins with the premium required to hold an average stock (RP_M) and is scaled up or down depending on the stock's beta.

l.	**Calculate the correlation coefficient between Blandy and the market. Use this and the previously calculated (or given) standard deviations of Blandy and the market to estimate Blandy's beta. Does Blandy contribute more or less risk to a well-diversified portfolio than does the average stock? Use the SML to estimate Blandy's required return.**

Answer: Using the formula for correlation or the Excel function, CORREL, Blandy's correlation with the market ($\rho_{B,M}$) is:

$$\rho_{B,M} = 0.481$$

$$b_i = \left(\frac{\sigma_i}{\sigma_M}\right)\rho_{iM} = \left(\frac{0.252}{0.201}\right)(0.481) = 0.6$$

Blandy's beta is less than 1, so it contributes less risk than that of an average stock.

Suppose the risk free rate is 4% and the market risk premium is 5%. The required rate of return on Blandy is

$$r_i = r_{RF} + b_i\,(RP_M)$$
$$r_i = 4\% + 0.60(5\%) = 7\%$$

m.	**Show how to estimate beta using regression analysis.**

Answer: Betas are calculated as the slope of the "characteristic" line, which is the regression line showing the relationship between a given stock's returns and the stock market's returns. The graph below shows this regression as calculated using Excel.

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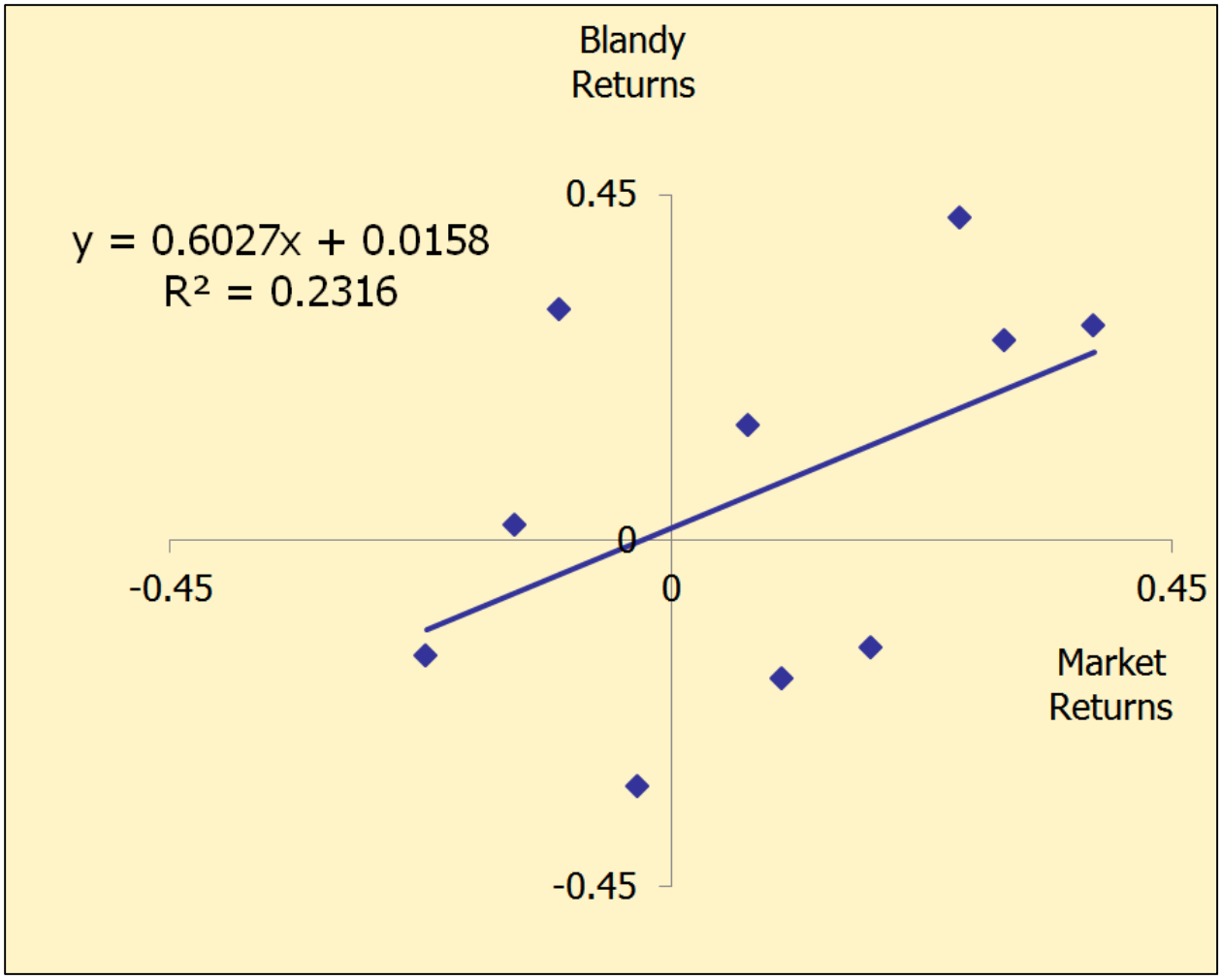

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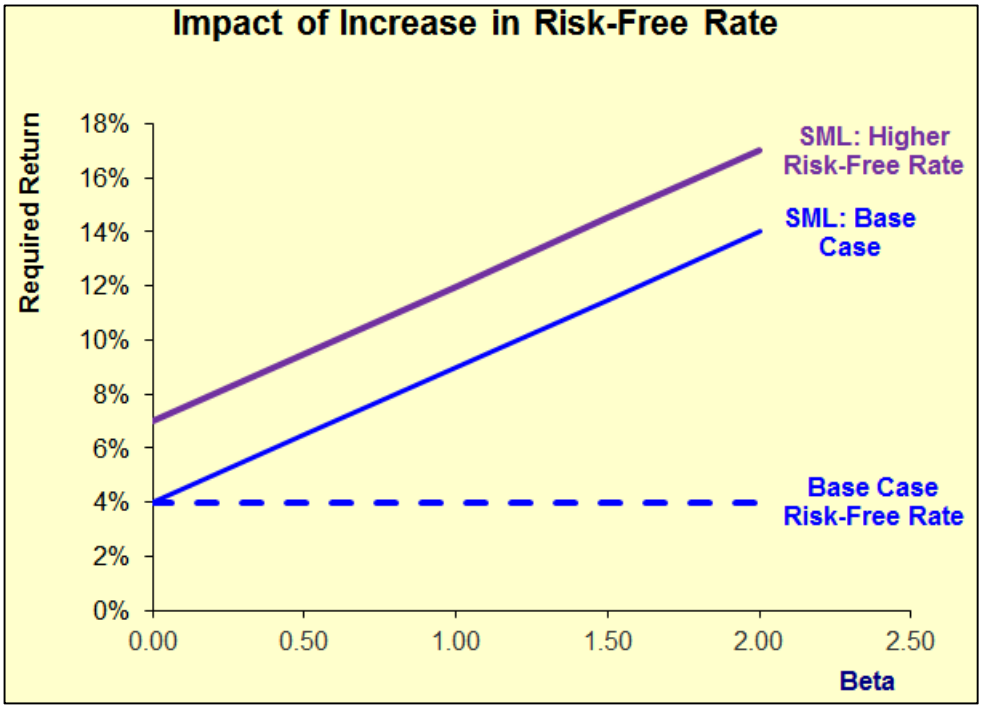
n.	**1.**	Suppose the risk-free rate goes up to 7%. What effect would higher interest rates have on the SML and on the returns required on high-risk and low-risk securities?

Answer: The SML is shifted higher, but the slope is unchanged.



Here we have plotted the SML for betas ranging from 0 to 2.0. The base case SML is based on r_{RF} = 4% and r_M = 5%. If interest rates increase by 3 percentage points, with no change in risk aversion, then the entire SML is shifted upward (parallel to the base case SML) by 3 percentage points. Now, r_{RF} = 7%, r_M = 12%, and all securities' required returns rise by 3 percentage points. Note that the market risk premium, $r_m - r_{RF}$, remains at 5 percentage points.

n.	**2.**	**Suppose instead that investors' risk aversion increased enough to cause the market risk premium to increase to 8%. (Assume the risk-free rate remains constant.) What effect would this have on the SML and on returns of high- and low-risk securities?**

Answer: When investors' risk aversion increases, the SML is rotated upward about the y-intercept, which is r_{RF}. Suppose r_{RF} remains at 4 percent, but now r_M increases to 12 percent, so the market risk premium increases to 8 percent. The required rate of return will rise sharply on high-risk (high-beta) stocks, but not much on low-beta securities.

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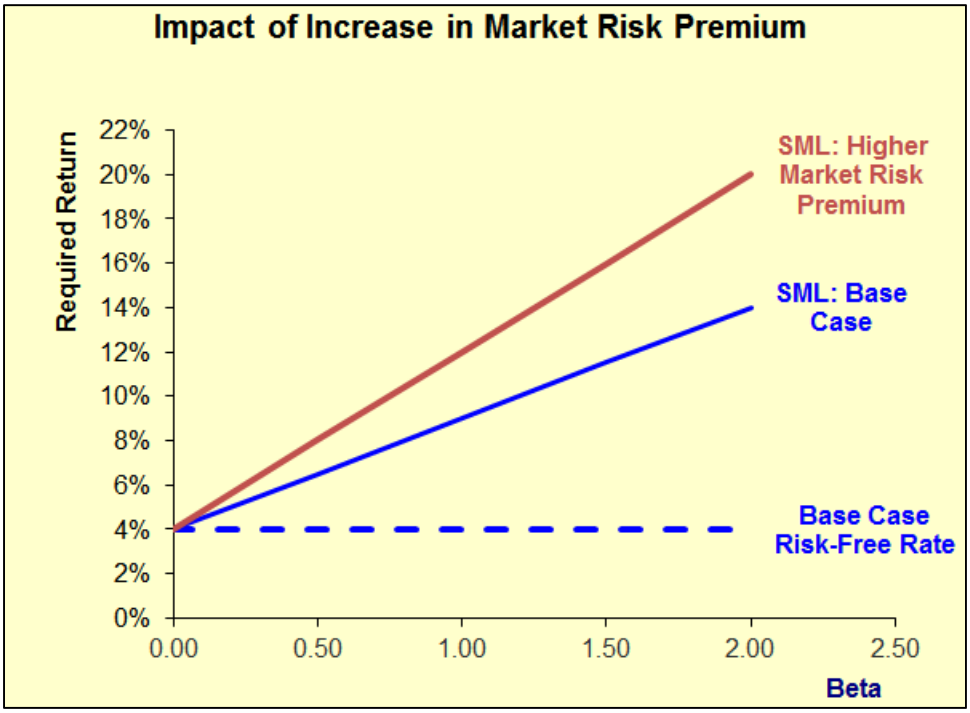

o.	**Your client decides to invest $1.4 million in Blandy stock and $0.6 million in Gourmange stock. What are the weights for this portfolio? What is the portfolio's beta? What is the required return for this portfolio?**

Answer: The portfolio's beta is the weighted average of the stocks' betas:

$$b_p = 0.7(b_{Blandy}) + 0.3(b_{Gour.})$$
$$= 0.7(0.60) + 0.3(1.30)$$
$$= 0.81.$$

There are two ways to calculate the portfolio's expected return. First, we can use the portfolio's beta and the SML:

$$r_p = r_{RF} + b_p(RP_M)$$
$$= 4.0\% + 0.81\%(5\%) = 8.05\%.$$

Second, we can find the weighted average of the stocks' expected returns:

$$r_p = \sum_{i=1}^{n} w_i r_i$$
$$= 0.7(7.0\%) + 0.3(10.5\%)$$
$$= 8.05\%.$$

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p.	**Jordan Jones (JJ) and Casey Carter (CC) are portfolio managers at your firm. Each manages a well-diversified portfolio. Your boss has asked for your opinion regarding their performance in the past year. JJ's portfolio has a beta of 0.6 and had a return of 8.5%; CC's portfolio has a beta of 1.4 and had a return of 9.5%. Which manager had better performance? Why?**

Answer: To evaluate the managers, calculate the required returns on their portfolios using the SML and compare the actual returns to the required returns, as follows:

	Portfolio Manager	
	JJ	CC
Portfolio beta =	0.7	1.4
Risk-free rate =	4%	4%
Market risk premium =	5%	5%
Portfolio required return =	7.50%	11.00%
Portfolio actual return =	8.50%	9.50%
Over (Under) Performance =	1.00%	-1.50%

Notice that JJ's portfolio had a higher return than investors required (given the risk of the portfolio) and CC's portfolio had a lower return than expected by investors. Therefore, JJ had the better performance.

q.	**What does market equilibrium mean? If equilibrium does not exist, how will it be established?**

Answer: Market equilibrium means that marginal investors (the ones whose trades determine prices) believe that all securities are fairly priced. This means that the market price of a security must equal the security's intrinsic value (intrinsic value reflects the size, timing, and risk of the future cash flows):

Market price = Intrinsic value

Market equilibrium also means that the expected return a security must equal its required return (which reflects the security's risk).

$$\hat{r} = r$$

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If the market is not in equilibrium, then some assets will be undervalued and/or some will be overvalued. If this is the case, traders will attempt to make a profit by purchasing undervalued securities and short-selling overvalued securities. The additional demand for undervalued securities will drive up their prices and the lack of demand for overvalued securities will drive down their prices. This will continue until market prices equal intrinsic values, at which point the traders will not be able to earn profits greater than justified by the assets' risks.

r.	**What is the Efficient Markets Hypothesis (EMH) and what are its three forms? What evidence supports the EMH? What evidence casts doubt on the EMH?**

Answer: The EMH is the hypothesis that securities are normally in equilibrium, and are "priced fairly," making it impossible to "beat the market."

Weak-form efficiency says that investors cannot profit from looking at past movements in stock prices--the fact that stocks went down for the last few days is no reason to think that they will go up (or down) in the future. This form has been proven by empirical tests, even though people still employ "technical analysis."

Semistrong-form efficiency says that all publicly available information is reflected in stock prices, hence that it won't do much good to pore over annual reports trying to find undervalued stocks. This one is (I think) largely true, but superior analysts can still obtain and process new information fast enough to gain a small advantage.

Strong-form efficiency says that all information, even inside information, is embedded in stock prices. This form does not hold--insiders know more, and could take advantage of that information to make abnormal profits in the markets. Trading on the basis of insider information is illegal.

Most empirical evidence supports weak-form EMH because very few trading strategies consistently earn in excess of the CAPM prediction, with two possible exceptions that earn very small excess returns: (1) short-term momentum and (2) long-term reversals.

Most empirical evidence supports the semistrong-form EMH. For example, the vast majority of portfolio managers do not consistently have returns in excess of CAPM predictions. There are two possible exceptions that earn excess returns: (1) small companies and (2) companies with high book-to-market ratios.

In addition, there are times when a market becomes overvalued. This is often called a bubble. Bubbles are hard to burst because trading strategies expose traders to possible big negative cash flows if the bubble is slow to burst.

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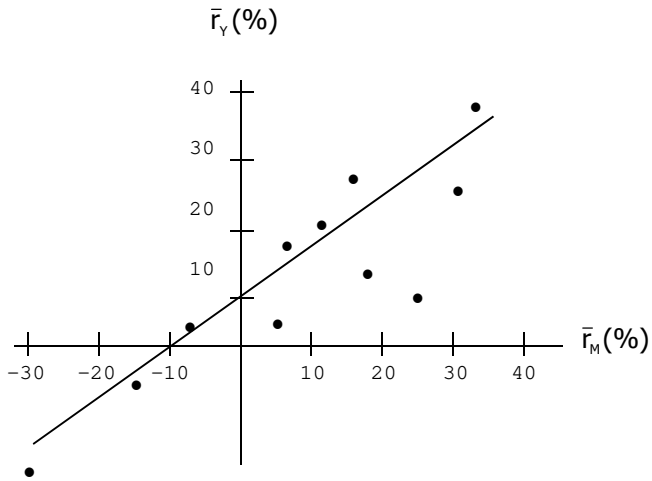
Web Appendix 6B
Calculating Beta Coefficients With a Financial Calculator

Solutions to Problems

6B-1 a.



b = Slope = 0.62. However, b will depend on students' freehand line. Using a calculator, we find b = 0.6171 ≈ 0.62.

b. Because b = 0.62, Stock Y is about 62% as volatile as the market; thus, its relative risk is about 62% that of an average stock.

c. 1. Stand-alone risk as measured by σ would be greater, but beta and hence systematic (relevant) risk would remain unchanged. However, in a 1-stock portfolio, Stock Y would be riskier under the new conditions.

2. CAPM assumes that company-specific risk will be eliminated in a portfolio, so the risk premium under the CAPM would not be affected. However, if the scatter were wide, we would not have as much confidence in the beta, and this could increase the stock's risk and thus its risk premium.

d. 1. The stock's variance and σ would not change, but the risk of the stock to an investor holding a diversified portfolio would be greatly reduced, because it would now have a negative correlation with r_M.

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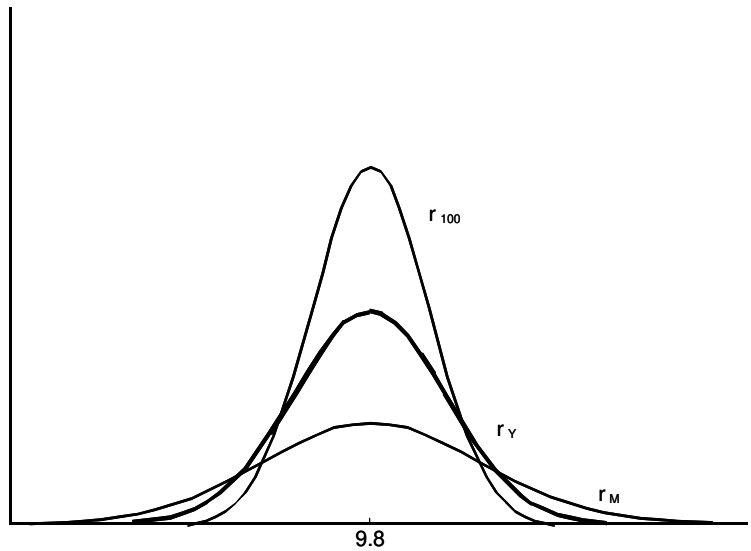
2. Because of a relative scarcity of such stocks and the beneficial net effect on portfolios that include it, its "risk premium" is likely to be very low or even negative. Theoretically, it should be negative.

e. The following figure shows a possible set of probability distributions. We can be reasonably sure that the 100-stock portfolio comprised of b = 0.62 stocks as described in Condition 2 will be less risky than the "market." Hence, the distribution for Condition 2 will be more peaked than that of Condition 3.



We can also say on the basis of the available information that σ_Y is smaller than σ_M; Stock Y's *market* risk is only 62% of the "market," but it does have company-specific risk, while the market portfolio does not, because it has been diversified away. However, we know from the given data that $\sigma_Y = 13.8\%$, while $\sigma_M = 19.6\%$. Thus, we have drawn the distribution for the single stock portfolio more peaked than that of the market. The relative rates of return are *not* reasonable. The return for any stock should be

$$r_i = r_{RF} + (r_M - r_{RF})b_i.$$

Stock Y has b = 0.62, while the average stock (M) has b = 1.0; therefore,

$$r_y = r_{RF} + (r_M - r_{RF})0.62 < r_M = r_{RF} + (r_M - r_{RF})1.0.$$

A disequilibrium exists—Stock Y should be bid up to drive its yield down. More likely, however, the data simply reflect the fact that past returns are not an exact basis for

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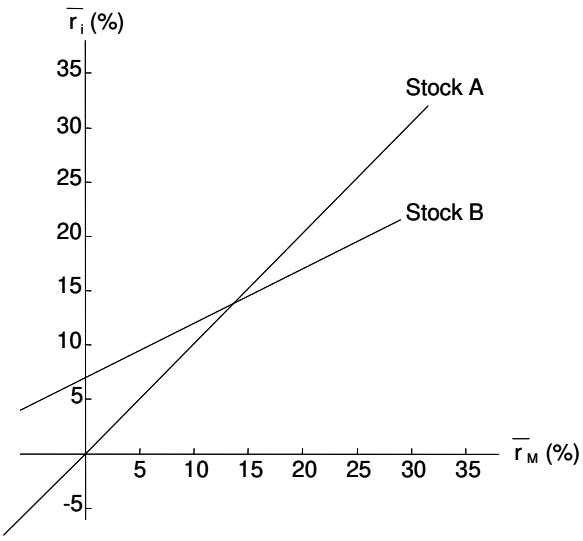
expectations of future returns.

f. The expected return could not be predicted with the historical characteristic line because the increased risk should change the beta used in the characteristic line.

g. The beta would decline to 0.53. A decline indicates that the stock has become less risky; however, with the change in the debt ratio the stock has actually become more risky. In periods of transition, when the risk of the firm is changing, the beta can yield conclusions that are exactly opposite to the actual facts. Once the company's risk stabilizes, the calculated beta should rise and should again approximate the true beta.

6B-2 a.



The slope of the characteristic line is the stock's beta coefficient.

$$\text{Slope} = \frac{\text{Rise}}{\text{Run}} = \frac{\Delta r_i}{\Delta \bar{r}_M}.$$

$$\text{Slope}_A = \text{Beta}_A = \frac{29.00 - 15.20}{29.00 - 15.20} = 1.0.$$

$$\text{Slope}_B = \text{Beta}_B = \frac{20.00 - 13.10}{29.00 - 15.20} = 0.5.$$

b. $\hat{r}_M = 0.1(-14\%) + 0.2(0\%) + 0.4(15\%) + 0.2(25\%) + 0.1(44\%)$
$= -1.4\% + 0\% + 6\% + 5\% + 4.4\% = 14\%.$

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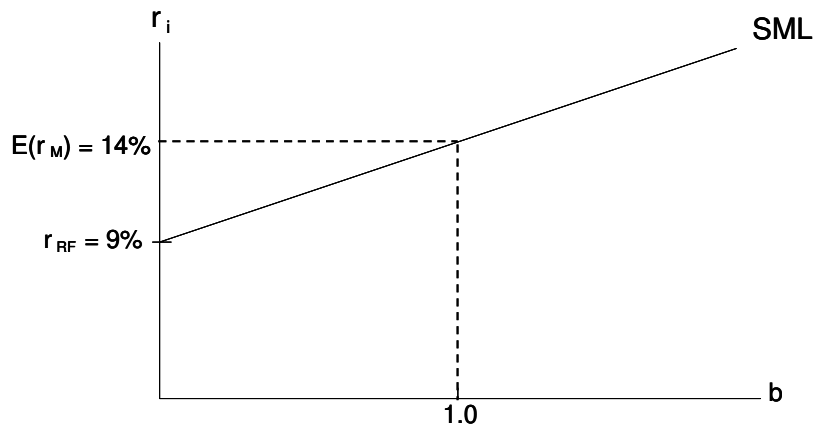
The graph of the SML is as follows:



The equation of the SML is thus:

$$r_i = r_{RF} + (r_M - r_{RF})b_i = 9\% + (14\% - 9\%)b_i = 9\% + (5\%)b_i.$$

c. Required rate of return on Stock A:

$$r_A = r_{RF} + (r_M - r_{RF})b_A = 9\% + (14\% - 9\%)1.0 = 14\%.$$

Required rate of return on Stock B:

$$r_B = 9\% + (14\% - 9\%)0.5 = 11.50\%.$$

d. Expected return on Stock C = $\hat{r}_c = 18\%$.

Return on Stock C if it is in equilibrium:

$$r_C = r_{RF} + (r_M - r_{RF})b_C = 9\% + (14\% - 9\%)2 = 19\% \neq 18\% = \hat{r}_c.$$

A stock is in equilibrium when its required return is equal to its expected return. Stock C's required return is greater than its expected return; therefore, Stock C is not in equilibrium. Equilibrium will be restored when the expected return on Stock C is driven up to 19%. With an expected return of 18% on Stock C, investors should sell it, driving its price down and its yield up.

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WEB EXTENSION 2B

Estimating Beta with a Financial Calculator

For an illustration of how betas are calculated with a financial calculator, consider Table 2B-1, which contains data showing the historical realized returns for Stock i and for the market over the last 5 years.

Recall that beta is estimated as the slope coefficient from a regression with the market return as the X variable and the stock return as the Y variable. The procedures that follow explain how to estimate the slope (which is the estimated beta) using either a Texas Instruments or Hewlett-Packard financial calculator.

2B-1 Texas Instruments BA-II Plus

1. Press [2nd] [DATA], [2nd] [CLR Work] to delete any observations in the statistics data registers. Once you do this, X01 appears on your screen with 0 as a value.
2. Key in 23.8 (the first X data point) and press [ENTER] to enter the first X variable.
3. Press [↓], key in 38.6, and press [ENTER] to enter the first Y variable.
4. Enter the remaining X and Y variables by repeating Step 3.
5. Once all the data have been entered, press [2nd] [STAT] to select the statistical function desired, and LIN (stands for standard linear regression) should appear on the calculator screen. If LIN doesn't appear on the screen, then press [2nd] [SET] until

TABLE 2B-1 Calculating Beta Coefficients

Year	X Variable: Market Return ($\bar{r}_M$)	Y Variable: Stock Return ($\bar{r}_i$)
1	23.8%	38.6%
2	–7.2	–24.7
3	6.6	12.3
4	20.5	8.2
5	30.6	40.1
Average: $\bar{r}$	14.9%	14.9%
Standard deviation: σ	15.1%	26.5%

it does. Then press [↓] to obtain statistics on the data. After pressing [↓] eight times, the y-intercept (a) will be shown, –8.92. Then press [↓] again and the slope coefficient (beta) will be shown, 1.60, and if you press [↓] one more time the correlation coefficient, 0.91, will be shown.

Putting it all together, you should have the regression line shown here:

$$\bar{r}_i = -8.92 + 1.60\bar{r}_M$$
$$\rho = 0.91$$

2B-2 Hewlett-Packard 10BII

1. Press ■ [CALL] to clear your memory registers.
2. Enter the first X value ($\bar{r}_M$ = 23.8 in our example), press [INPUT], and then enter the first Y value ($\bar{r}_i$ = 38.6) and press [Σ+]. Be *sure* to enter the X variable first.
3. Repeat Step 2 until all values have been entered.
4. To display the vertical axis intercept, press 0 ■ [ŷ ,m]. Then −8.92 should appear.
5. To display the beta coefficient, b, press ■ [SWAP]. Then 1.60 should appear.
6. To obtain the correlation coefficient, press ■ [x̂,r] and then ■ [SWAP] to get r = 0.91.

Putting it all together, you should have the regression line shown here:

$$\bar{r}_i = -8.92 + 1.60\bar{r}_M$$
$$\rho = 0.91$$

PROBLEMS

2B–1 Beta Coefficients and Rates of Return

You are given the following set of data:

	Historical Rates of Return ($\bar{r}$)	
Year	**Stock Y ($\bar{r}_Y$)**	**NYSE ($\bar{r}_M$)**
1	3.0%	4.0%
2	18.2	14.3
3	9.1	19.0
4	−6.0	−14.7
5	−15.3	−26.5
6	33.1	37.2
7	6.1	23.8
8	3.2	−7.2
9	14.8	6.6
10	24.1	20.5
11	18.0	30.6
Mean	9.8%	9.8%
$\sigma_{\bar{r}}$	13.8	19.6

a. Construct a scatter diagram graph (on *graph paper*) showing the relationship between returns on Stock Y and the market, with Stock Y on the y-axis and the market on the x-axis; then draw a freehand approximation of the regression line. What is the approximate value of the beta coefficient? (If you have a calculator with statistical functions, use it to calculate beta.)
b. Give a verbal interpretation of what the regression line and the beta coefficient show about Stock Y's volatility and relative riskiness as compared with other stocks.
c. Suppose the scatter of points had been more spread out, yet the regression line was exactly where your present graph shows it. How would this affect: (1) the firm's risk if the stock were held in a one-asset portfolio and (2) the actual risk premium on the stock if the CAPM held exactly? How would the degree of scatter (or the correlation coefficient) affect your confidence that the calculated beta will hold true in the years ahead?
d. Suppose the regression line had been downward sloping and the beta coefficient had been negative. What would this imply about (1) Stock Y's relative riskiness and (2) its probable risk premium?
e. Construct an illustrative probability distribution graph of returns for portfolios consisting of (1) only Stock Y, (2) 1% each of 100 stocks with beta coefficients similar to that of Stock Y, and (3) all stocks (that is, the distribution of returns on the market). Use as the expected rate of return the arithmetic mean given previously for both Stock Y and the market, and assume that the distributions are normal. Are the expected returns "reasonable"—that is, is it reasonable that $\hat{r}_Y = \hat{r}_M = 9.8\%$?
f. Now suppose that in the next year, Year 12, the market return was 27% and Firm Y increased its use of debt, which raised its perceived risk to investors. Do you think that the return on Stock Y in Year 12 could be approximated by the following historically based expression?

$$\hat{r}_Y = 3.8\% + 0.62(\hat{r}_M) = 3.8\% + 0.62(27\%) = 20.5\%$$

g. Now suppose that $\hat{r}_Y$ in Year 12, after the debt ratio was increased, had actually been 0%. What would the new beta be, based on the most recent 11 years of data (that is, Years 2 through 12)? Does this beta seem reasonable—that is, is the change in beta consistent with the other facts given in the problem?

2B–2 Security Market Line

You are given the following historical data on market returns, $\bar{r}_M$, and the returns on Stocks A and B, $\bar{r}_A$ and $\bar{r}_B$:

Year	$\bar{r}_M$	$\bar{r}_A$	$\bar{r}_B$
1	29.00%	29.00%	20.00%
2	15.20	15.20	13.10
3	−10.00	−10.00	0.50
4	3.30	3.30	7.15
5	23.00	23.00	17.00
6	31.70	31.70	21.35

The risk-free rate, r_{RF}, is 9%. Your probability distribution for r_M for next year is as follows:

Probability	r_M
0.1	–14%
0.2	0
0.4	15
0.2	25
0.1	44

a. Determine graphically the beta coefficients for Stocks A and B.
b. Graph the Security Market Line, and give its equation.
c. Calculate the required rates of return on Stocks A and B.
d. Suppose a new stock, C, with $\hat{r}_C = 18\%$ and $b_C = 2.0$, becomes available. Is this stock in equilibrium—that is, does the required rate of return on Stock C equal its expected return? Explain. If the stock is not in equilibrium, explain how equilibrium will be restored.

Continuous Probability Distributions

WEB EXTENSION 2A

In Chapter 2, we illustrated risk/return concepts using discrete distributions, and we assumed that only three states of the economy could exist. In reality, however, the state of the economy can range from a deep recession to a fantastic boom, and there is an infinite number of possibilities in between. It is inconvenient to work with a large number of outcomes using discrete distributions, but it is relatively easy to deal with such situations with **continuous distributions** because many such distributions can be completely specified by only two or three summary statistics such as the mean (or expected value), standard deviation, and a measure of skewness. In the past, financial managers did not have the tools necessary to use continuous distributions in practical risk analyses. Now, however, firms have access to computers and powerful software packages (including spreadsheet add-ins) that can process continuous distributions. So if financial risk analysis is computerized, as is almost always the case, it is often preferable to use continuous distributions to express the distribution of outcomes.

2A-1 Uniform Distribution

One continuous distribution that is often used in financial models is the **uniform distribution**, in which each possible outcome has the same probability of occurrence as any other outcome; hence, there is no clustering of values. Figure 2A-1 shows two uniform distributions.

Distribution A of Figure 2A-1 has a range of −5% to +15%. Therefore, the absolute size of the range is 20 units, where 1 unit is 1%. Because the entire area under the density function must equal 1.00, the height of the distribution, h, must be 0.05: $20h = 1.0$, so $h = 1/20 = 0.05$. We can use this information to find the probability of different outcomes. For example, suppose we want to find the probability that the rate of return will be less than zero. The probability is the shaded area under the density function from −5% to 0%:

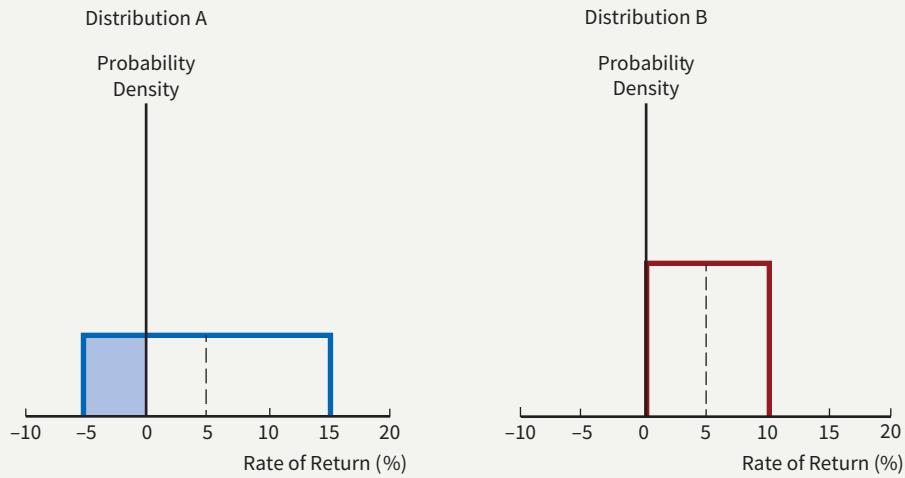
$$\begin{aligned}\text{Area} &= (\text{Right point} - \text{Left point})(\text{Height of distribution})\\ &= [0 - (-5)][0.05] = 0.25 = 25\%\end{aligned}$$

Similarly, the probability of a rate of return between 5 and 15 is 50%:

$$\text{Probability} = \text{Area} = (15 - 5)(0.05) = 0.50 = 50\%$$

The expected rate of return is the mid-point of the range, or 5%, for both distributions in Figure 2A-1. Because there is a smaller probability of the actual return falling far below the expected return in Distribution B, Distribution B depicts a less risky situation in the sense of stand-alone risk.

FIGURE 2A-1 Uniform Probability Distributions

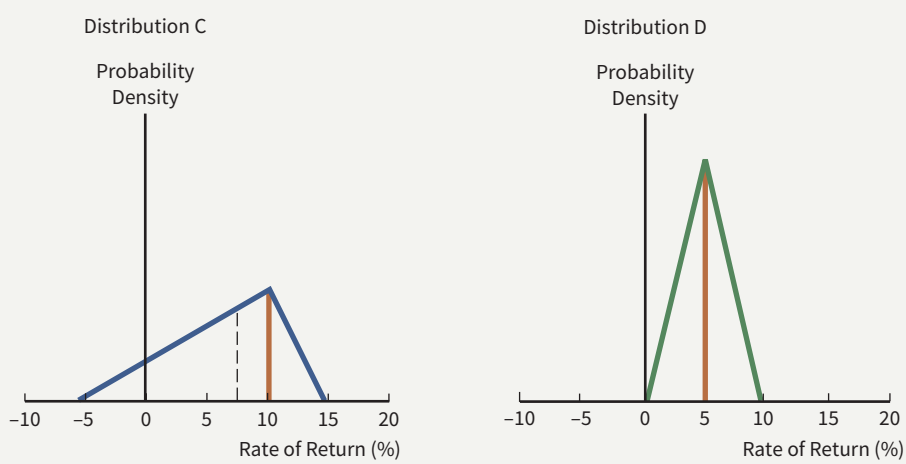


Notes: The expected rate of return for both distributions is $\hat{r} = 5\%$.

2A-2 Triangular Distribution

Another useful continuous distribution is the **triangular distribution**. This type of distribution, which is illustrated in Figure 2A-2, has a clustering of values around the most likely outcome, and the probability of occurrence declines in each direction from the most likely outcome. Distribution C has a range of −5 to +15% and a most likely return of +10%. Distribution D has a most likely return of 5%, but its

FIGURE 2A-2 Triangular Probability Distributions



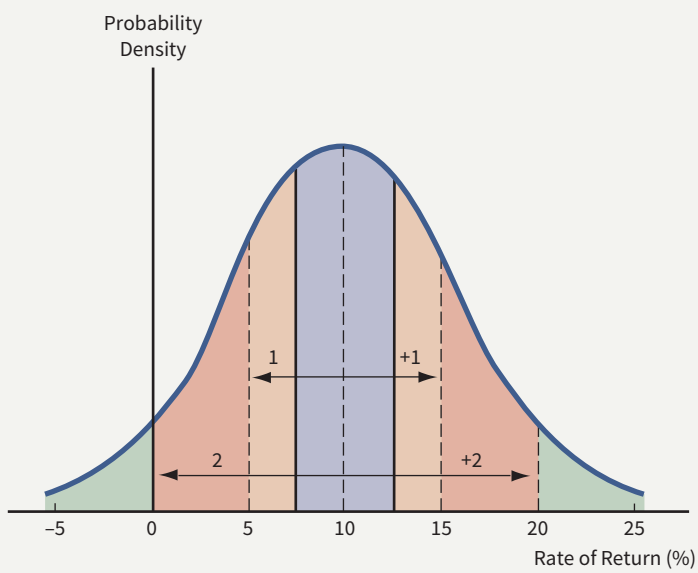
Notes: The most likely rate of return is 10% for Distribution C and 5% for Distribution D; the expected rates of return are $\hat{r}_C = 6.67\%$ and $\hat{r}_D = 5\%$.

range is only from 0 to +10%. Note that Distribution C is skewed to the left, whereas Distribution D is symmetric. The expected rate of return for Distribution C is 6.67%, whereas that of D is only 5%.[1] However, it is obvious that Distribution C is riskier: Its dispersion about the mean is greater than that for Distribution D, and it has a significant chance of actual losses, whereas losses are not possible in Distribution D.

2A-3 Normal Distribution

Because it conforms well to so many real-world situations, the most commonly used continuous distribution is the **normal distribution**. It is symmetric about the expected value, and its tails extend out to plus and minus infinity. Figure 2A-3 is a normal distribution with an expected, or mean (μ, pronounced "mu"), rate of return of 10% and a standard deviation (σ, or sigma) of 5%. Approximately 68.3% of the area under any normal curve lies within $\pm 1\sigma$ of its mean, 95.5% lies within $\pm 2\sigma$, and 99.7% lies within $\pm 3\sigma$. Therefore, the probability of actually achieving a rate of return within the range of 5% to 15% ($\mu \pm 1\sigma$) is 68.3%, and so forth. Obviously, the smaller the standard deviation, the smaller the probability of the actual outcome deviating much from the expected value; hence, the smaller the total risk of the investment.

FIGURE 2A-3 Normal Probability Distribution



Notes: The most likely and expected rates of return are both 10%.

[1]Note that the most likely outcome equals the expected outcome only when the distribution is symmetric. If the distribution is skewed to the left, then the expected outcome falls to the left of the most likely outcome, and vice versa. Also, note that the expected outcome of a triangular distribution is found from the following expression:

$$(\text{Lower limit} + \text{Most likely outcome} + \text{Upper limit})/3$$

Thus, the expected rate of return for Distribution C is $(-5\% + 10\% + 15\%)/3 = 6.67\%$.

If we want to find the probability that an outcome will fall between 7.5% and 12.5%, we must calculate the area beneath the curve between these points, or the shaded area in Figure 2A-3. This area can be determined by numerical integration, or, more easily, by the use of statistical tables of the area under the normal curve, or still more easily, by using the **NORMDIST** function in **Excel**.[2] To use the tables, we first use the following formula to standardize the distribution:

$$z = \frac{x - \mu}{\sigma} \qquad \textbf{(2A–1)}$$

Here z is the standardized variable, or the number of standard deviations from the mean; x is the outcome of interest; and μ and σ are the mean and standard deviation of the distribution, respectively.[3] In our example, we are interested in the probability that an outcome will fall between 7.5% and 12.5%. Because the mean of the distribution is 10 and because it is between the two points of interest, we must evaluate and then combine two probabilities: one to the left and one to the right of the mean. We first normalize these points by using Equation 2A-1:

$$z_{\text{Left}} = \frac{7.5 - 10}{5} = -0.5$$

and

$$z_{\text{Right}} = \frac{12.5 - 10}{5} = +0.5$$

The areas associated with these z-values as found in Table 2A-1 are 0.1915 and 0.1915.[4] This means that the probability is 0.1915 that the actual outcome will fall between 7.5% and 10% and also 0.1915 that it will fall between 10% and 12.5%. Thus, the probability that the outcome will fall between 7.5% and 12.5% is 0.1915 + 0.1915 = 0.3830, or 38.3%.

Suppose we are interested in determining the probability that the actual outcome will be less than zero. We first determine that the probability of an outcome between 0% and 10% is 0.4773 and then observe that the probability of an outcome less than the mean of 10 is 0.5000. Thus, the probability of an outcome less than zero is 0.5000 − 0.4773 = 0.0227, or 2.27%.

---

[2]The equation for the normal curve must be integrated numerically, which makes using tables much more convenient. The equation for the normal curve is:

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(x-\mu)^2/2\sigma^2}$$

where π and e are mathematical constants, μ and σ denote the expected value (or mean) and standard deviation of the probability distribution, respectively, and x is any possible outcome. Even easier than tables are the *Excel* functions NORMSDIST and NORMDIST, which can either evaluate the function f(x) or the area under the curve, depending on the parameters you enter into f(x). NORMSDIST evaluates the f(x) for $\mu = 0$ and $\sigma = 1$, and NORMDIST evaluates it for arbitrary μ and σ. The ***Tool Kit*** for Chapter 5 shows how to use the NORMSDIST function in the context of the Black and Scholes Option Pricing Model.

[3]Note that if the point of interest is 1σ away from the mean, then $x - \mu = \sigma$, so $z = \sigma/\sigma = 1.0$. Thus, when $z = 1.0$, the point of interest is 1σ away from the mean; when $z = 2$, the deviation is 2σ away from the mean; and so forth.

[4]Note that the negative sign on z_{Left} is ignored. Because the normal curve is symmetric about the mean, the minus sign merely indicates that the point of interest lies to the left of the mean.

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TABLE 2A-1 Area under the Normal Curve

z	Area from the Mean to the Point of Interest
0.0	0.0000
0.5	0.1915
1.0	0.3413
1.5	0.4332
2.0	0.4773
2.5	0.4938
3.0	0.4987

Note: Here, z is the number of standard deviations from the mean. Some area tables are set up to indicate the area to the left or right of the indicated z-values, but in our table we indicate the area between the mean and the z-value. Thus, the area from the mean to either z = ±0.5 is 0.1915, or 19.15% of the total area, which is the probability. A more complete set of values can be found in Appendix A of the textbook.

Alternatively, you could use the *Excel* function **NORMDIST** to find the area to the left of a value. For example, **=NORMDIST(0,10,5,True)** returns an answer of 0.02275, which is the probability of getting a return of less than zero from a normal distribution with a mean of 10 and a standard deviation of 5. The fourth argument of the **NORMDIST** function, True, tells the function to find the cumulative probability.

2A-4 Using Continuous Distributions

Continuous distributions are generally used in financial analysis in the following manner.

1. Someone with a good knowledge of a particular situation is asked to specify the most applicable type of distribution and its parameters. For example, a company's marketing manager might be asked to supply this information for sales of a given product, or an engineer might be asked to estimate the construction costs of a capital project.
2. A financial analyst could then use these input data to help evaluate the risk of a given decision. For example, the analyst might conclude that the probability is 50% that the actual rate of return on a project will be between 5% and 10%, that the probability of a loss (negative rate of return) on the project is 15%, or that the probability of a return greater than 10% is 25%. Generally, a computer program would perform such an analysis.

In theory, we should use the specific distribution that best represents the true situation. Sometimes the true distribution is known, but with most financial data it is not known. For example, we might think that interest rates could range from 8% to 15% next year, with a most likely value of 10%. This suggests a triangular distribution. Or we might think that interest rates next year can best be represented by a normal distribution, with a mean of 10% and a standard deviation of 2.5%. The point is that there is simply no type of distribution that is always "best"; you need to be familiar with different types of distributions and their properties, and then you must select the best distribution for the problem at hand.

CHAPTER 2

Risk and Return: Part I

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Topics in Chapter

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

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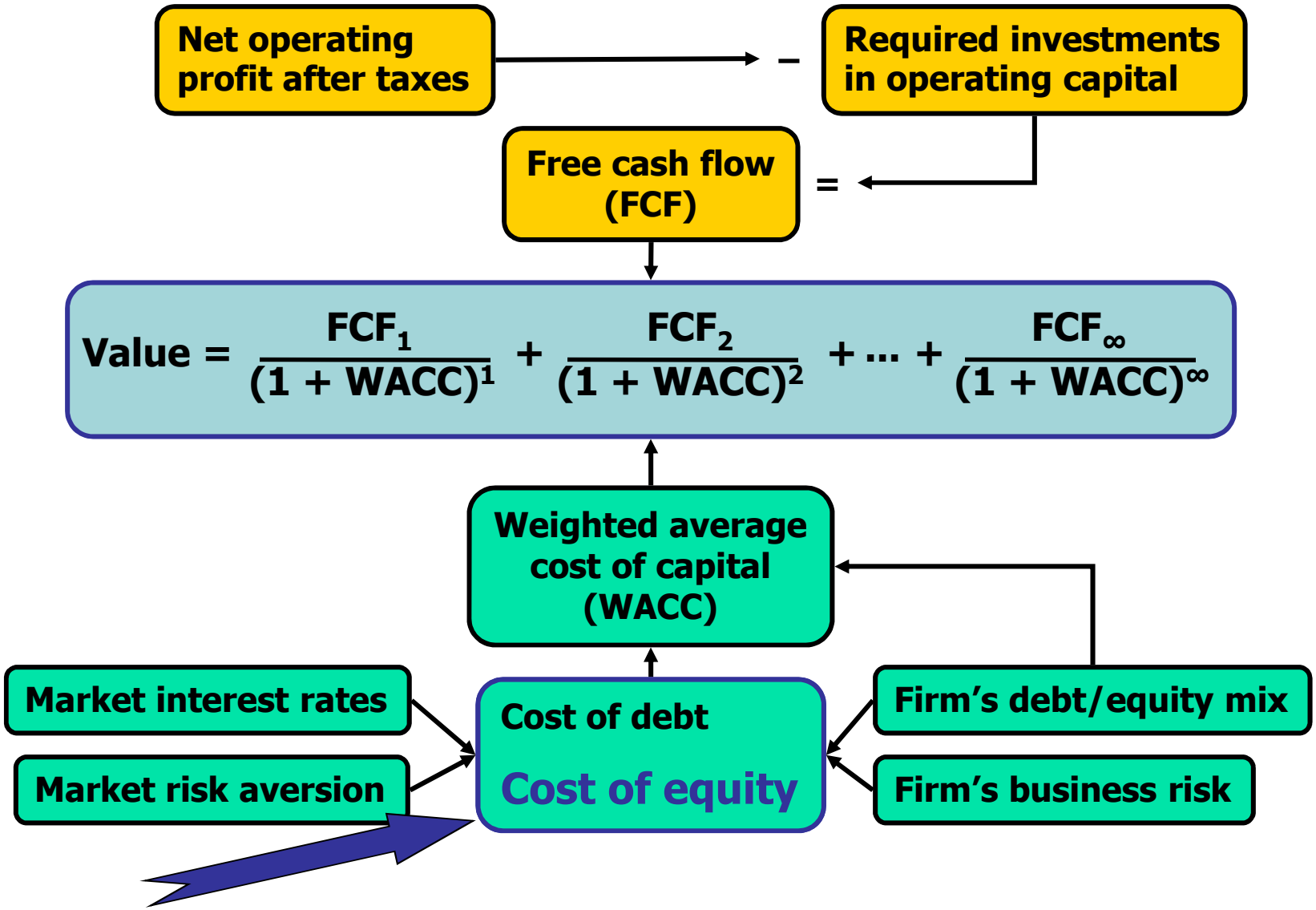
Determinants of Intrinsic Value: The Cost of Equity



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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.

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An investment costs $1,000 and is sold after 1 year for $1,060.

Dollar return:

$ Received - $ Invested

$1,060 - $1,000 = $60.

Percentage return:

$ Return/$ Invested

$60/$1,000 = 0.06 = 6%.

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What is investment risk?

- Investment risk is exposure to the chance of earning less than expected.
- The greater the chance of a return far below the expected return, the greater the risk.

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Scenarios and Returns for the 10-Year Zero Coupon T-bond Over the Next Year

Scenario	Probability	Return
Worst Case	0.10	–14%
Poor Case	0.20	–4%
Most Likely	0.40	6%
Good Case	0.20	16%
Best Case	0.10	26%
	1.00	

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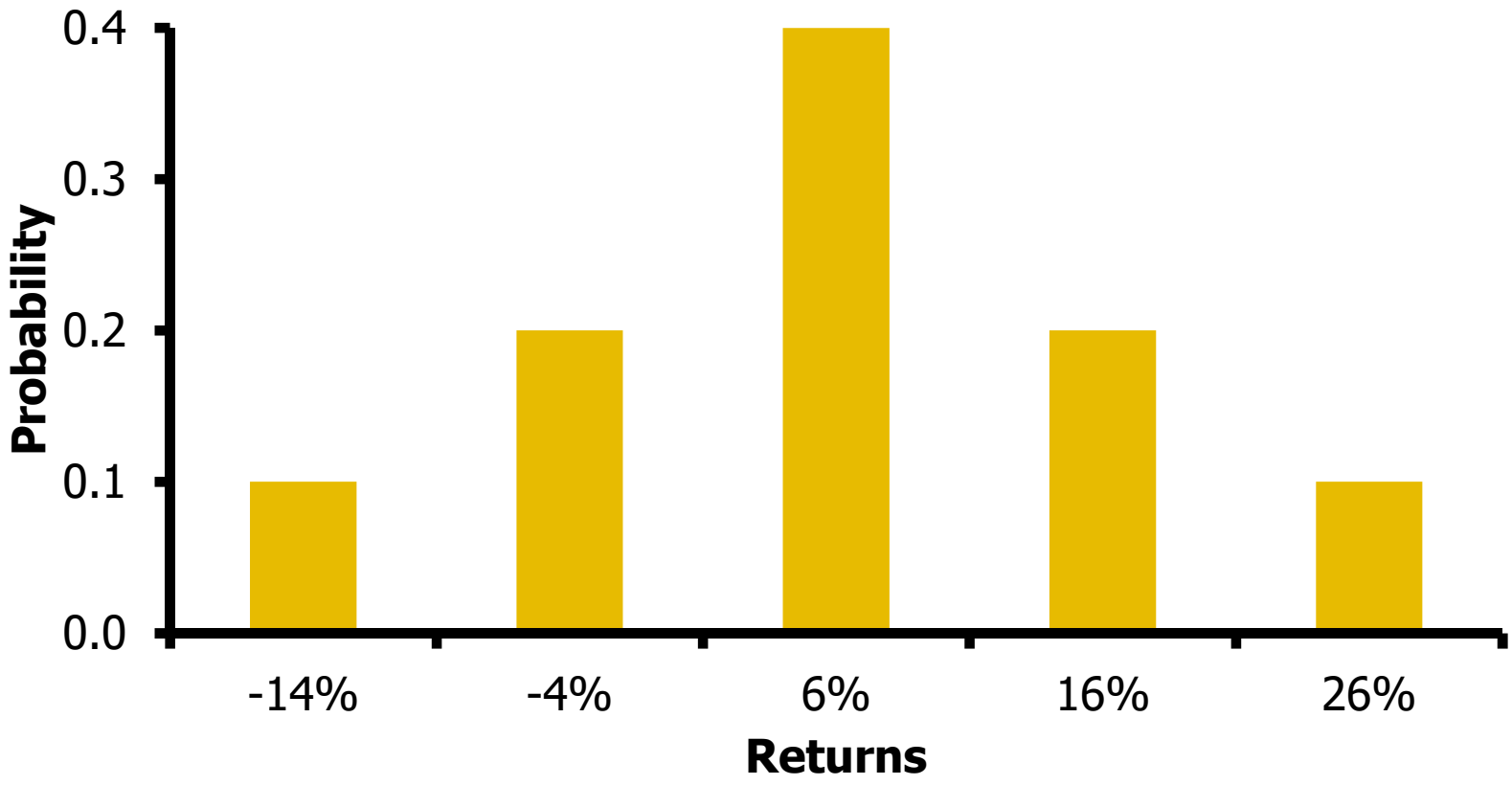
Discrete Probability Distribution for Scenarios



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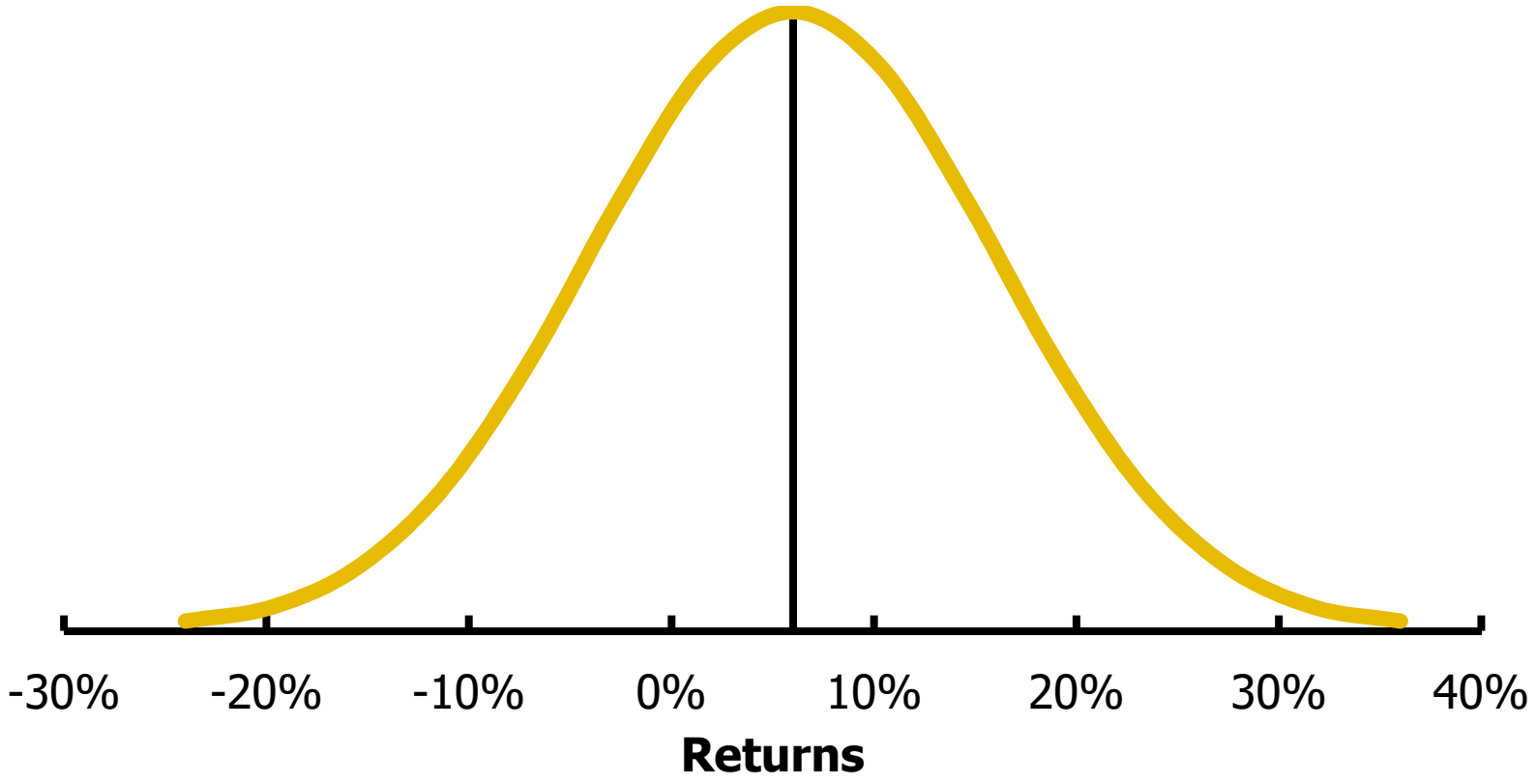
Example of a Continuous Probability Distribution



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Calculate the expected rate of return ($\hat{r}$) on the bond for the next year.

$$\hat{r} = \sum_{i=1}^{n} [p_i r_i]$$

$$\hat{r} = 0.10(-14\%) + 0.20(-4\%) + 0.40(6\%) + 0.20(16\%) + 0.10(26\%)$$

$$\hat{r} = 6\%$$

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Use *Excel* to Calculate the Expected Value of a Discrete Distribution

- $\hat{r}$ = SUMPRODUCT(Probabilities,Returns)
- SUMPRODUCT:
  - Multiplies each value in the first array (the range of cells with probabilities) by its corresponding value in the second array (the range of cells with returns).
  - Sums the products.
  - This is identical to the formula on the previous slide.
- See *Ch02 Mini Case.xlsx*

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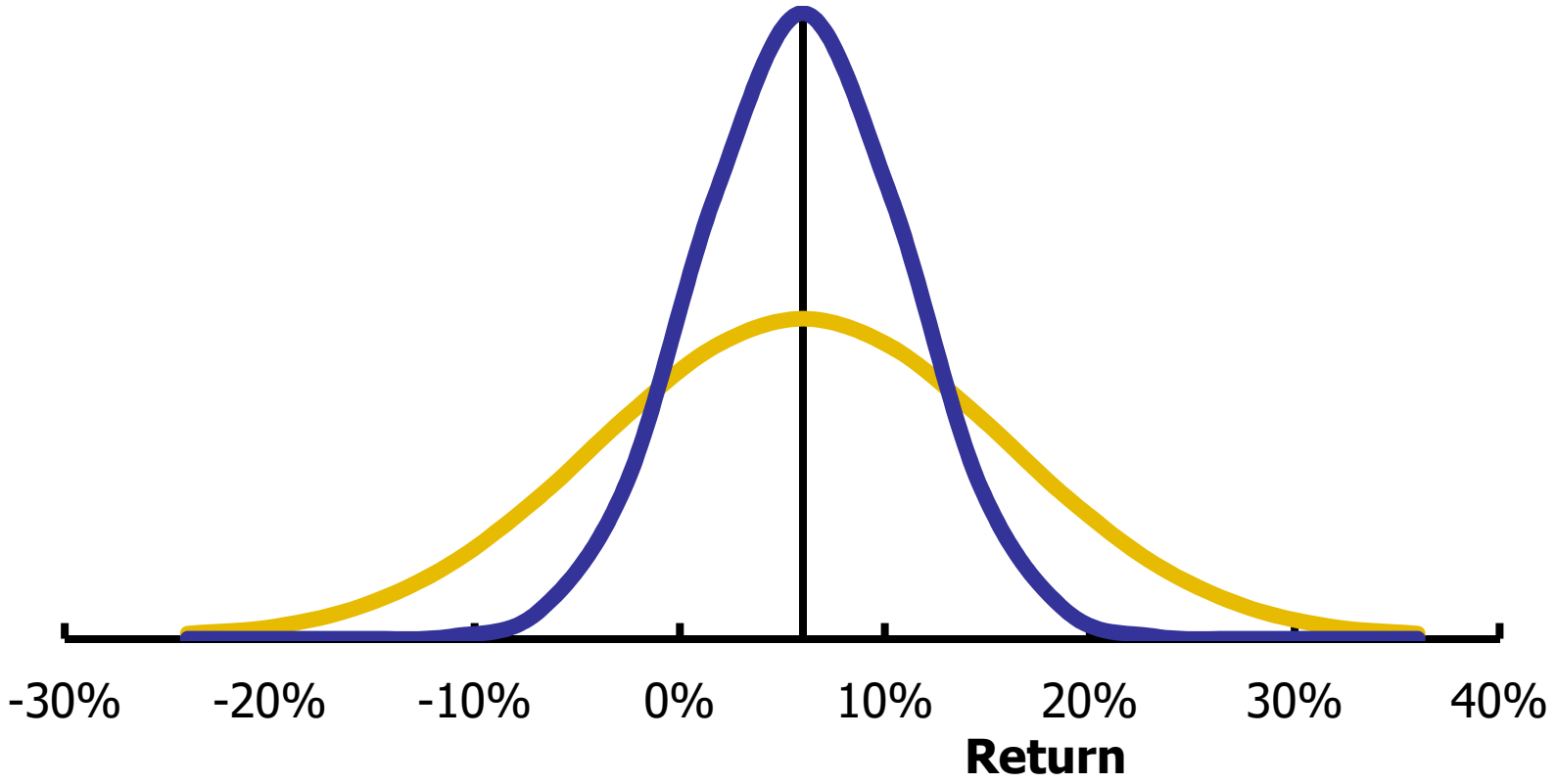
Consider these probability distributions for two investments. Which riskier? Why?



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Stand-Alone Risk: Standard Deviation

- Stand-alone risk is the risk of each asset held by itself.
- Standard deviation measures the dispersion of possible outcomes.
- For a single asset:
  - Stand-alone risk = Standard deviation

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Variance (σ^2) and Standard Deviation (σ) for Discrete Probabilities

$$\boldsymbol{\sigma^2 = \sum_{i=1}^{n} \left[p_i(r_i - \hat{r})^2\right]}$$

$$\boldsymbol{\sigma = \sqrt{\sum_{i=1}^{n} \left[p_i(r_i - \hat{r})^2\right]}}$$

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Standard Deviation of the Bond's Return During the Next Year

$$\sigma^2 = 0.10\,(-0.14 - 0.06)^2 + 0.20\,(-0.04 - 0.06)^2 + 0.40\,(0.06 - 0.06)^2 + 0.20\,(0.16 - 0.06)^2 + 0.10\,(0.26 - 0.06)^2$$

$$\sigma^2 = 0.0120$$

$$\sigma = \sqrt{\sigma^2} = \sqrt{.0120}$$

$$\sigma = 0.1095 = 10.95\%$$

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Use *Excel* to Calculate the Variance and Standard Deviation of a Discrete Distribution

σ^2 = SUMPRODUCT(Probabilities,Returns− $\hat{r}$,Returns−$\hat{r}$)

- SUMPRODUCT:
  - Multiplies each value in the first array (the range of cells with probabilities) by its corresponding value in the second array (the range of cells with returns less the expected return) and by the third array (which is identical to the second array).
  - Sums the products; the result is variance.
- Take the square root of the variance to get the standard deviation. Se*e Ch02 Mini Case.xlsx*

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Understanding the Standard Deviation

- If the returns are normally distributed:
  - Outcome will be more than 1 σ away from $\hat{r}$ about 31.74% ≈ 32% of the time:
    - 16% of the time below $\hat{r}-\sigma$
    - 16% of the time above $\hat{r}+\sigma$.
  - If $\hat{r}$ = 6% and σ =10.95% ≈ 11%:
    - 16% of the time return <−5% = 6% − 11%
    - 16% of the time return > 17% = 6% + 11

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Useful in Comparing Investments

- Investments with bigger standard deviations have more risk.
- High risk doesn't mean you should reject the investment, but:
  - You should know the risk before investing
  - You should expect a higher return as compensation for bearing the risk.

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Using Historical Data to Estimate Risk

- Analysts often use discrete outcomes to analyze risk for projects; see Chapter 13.
- But for investments, most analysts normally use historical data rather than discrete forecasts to estimate an investment's risk unless it is a very special situation.
- Most analysts use:
  - 48 to 60 months of monthly data, or
  - 52 weeks of weekly data, or
  - Shorter period using daily data.
- Use annual returns here for sake of simplicity.

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Formulas for a Sample of T Historical Returns

$$\bar{r}_{Avg} = \left[\sum_{t=1}^{T} \bar{r}_t\right] / T$$

$$\text{Est.}\,\sigma^2 = S^2 = \left[\sum_{t=1}^{T} \left(\bar{r}_t - \bar{r}_{Avg}\right)^2\right] / (T-1)$$

Tedious to calculate by hand, easy in *Excel*. See next slide.

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Excel Functions a Sample of T Historical Returns

Suppose "SampleData" is the cell range with the T historical returns.

$\bar{r}_{Avg}$ =AVERAGE(SampleData)

$\text{Est.}\,\sigma = S$ =STDEV(SampleData)

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Historical Data for Stock Returns

Year	Market	Blandy	Gourmange
1	30%	26%	47%
2	7	15	−54
3	18	−14	15
4	−22	−15	7
5	−14	2	−28
6	10	−18	40
7	26	42	17
8	−10	30	−23
9	−3	−32	−4
10	38	28	75

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Average and Standard Deviations for Stand-Alone Investments

- Use formulas shown previously (tedious) or use *Excel* (easy)
- What is Blandy's stand-alone risk?
- Note: analysts often use past risk as a predictor of future risk, but **past returns are not a good prediction of future returns**.

	Market	Blandy	Gourmange
Average return	8.0%	6.4%	9.2%
Standard deviation	20.1%	25.2%	38.6%

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How risky is Blandy stock?

- Assumptions:
  - Returns are normally distributed.
  - σ is 25.2%
  - Expected return is about 6.4%.
- 16% of the time (approximately), return will be:
  - < −18.8% (6.4%−25.2% = −18.8)
  - > 32.6% (6.4%+25.2% = 32.6)
- Stocks are very risky!

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Portfolio Returns

- The percentage of a portfolio's value that is invested in Stock i is denoted by the "weight" w_i. Notice that the sum of all the weights must equal 1.
- With n stocks in the portfolio, its return each year will be:

$$\bar{r}_{p,t} = \sum_{i=1}^{n} w_i \, \bar{r}_{i,t}$$

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Example: 2-Stock Portfolio

- Form a portfolio by selling 25% of the Blandy stock and investing it in the higher-risk Gourmange stock.
- The portfolio return each year will be:
  - $\bar{r}_{P,t} = w_{Blandy}\left(\bar{r}_{Blandy,t}\right) + w_{Gour.}\left(\bar{r}_{Gour.,t}\right)$
  - $\bar{r}_{P,t} = 0.75\left(\bar{r}_{Blandy,t}\right) + 0.25\left(\bar{r}_{Gour.,t}\right)$

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Historical Data for Stocks and Portfolio Returns

Year	Blandy	Gourmange	Portfolio of Blandy and Gourmange
1	26%	47%	31.3%
2	15	–54	–2.3
3	–14	15	–6.8
4	–15	7	–9.5
5	2	–28	–5.5
6	–18	40	–3.5
7	42	17	35.8
8	30	–23	16.8
9	–32	–4	–25.0
10	28	75	39.8

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Portfolio Historical Average and Standard Deviation

- The portfolio's average return is the weighted average of the stocks' average returns.
- The portfolio's standard deviation is *less* than either stock's σ!
- What explains this?

	Blandy	Gourmange	Portfolio
Average return	6.4%	9.2%	7.1%
Standard deviation	25.2%	38.6%	**22.2%**

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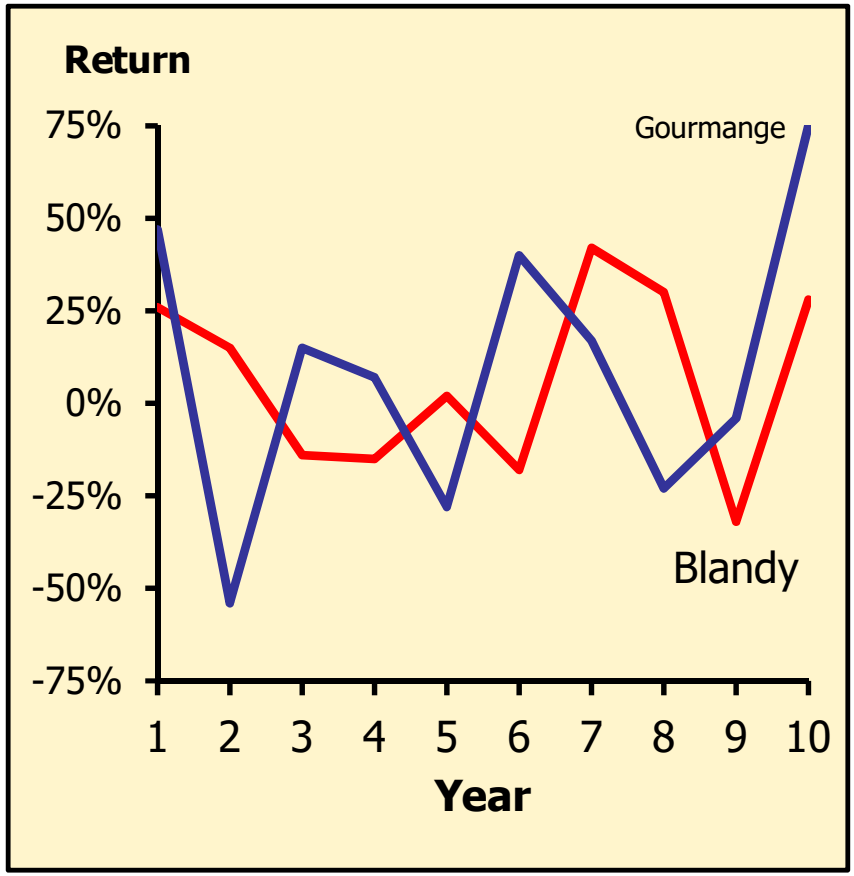
How closely do the returns follow one another?



Notice that the returns don't move in perfect lock-step: Sometimes one is up and the other is down.

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Correlation Coefficient ($\rho_{i,j}$)

- Loosely speaking, the correlation (ρ) coefficient measures the tendency of two variables to move together.
- Estimating $\rho_{i,j}$ with historical data is tedious:

$$\frac{\sum_{t=1}^{T} \left(r_{i,t} - r_{i,Avg}\right)\left(r_{j,t} - r_{j,Avg}\right)}{\sqrt{\sum_{t=1}^{T} \left(r_{i,t} - r_{i,Avg}\right)^2 \sum_{t=1}^{T} \left(r_{j,t} - r_{j,Avg}\right)^2}}$$

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Excel Functions to Estimate the Correlation Coefficient ($\rho_{i,j}$)

"$Stock_i$" and "$Stock_j$" are the cell ranges with historical returns for Stocks i and j.

$$\text{Est. } \rho_{i,j} = R_{ij} = \text{Correl}(Stock_i, Stock_j)$$

Correlation between Blandy (B) and Gourmange (G):

$$\textbf{Est. } \boldsymbol{\rho_{B,G} = 0.11}$$

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2-Stock Portfolios

- $\rho = -1$
  - 2 stocks can be combined to form a riskless portfolio: $\sigma_p = 0$.
- $\rho = +1$
  - Risk is not "reduced"
  - σ_p is just the weighted average of the 2 stocks' standard deviations.
- $-1 < \rho < -1$
  - Risk is reduced but not eliminated.

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Adding Stocks to a Portfolio

- What would happen to the risk of an average 1-stock portfolio as more randomly selected stocks were added?
- σ_p would decrease because the added stocks would not be perfectly correlated.

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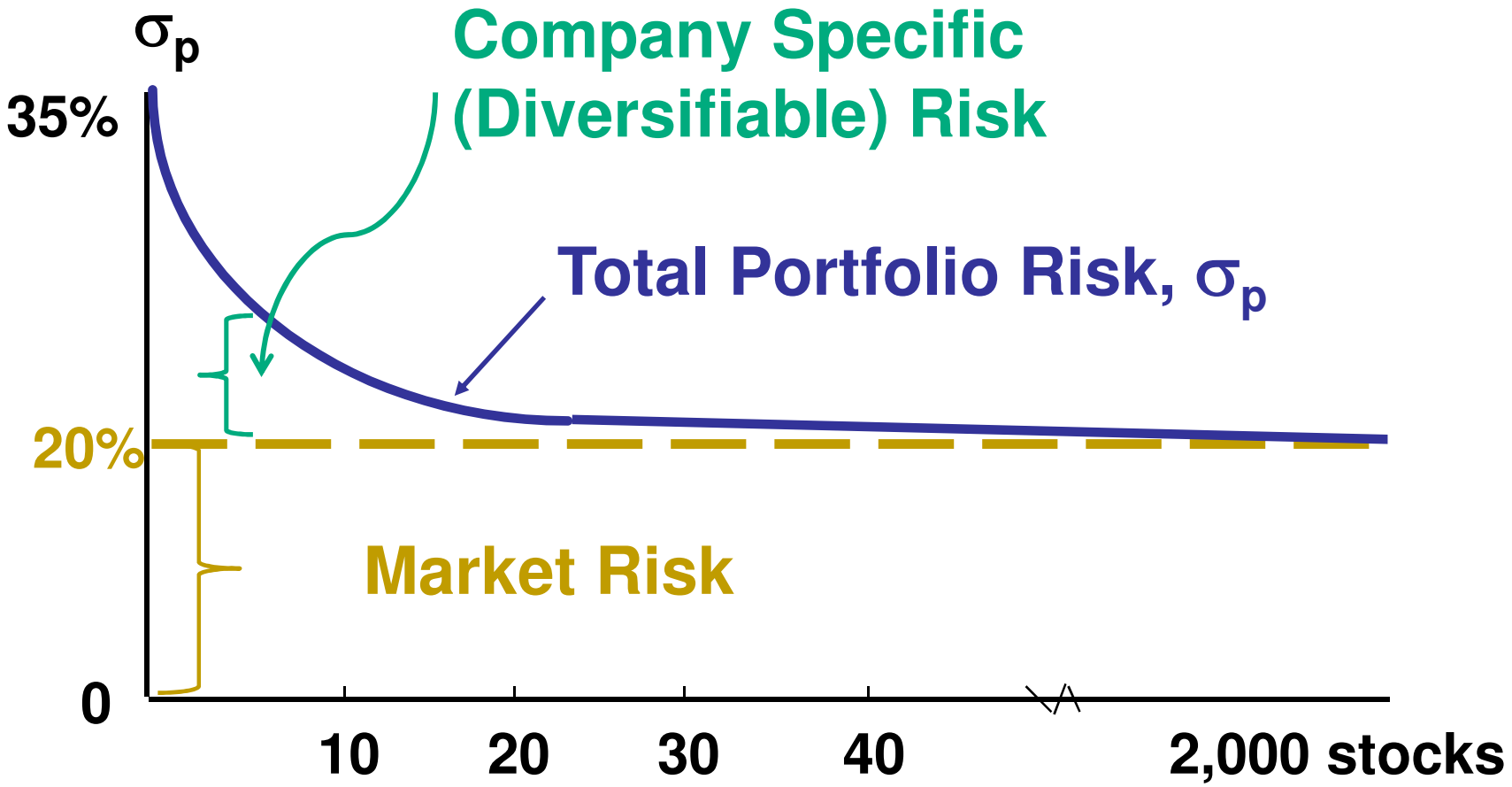
Risk vs. Number of Stocks in Portfolio



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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.

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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% = σ_M .
- By forming well-diversified portfolios, investors can eliminate about half the risk of owning a single stock.

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

- No. Rational investors will minimize risk by holding portfolios.
- Investors bear only market risk, so prices and returns reflect the amount of market risk an individual stock brings to a portfolio, *not the stand-alone risk of individual stock*.

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Market Risk Due to an Individual Stock

- How do you measure the amount of market risk that an individual stock brings to a well-diversified portfolio?
- William Sharpe developed the Capital Asset Pricing Model (CAPM) to answer this question.
- And the answer is….. See next slide.

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Market Risk as Defined by the CAPM

- Define:
  - w_i is the percent of the portfolio invested in Stock i.
  - σ_M is the standard deviation of the market index.
  - $\rho_{i,M}$ is the correlation between Stock i and the market.
- The contribution of Stock i to the standard deviation of a well-diversified portfolio (σ_p) is:

$$\mathbf{w_i\ \sigma_M \left(\frac{\rho_{i,M}\ \sigma_i}{\sigma_M}\right)}$$

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Market Risk and Beta

- The beta of Stock i (b_i) is defined:

$$b_i = \frac{\rho_{i,M}\,\sigma_i}{\sigma_M}$$

- The contribution of Stock i to the standard deviation of a well-diversified portfolio (σ_p) is:

$$w_i\,\sigma_M\,b_i$$

- Given the standard deviation of the market and the percent of the portfolio invested in Stock i, **beta measures the impact of Stock i on σ_p.**

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Market Risk and Beta

- So Stock i contributes more risk (has a higher beta) if
  - its correlation with the market, $\rho_{i,M}$, is larger and/or
  - its stand-alone risk, σ_i, is larger

$$b_i = \frac{\rho_{i,M}\,\sigma_i}{\sigma_M}$$

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Required Return and Risk: General Concept

- Investors require a **return for time** (for tying their funds up in the investment).
  - r_{RF}, the risk-free rate
- Investors require a **return for risk**, which is the extra return above the risk-free rate that investors require to induce them to invest in Stock i.
  - RP_i, the risk premium of Stock i.

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Required Return and Risk: The CAPM

- RP_M is the market risk premium. It is the extra return above the risk-free rate that that investors require to invest in the overall stock market:
  - $RP_M = r_M - r_{RF}$.
- The CAPM defines the risk premium for Stock i as:
  - $RP_i = b_i (RP_M)$

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The Security Market Line: Relating Risk and Required Return

- The Security Market Line (SML) puts the pieces together, showing how to determine the return required for bearing a stock's risk:

$$\text{SML:} \quad r_i = r_{RF} + (RP_M)b_i$$

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The Security Market Line: Relating Risk and Required Return

- Risk depends on beta:

  The part of σ_p due to Stock i = $w_i \sigma_M b_i$

- Required return depends on beta:

$$r_i = r_{RF} + (RP_M) b_i$$

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Correlation Between Blandy and the Market

- Using the formula for correlation or the Excel function =CORREL, Blandy's correlation with the market ($\rho_{B,M}$) is:
  - $\rho_{B,M} = 0.481$

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Beta for Blandy

- Use the previously calculated standard deviations for Blandy and the market to estimate Blandy's beta:
  - $b = \rho_{B,M} (\sigma_B/\sigma_M)$
  - $b = 0.481(.252/.201) = 0.60$
- The average beta is equal to 1.0, so Blandy's stock contributes less risk to a well-diversified portfolio than does the average stock.

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Required Return for Blandy

- Inputs:
  - r_{RF} = 4% (given)
  - R_{PM} = 5% (given)
  - b = 0.60 (estimated)
- $r_i = r_{RF} + b_i (RP_M)$

$$r_i = 4\% + 0.60(5\%) = 7\%$$

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Comparing Risk and Return for Different Stocks

- The beta of an average stock is 1.0; Gourmange's beta is 1.3. How do their required returns compare with Blandy's?

$$r_{Avg_company} = 4\% + 1.0\,(5\%) = 9\%$$
$$r_G = 4\% + 1.3\,(5\%) = 10.5\%$$
$$r_B = 4\% + 0.6\,(5\%) = 7\%$$

- Blandy's stock contributes less risk to a well-diversified portfolio than do Gourmange or the average stock, so Blandy's investors require a lower rate of return.

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Using a Regression to Estimate Beta

- Run a regression with returns on the stock plotted on the Y-axis and returns on the market portfolio plotted on the X-axis.
- The slope of the regression line is equal to the stock's beta coefficient.

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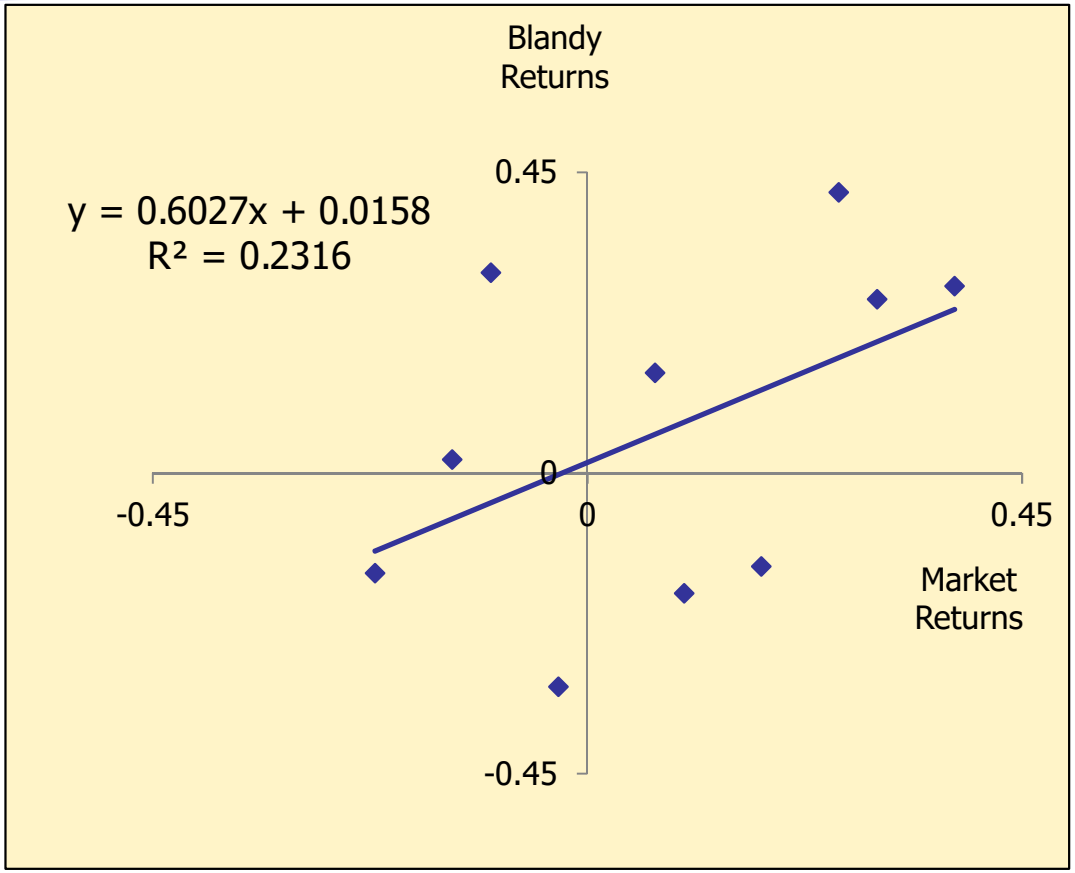
Excel: Plot Trendline Right on Chart



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Estimated Beta from Regression

- The trendline is plotted on the previous slide, including the regression equation.
  - y = 0.6027x + 0.0158
  - b = Slope = 0.6027 (same as before)
- Easier way—use the *Excel* SLOPE function.
  - b =SLOPE(y_values,x_values)

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Web Sites for Beta

- 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.
- www.valueline.com
  - Enter a ticker symbol at the top of the page (registration is free).
- Most stocks have betas in the range of 0.5 to 1.5.

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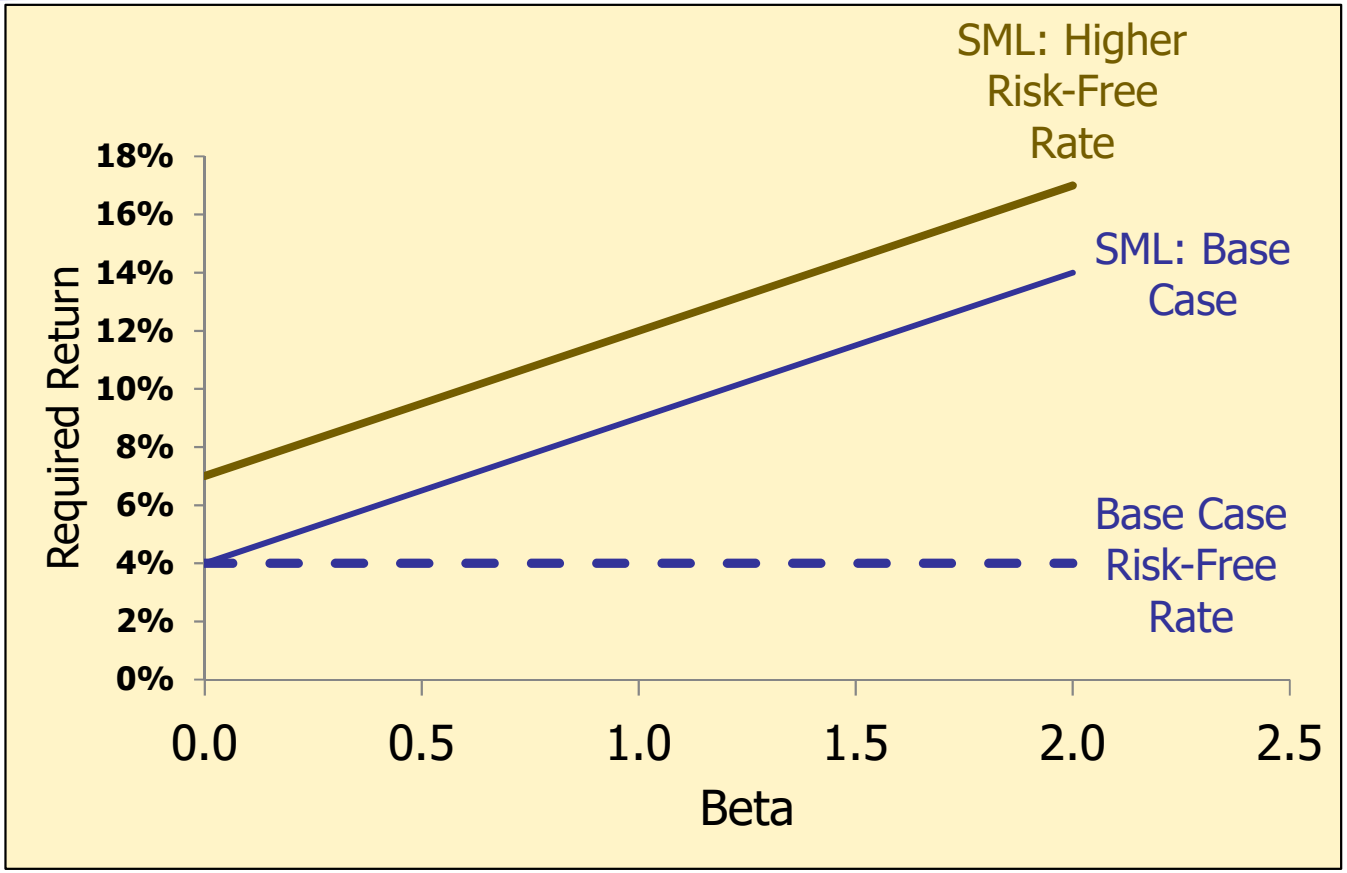
Impact on SML of Increase in Risk-Free Rate



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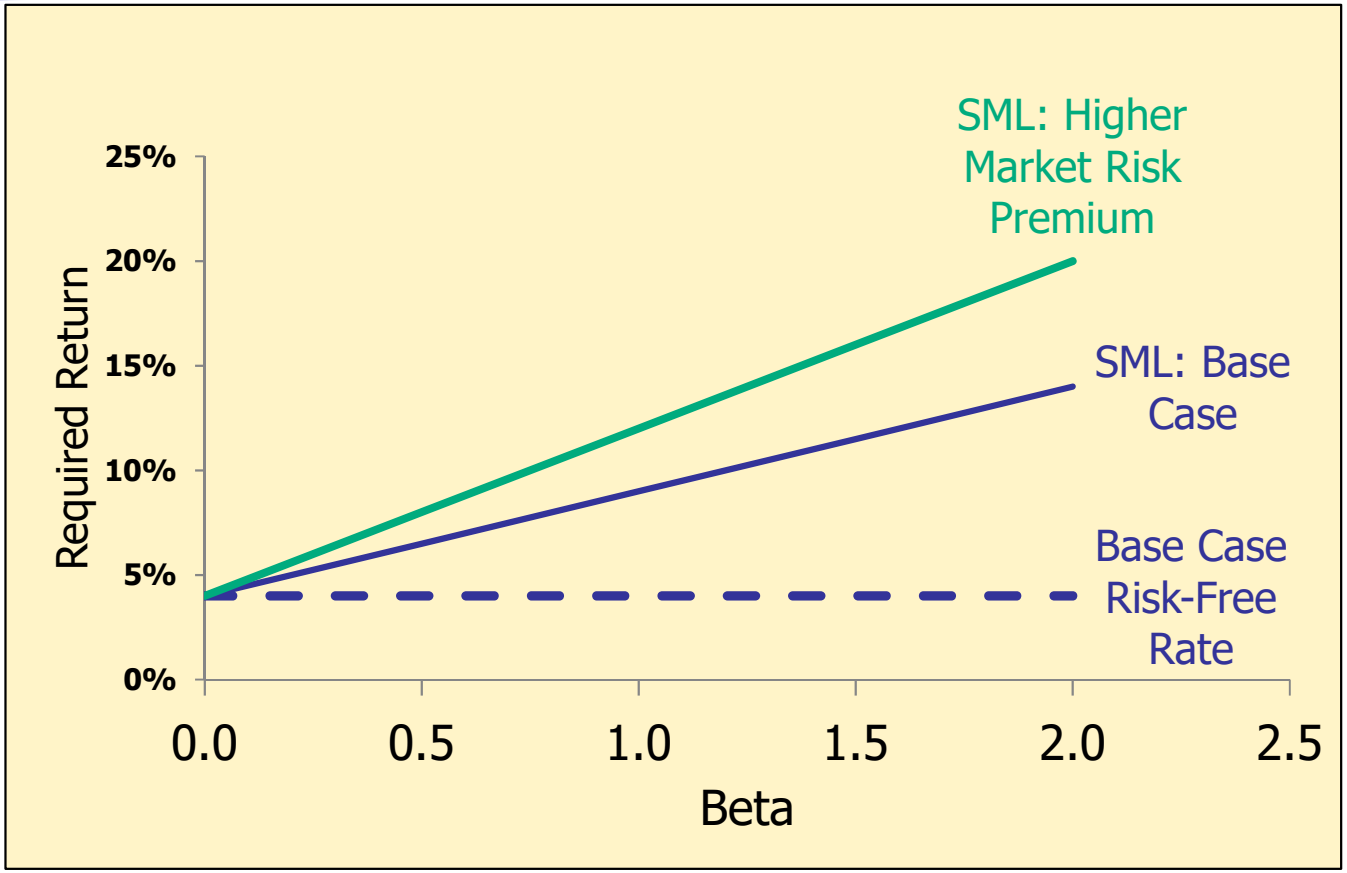
Impact on SML of Increase in Risk Aversion



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Calculate the weights for a portfolio with $1.4 million in Blandy and $0.6 million in Gourmange.

- Find the weights:
  - w_B = $1.4/($1.4+$0.6) = 70%
  - w_G = $0.6/($1.4+$0.6) = 30%
- The portfolio beta is the weighted average of the stocks' betas:

$$\mathbf{b_p = \sum_{i=1}^{n} w_i b_i}$$

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Calculate the portfolio beta.

$$
\begin{aligned}
b_p &= 0.7(b_{Blandy}) + 0.3(b_{Gour.}) \\
&= 0.7(0.60) + 0.3(1.30) \\
&= 0.81.
\end{aligned}
$$

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What is the Required Return on the Portfolio?

(1) Use SML:

$r_p = r_{RF} + b_p (RP_M)$

$= 4.0\% + 0.81\%(5\%) = \mathbf{8.05\%}$.

(2)Use fact that $r_p = \sum_{i=1}^{n} w_i r_i$

$r_p = 0.7(7.0\%) + 0.3(10.5\%)$

$= \mathbf{8.05\%}$.

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Portfolio Performance Evaluation Relative to SML

	Portfolio Manager	
	JJ	CC
Portfolio beta	0.7	1.4
Risk-free rate	4%	4%
Market risk premium	5%	5%
Portfolio required return	7.5%	11.0%
Portfolio actual return	8.5%	9.5%
Over/under performance	**+1.0%**	**–1.5%**

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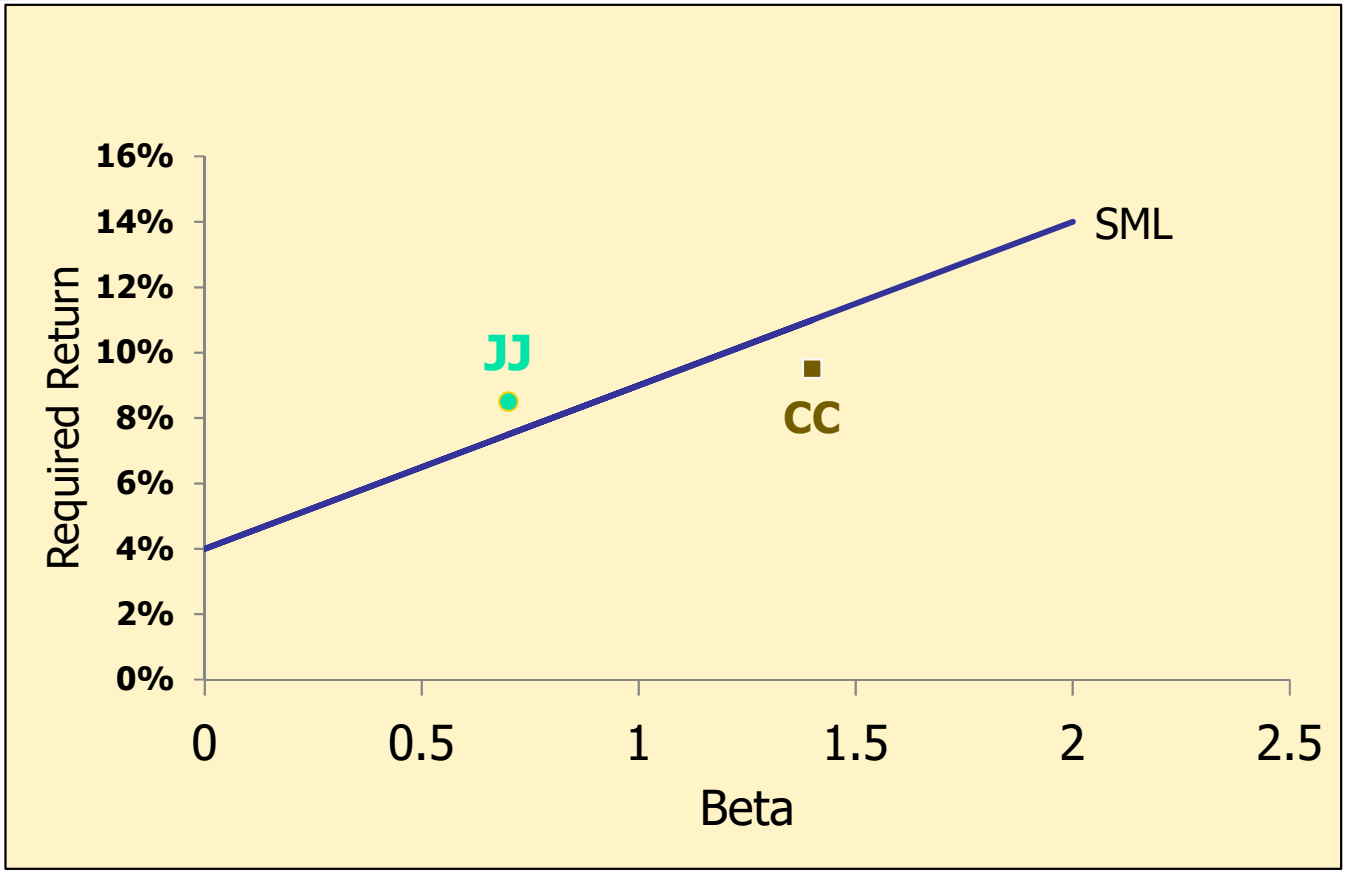
Performance Relative to the SML



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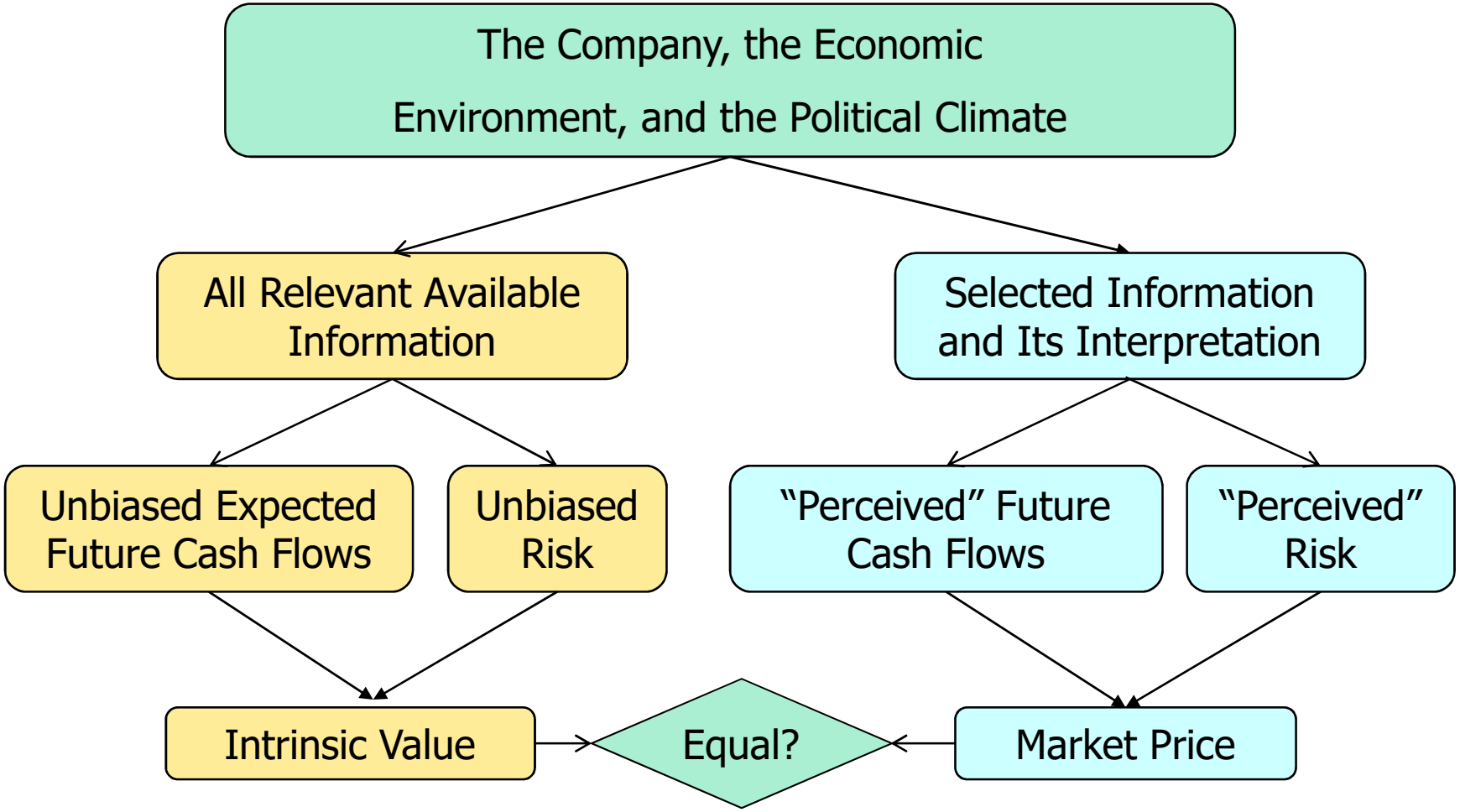
Intrinsic Values and Market Prices



What is required for the market to be in equilibrium?

- The market price of a security must equal the security's intrinsic value (intrinsic value reflects the size, timing, and risk of the future cash flows).

Market price = Intrinsic value

- The expected return a security must equal its required return (which reflects the security's risk).

$$\hat{r} = r$$

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How is equilibrium established?

- If the market price is below the intrinsic value (or if the expected return is above the required return), then the security is a "bargain."
- Buy orders will exceed sell orders, bidding up the market price (which also drives down the expected return, given no change in the asset's cash flows).
- "Profitable" trading (i.e., earning a return greater than justified by risk) will continue until the market price is equal to the intrinsic value.
- The opposite occurs if the market price is above the intrinsic value.

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Efficient Market Hypothesis (EMH): It's all about the info.

- The EMH asserts that when new information arrives, prices move to the new equilibrium price very, very quickly because:
  - There are many really smart analysts looking for mispriced securities.
  - New information is available to most professional traders almost instantly.
  - When mispricing occurs (due to new info or inefficient markets), analysts have billions of dollars to use in taking advantage of the mispricing– which then quickly eliminates the mispricing.

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Implications of Efficient Market Hypothesis (EMH)

- Stocks are normally in equilibrium.
- One cannot "beat the market" by consistently earning a return higher than is justified by a stock's risk.

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Testing the EMH

- Choose a trading strategy and implement it over a large sample.
- Pick an asset pricing model, like the CAPM, and measure the required return of the strategy's investments.
- Measure the actual return.
  - Actual > required? Reject EMH.
- Notice that this is a "joint" test of the EMH and the particular asset model– if the test rejects the EMH, it could be that the asset pricing model is wrong.

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Weak-form EMH

- Current prices already reflect all the information "contained" in past prices, so you cannot earn excess returns with strategies based on past prices.
- Example strategy: Invest in stocks that have declined below their previous 52-week low.
- This is a type of "technical" analysis.

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Weak-form EMH: Empirical Evidence

- Most empirical evidence supports weak-form EMH because very few trading strategies consistently earn in excess of the CAPM prediction.
- Two exceptions with small excess returns:
  - Short-term momentum
  - Long-term reversals

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Semistrong-form EMH

- Current prices already reflect all publicly available information, so you cannot earn excess returns with strategies based on information from financial statements or other public sources.
- Example strategy: Invest in stocks with past 3-year annual earnings growth greater than 10% and a ratio of R&D to sales greater than 10%.
- This is a type of "fundamental" analysis.

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Semistrong-form EMH: Empirical Evidence

- Most empirical evidence supports the semistrong-form EMH.
  - In fact, the vast majority of portfolio managers do not consistently have returns in excess of CAPM predictions.
- Two exceptions that earn excess returns:
  - Small companies
  - Companies with high book-to-market ratios

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Strong-form EMH

- All information, even inside information, is embedded in stock prices so you cannot earn excess returns ever.
- Not true—excess returns can be gained by trading on the basis of insider information.
  - Illegal! Go to jail now!

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Market Bubbles and Market Efficiency

- Market bubbles:
  - Prices climb rapidly to heights that would have been considered extremely unlikely before the run-up.
  - Trading volume is unusually high.
  - Many new investors (or speculators?) eagerly enter the market.
  - Prices suddenly fall precipitously.
- What does this imply about the EMH?

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Bubbles are hard to puncture.

- If there is a bubble, why don't traders take positions that make big profits when the bubble bursts?
  - It is hard to recognize a bubble until after it bursts—then it seems obvious!
  - Trading strategies expose traders to possible big negative cash flows if the bubble is slow to burst.

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Market Efficiency: The Bottom Line

- For most stocks, for most of the time, it is generally safe to assume that the market is reasonably efficient.
- Many investors have given up trying to beat the market, which helps explain the popularity of index funds.
- However, bubbles do occur infrequently.

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The CAPM: The Bottom Line

- Empirical tests of CAPM have statistical problems that make empirical verification or rejection virtually impossible.
- Most corporations use the CAPM to determine their stock's required return.
- Most researchers use multi-factor models to identify the portion of a stock's return that remains unexplained after accounting for the model's factors.

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Has the CAPM been completely confirmed or refuted?

- 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.

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