Chapter 11 Lecture – Risk and Return

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Learning Objectives

After studying this chapter, you should be able to:

LO1 Calculate expected returns.

LO2 Explain the impact of diversification.

LO3 Define the systematic risk principle.

LO4 Discuss the security market line and the risk-return trade-off.

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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 (or any other currency) terms.
  - Percentage terms.

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

- Dollar return:$ Received - $ Invested
  $1,100 - $1,000= $100.
- Percentage return:$ Return/$ Invested
  $100/$1,000 = 0.10 = 10%.

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What is Investment Risk?

- Typically, investment returns are not known with certainty.
- Investment risk pertains to the probability of earning a return less than that expected.
- The greater the chance of a return far below the expected return, the greater the risk.

Risk-averse investors require higher rates of return to invest in higher-risk securities

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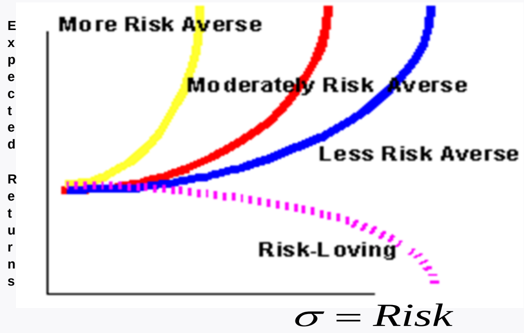
Indifference Curves for Risk Adverse and Risk-Loving Investors



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Expected Returns

- Expected returns are based on the probabilities of possible outcomes

$$E(R) = \sum_{i=1}^{n} p_i R_i$$

Where:

pi = the probability of state "i" occurring
Ri = the expected return on an asset in state i

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Example: Expected Returns

		E(R)			
		Stock A		Stock B	
State (i)	p(i)	E(Ra)	p(i) x E(Ra)	E(Rb)	p(i) x E(Rb)
Recession	0.25	-20%	-5.0%	30%	7.5%
Neutral	0.50	15%	7.5%	15%	7.5%
Boom	0.25	35%	8.8%	-10%	-2.5%
E(R)			11.25%		12.50%

$$E(R) = \sum_{i=1}^{n} p_i R_i$$

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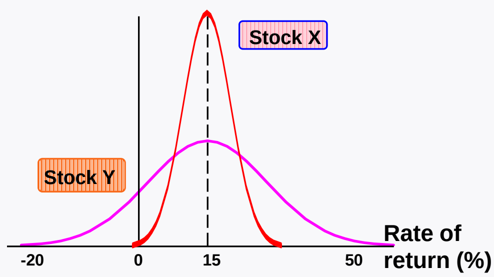
Probability distribution



- Which stock is riskier? Why?

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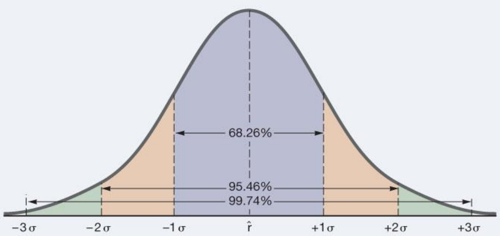

Notes:

a. The area under the normal curve always equals 1.0, or 100%. Thus, the areas under any pair of normal curves drawn on the same scale, whether they are peaked or flat, must be equal.

b. Half of the area under a normal curve is to the left of the mean, indicating that there is a 50% probability that the actual outcome will be less than the mean, and half is to the right of r̂, indicating a 50% probability that it will be greater than the mean.

c. Of the area under the curve, 68.26% is within ±1σ of the mean, indicating that the probability is 68.26% that the actual outcome will be within the range r̂ − σ to r̂ + σ.

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Variance and Standard Deviation

- Variance and standard deviation measure the volatility of returns
- Variance = Weighted average of squared deviations
- Standard Deviation = Square root of variance

$$\sigma^2 = \sum_{i=1}^{n} p_i (R_i - E(R))^2$$

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Variance & Standard Deviation

Variance & Standard Deviation

State (i)	p(i)	E(R)	DEV^2	x p(i)
		Stock A		
Recession	0.25	-20%	0.097656	0.0244141
Neutral	0.50	15%	0.001406	0.0007031
Boom	0.25	35%	0.056406	0.0141016
	1.00			
Expected Return		11.25%		
Variance				0.03921875
Standard Deviation				19.8%

State (i)	p(i)	E(R)	DEV^2	x p(i)
		Stock B		
Recession	0.25	30%	0.030625	0.0076563
Neutral	0.50	15%	0.000625	0.0003125
Boom	0.25	-10%	0.050625	0.0126563
	1.00			
Expected Return		12.50%		
Variance				0.0206
Standard Deviation				14.4%

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Example - Assume the Following Investment Alternatives

Economy	Prob.	T-Bill	Stock Al	Stock Bob	Stock Cuc	Market
Recession	0.10	8.0%	-22.0%	28.0%	10.0%	-13.0%
Below avg.	0.20	8.0	-2.0	14.7	-10.0	1.0
Average	0.40	8.0	20.0	0.0	7.0	15.0
Above avg.	0.20	8.0	35.0	-10.0	45.0	29.0
Boom	0.10	8.0	50.0	-20.0	30.0	43.0
	1.00					

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What is Unique about the Treasury bill Return? What is Correlation?

The T-bill will return 8% regardless of the state of the economy.

Is the T-bill riskless? Explain. Do the returns of Stocks Al, Bob and Cuc move with or counter to the economy? Stock Al moves with the economy, so it is positively correlated with the economy. Positively correlated stocks have rates of return that move in the same direction.

Stock Bob moves counter to the economy. Such negative correlation is unusual. Negatively correlated stocks have rates of return that move in opposite directions.

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Calculate the Expected Rate of Return on Each Alternative.

$\hat{r}$ = expected rate of return.

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

$\hat{r}_{Al}$ = 0.10(-22%) + 0.20(-2%) + 0.40(20%) + 0.20(35%) + 0.10(50%) = 17.4%.

	$\hat{r}$
Market	15.0
Cuc	13.8
T-bill	8.0
Bob	1.7

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

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What is the Standard Deviation of Returns for Each Alternative?

$$\sigma = \text{Standard deviation}$$

$$\sigma = \sqrt{\text{Variance}} = \sqrt{\sigma^2} = \sqrt{\sum_{i=1}^{n}\left(r_i - \hat{r}\right)^2 P_i}.$$

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

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

$\sigma_{Bob} = 13.4$

$\sigma_{Cuc} = 18.8$

$\sigma_{Market} = 15.3\%$

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

Al:

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

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

σ_{Al} = 20.0%.

σ_{Bob} = 13.4%.

σ_{Cuc} = 18.8%.

σ_{Market} = 15.3%.

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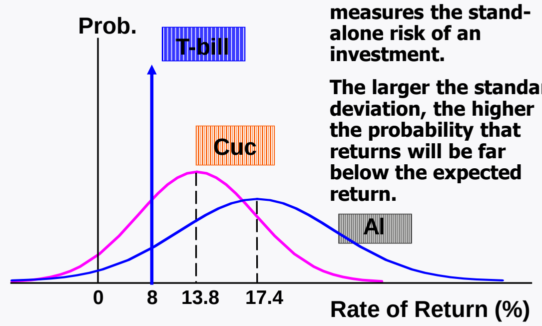

Standard deviation measures the stand-alone risk of an investment.

The larger the standard deviation, the higher the probability that returns will be far below the expected return.

An alternative measure of stand-alone risk is the Coefficient of Variation (CV). CV = Standard deviation/expected return

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Expected Return versus Risk versus Coefficient of Variation

Security	Expected return	Risk, σ
Al	17.4%	20.0%
Market	15.0	15.3
Cuc	13.8	18.8
T-bills	8.0	0.0
Bob	1.7	13.4

$CV_{T\text{-}bills}$ = 0.0%/8.0% = 0.0.
CV_{Al} = 20.0%/17.4% = 1.1.
CV_{Bob} = 13.4%/1.7% = 7.9.
CV_{Cuc} = 18.8%/13.8% = 1.4.
CV_{Market} = 15.3%/15.0% = 1.0.

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Portfolios

- Portfolio = collection of assets
- An asset's risk and return impact how the stock affects the risk and return of the portfolio
- The risk-return trade-off for a portfolio is measured by the portfolio expected return and standard deviation, just as with individual assets

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Portfolio Expected Returns

- The expected return of a portfolio is the weighted average of the expected returns for each asset in the portfolio
- Weights (w_j) = % of portfolio invested in each asset

$$E(R_P) = \sum_{j=1}^{m} w_j E(R_j)$$

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Example: Portfolio Weights

Asset	Dollars Invested	% of Pf w(j)	E(Rj)	w(j) x E(Rj)
A	$15,000	29.9%	12.50%	3.735%
B	$8,600	17.1%	9.50%	1.627%
C	$11,000	21.9%	10.00%	2.191%
D	$9,800	19.5%	7.50%	1.464%
E	$5,800	11.6%	8.50%	0.982%
	$50,200	100%		10.000%

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Portfolio Risk
Variance & Standard Deviation

- Portfolio standard deviation is NOT a weighted average of the standard deviation of the component securities' risk
  - If it were, there would be no benefit to diversification.

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Variance and Standard Deviation of Portfolio

The standard deviation of the portfolio return (s_p) or (σ_p)is used as a measure of portfolio risk. For a two-security portfolio, the standard deviation is:

$$\sigma_p = \sqrt{w_A^2\sigma_A^2 + w_B^2\sigma_B^2 + 2\,w_A w_B \rho_{AB}\sigma_A\sigma_B}$$

where σ_A^2 and σ_B^2 are the variances of returns for securities A and B, σ_A and σ_B are their standard deviations, and $\rho_{A,B}$ is the correlation coefficient of the returns between securities A and B.

$$CorrelationCoefficient = \rho_{A,B} = \frac{\sigma^2_{A,B}}{\sigma_A \sigma_B}$$

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Two-Stock Portfolios

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

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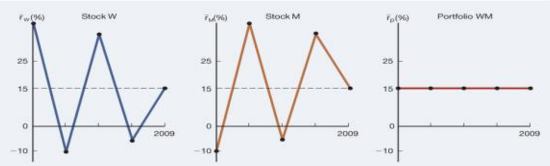
Returns Distribution for Two Perfectly Negatively Correlated Stocks (ρ = -1.0) and for Portfolio WM:



Year	Stock W ($\bar{r}_W$)	Stock M ($\bar{r}_M$)	Portfolio WM ($\bar{r}_P$)
2005	40.0%	(10.0%)	15.0%
2006	(10.0)	40.0	15.0
2007	35.0	(5.0)	15.0
2008	(5.0)	35.0	15.0
2009	15.0	15.0	15.0
Average return	15.0%	15.0%	15.0%
Standard deviation	22.6%	22.6%	0.0%

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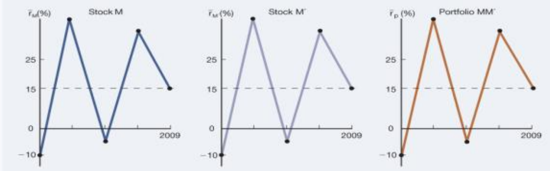
Returns Distribution for Two Perfectly Positively Correlated Stocks (ρ = 1.0) and for Portfolio WM



Year	Stock M ($\bar{r}_M$)	Stock M′ ($\bar{r}_M$)	Portfolio MM′ ($\bar{r}_P$)
2005	(10.0%)	(10.0%)	(10.0%)
2006	40.0	40.0	40.0
2007	(5.0)	(5.0)	(5.0)
2008	35.0	35.0	35.0
2009	15.0	15.0	15.0
Average return	15.0%	15.0%	15.0%
Standard deviation	22.6%	22.6%	22.6%

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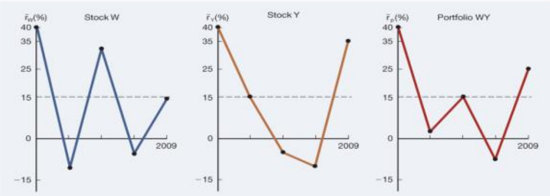
What About These Stocks?



Year	Stock W ($\bar{r}_W$)	Stock Y ($\bar{r}_Y$)	Portfolio WY ($\bar{r}_P$)
2005	40.0%	40.0%	40.0%
2006	(10.0)	15.0	2.5
2007	35.0	(5.0)	15.0
2008	(5.0)	(10.0)	(7.5)
2009	15.0	35.0	25.0
Average return	15.0%	15.0%	15.0%
Standard deviation	22.6%	22.6%	18.6%

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Announcements, News and Efficient markets

- Announcements and news contain both expected and surprise components
- The surprise component affects stock prices
- Efficient markets result from investors trading on unexpected news
  - The easier it is to trade on surprises, the more efficient markets should be
- Efficient markets involve random price changes because we cannot predict surprises

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Returns

- Total Return = Expected return + unexpected return

$$R = E(R) + U$$

- Unexpected return (U) = Systematic portion (m) + Unsystematic portion (ε)
- Total Return = Expected return $E(R)$ + Systematic portion (m) + Unsystematic portion (ε)

$$R = E(R) + m + \varepsilon$$

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Systematic Risk

- Factors that affect a large number of assets
- "Non-diversifiable risk"
- "Market risk"
- Caused by events that affect most stocks similarly
- Is market wide
- Examples would include changes in macroeconomic factors such interest rates, inflation, and business cycle.

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Unsystematic Risk

- = Diversifiable risk
- Risk factors that affect a limited number of assets
- Risk that can be eliminated by combining assets into portfolios
- "Unique risk" or "Asset-specific risk"
  - Example would include litigation, poor management, labor strife, and raw material shortages
- Examples: labor strikes, part shortages, etc.

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Once Again

Total Risk =Market Risk + Diversifiable Risk

Systematic (non- diversifiable) Risk or Market Rick:

- Is caused by events that affect most stocks similarly
- Is market wide
- Examples would include changes in macroeconomic factors such interest rates, inflation, and business cycle.

Non-Systematic (diversifiable) Risk or Firm Specific

- Caused by random events that will effect only one or a few of the assets in a portfolio
- Firm specific
- Example would include litigation, poor management, labor strife, and raw material shortages

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The Principle of Diversification

- Diversification can substantially reduce risk without an equivalent reduction in expected returns
  - Reduces the variability of returns
  - Caused by the offset of worse-than-expected returns from one asset by better-than-expected returns from another
- Minimum level of risk that cannot be diversified away = *systematic portion*

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Standard Deviations of Annual Portfolio Returns

(1) Number of Stocks in Portfolio	(2) Average Standard Deviation of Annual Portfolio Returns	(3) Ratio of Portfolio Standard Deviation to Standard Deviation of a Single Stock
1	49.24%	1.00
2	37.36	.76
4	29.69	.60
6	26.64	.54
8	24.98	.51
10	23.93	.49
20	21.68	.44
30	20.87	.42
40	20.46	.42
50	20.20	.41
100	19.69	.40
200	19.42	.39
300	19.34	.39
400	19.29	.39
500	19.27	.39
1,000	19.21	.39

These figures are from Table 1 in Meir Statman, How Many Stocks Make a Diversified Portfolio? *Journal of Financial and Quantitative Analysis* 22 (September 1987), pp. 353—64They were derived from E. J. Elton and M. J. Gruber, Risk Reduction and Portfolio Size: An Analytic Solution, *Journal of Business* 50 (October 1977), pp. 415—37.

Values depend on how stock are correlated

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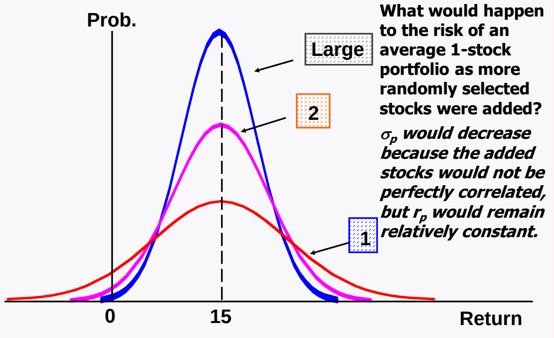

What would happen to the risk of an average 1-stock portfolio as more randomly selected stocks were added?

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

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

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Portfolio 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 $\sigma_p \approx 20\% = \sigma_M$.

➡ Forming well-diversified portfolios can eliminate about half the risk of owning a single stock.

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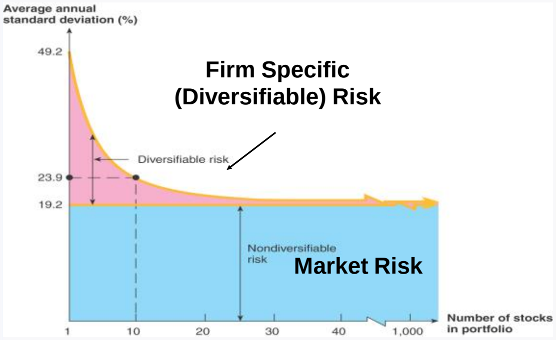
Portfolio Diversification



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Market Risk for Individual Securities

- The contribution of a security to the overall riskiness of a portfolio
- Relevant for stocks held in well-diversified portfolios
- Measured by a stock's beta coefficient, β_j
- Measures the stock's volatility relative to the market

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Interpretation of Beta

- If $\beta = 1.0$, stock has average risk
- If $\beta > 1.0$, stock is riskier than average
- If $\beta < 1.0$, stock is less risky than average
- Most stocks have betas in the range of 0.5 to 1.5
- Beta of the market = 1.0
- Beta of a T-Bill = 0

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Beta Coefficients for Selected Companies

Company	Beta Coefficient (β_j)
Costco	.48
Amazon.com	.72
Yum! Brands	.82
Home Depot	.98
Apple	1.04
Google	1.13
Starbucks	1.28
eBay	1.36
Citigroup	2.47

Sources: finance.yahoo.com, 2012.

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Portfolio Beta

β_p = Weighted average of the Betas of the assets in the portfolio

Weights (w_j) = % of portfolio invested in asset j

$$\beta_P = \sum_{j=1}^{n} w_j \beta_j$$

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Beta and the Risk Premium

- Risk premium = E(R) – R_f
- R_f = return on risk free asset.
- The higher the beta, the greater the risk premium should be
- Can we define the relationship between the risk premium and beta so that we can estimate the expected return?
  - YES!

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Beta and the Risk Premium

- Consider a portfolio made up of Asset with an expected return of $E(R_A)$ = 20% and a beta of β_A = 1.6. Furthermore, the risk-free rate is R_f = 8%. Notice that a risk-free asset, by definition, has no systematic risk (or unsystematic risk), so a risk-free asset has a beta of 0.
- We can calculate some different possible portfolio expected returns and betas by varying the percentages invested in these two assets.
- For example, if 25 percent of the portfolio is invested in Asset A, then the expected return is:

$$E(R_p) = .25 \times E(R_A) + (1 - .25) \times R_f$$
$$= .25 \times 20\% + .75 \times 8\%$$
$$= 11.0\%$$

- Similarly, the beta on the portfolio, β_P, would be:

$$\beta_p = .25 \times \beta_A + (1 - .25) \times 0$$
$$= .25 \times 1.6$$
$$= .40$$

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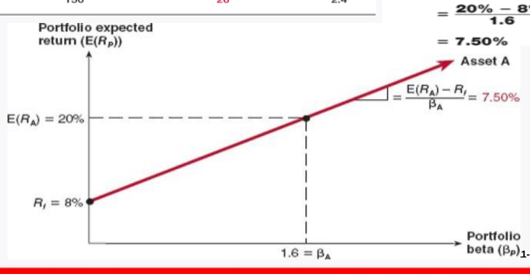
Portfolio Expected Returns and Betas for Asset A

Percentage of Portfolio in Asset A	Portfolio Expected Return	Portfolio Beta
0%	8%	.0
25	11	.4
50	14	.8
75	17	1.2
100	20	1.6
125	23	2.0
150	26	2.4

$$\frac{E(R_p) - R_f}{\beta_p}$$

$$\text{Slope} = \frac{E(R_A) - R_f}{\beta_A} = \frac{20\% - 8\%}{1.6} = 7.50\%$$



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Market Equilibrium

- In equilibrium, all assets and portfolios must have the same reward-to-risk ratio
- Each ratio must equal the reward-to-risk ratio for the market

$$\frac{E(R_A) - R_f}{\beta_A} = \frac{E(R_M - R_f)}{\beta_M}$$

since $\beta_M = 1$, $\frac{E(R_A) - R_f}{\beta_A} = E(R_M - R_f)$

so $E(R_A) - R_f = (\beta_A)E(R_M - R_f)$

or $E(R_A) = R_f + (\beta_A)E(R_M - R_f)$

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The Security Market Line

- The line that results when we plot expected returns and beta coefficients is obviously of some importance, so it's time we gave it a name.
- This line, which we use to describe the relationship between systematic risk and expected return in financial markets, is usually called the security market line, or SML.
- After NPV, the SML is arguably the most important concept in modern finance.

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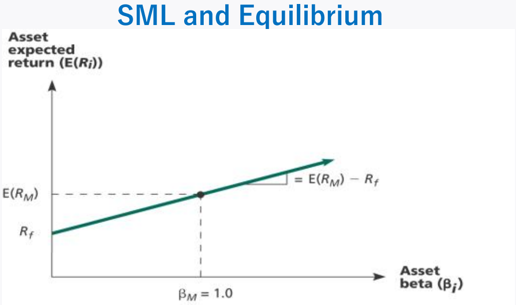
SML and Equilibrium



The slope of the security market line is equal to the market risk premium; i.e., the reward for bearing an average amount of systematic risk. The equation describing the SML can be written:

$$E(R_i) = R_f + \beta_i \times [E(R_M) - R_f]$$

which is the capital asset pricing model (CAPM).

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Security Market Line

- The security market line (SML) is the representation of market equilibrium
- The slope of the SML = reward-to-risk ratio
  $(E(R_M) - R_f) / \beta_M$
- Slope = $E(R_M) - R_f$ = market risk premium
  - Since β of the market is always 1.0

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The SML and Required Return

- The Security Market Line (SML) is part of the Capital Asset Pricing Model (CAPM)

$$E(R_j) = R_f + \left(E(R_M) - R_f\right)\beta_j$$
$$E(R_j) = R_f + \left(RP_M\right)\beta_j$$

R_f = Risk-free rate (T-Bill or T-Bond)
R_M = Market return ≈ S&P 500
RP_M = Market risk premium = $E(R_M) - R_f$
$E(R_j)$ = "Required Return of Asset j"

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Capital Asset Pricing Model

- The capital asset pricing model (CAPM) defines the relationship between risk and return

$$E(R_A) = R_f + (E(R_M) - R_f)\ \beta_A$$

- If an asset's systematic risk (β) is known, CAPM can be used to determine its expected return

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Factors Affecting Required Return

$$R = R_f + \beta_j (E(R_M) - R_f)$$

- R_f measures the pure time value of money
- $RP_M = (E(R_M) - R_f)$ measures the reward for bearing systematic risk
- β_j measures the amount of systematic risk

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SML Example

Required Return

Stock	Beta	Req R
A	1.3	13.35%
B	0.8	11.10%

Assume:	Market Return =	12.0%
	Risk-free rate =	7.5%

$$E(R_j) = R_f + \left(E(R_M) - R_f\right)\beta_j$$

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Quick Quiz

Consider an asset with a beta of 1.2, a risk-free rate of 5%, and a market return of 13%.

– What is the expected return on the asset?

E(R) = 5% + (13% - 5%)* 1.2 = 14.6%

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Using a Regression to Estimate Beta

- Run a regression with returns on the stock in question plotted on the Y axis and returns on the market portfolio plotted on the X axis
- The slope of the regression line, which measures relative volatility, is defined as the stock's beta coefficient, or b.

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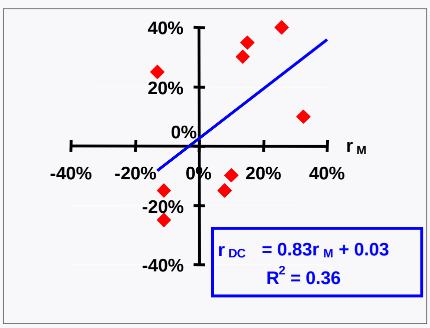
Calculating Beta for DennisCo.

Data on Course Outline



In this example, b = 0.83

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International Diversification

- Including foreign stocks and bonds in a portfolio of U.S. corporate and government securities enhances risk reduction.
- Over a longtime horizon international diversification strategies tend to yield returns superior to those yielded by domestic strategies
- Investors must beware of political risks involved with international investing.

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