

# Part 1: Risk

2023 Nov 9 - 2023 Nov 9

Nemo

## Contents

1 Introduction to Risk and Return .....	2
1.1 Using Historic Data .....	2
1.1.1 Arithmetic Averages and Compound Annual Return .....	2
1.2 Measuring Portfolio Risk .....	2
1.2.1 Variance and Standard Deviation .....	2
1.2.2 How Diversification Reduces Risk .....	2
1.3 Calculating Portfolio Risk .....	2
1.4 How Individual Securities Affect Portfolio Risk .....	2
1.4.1 Market Risk Is Measured by Beta .....	3
1.4.2 Calculating Beta .....	3
<i>Definition 1: Beta</i> .....	3
1.5 Diversification and Value Additivity .....	3

# 1 Introduction to Risk and Return

## 1.1 Using Historic Data

### 1.1.1 Arithmetic Averages and Compound Annual Return

*Moral:* If the cost of capital is estimated from historical returns or risk premiums, use arithmetic averages, not compound annual rates of return.

**Arithmetic Averages** For example the return of a firms stock may be +10%, -10% or +30% the average return is  $\frac{-10+10+30}{3}\% = 10\%$ .

## 1.2 Measuring Portfolio Risk

### 1.2.1 Variance and Standard Deviation

The standard statistical measures of spread are variance and standard deviation.

$$\text{Variance}(\tilde{r}_m) = \frac{1}{N-1} \sum_{i=1}^N (\tilde{r}_m - \bar{r}_m)^2$$

$$\text{Standard deviation of } \tilde{r}_m = \sqrt{\text{variance}(\tilde{r})_m}$$

### 1.2.2 How Diversification Reduces Risk

Diversification reduces portfolio risk because different stocks don't move exactly together, when you invest multiple stocks you can reduce fluctuations.

The risk that can be eliminated by diversification is called *specific risk*. The risk you cannot avoid regardless of how much you diversify is known as *market risk*.

For a well diversified portfolio, only the market risk matters.

## 1.3 Calculating Portfolio Risk

	Stock 1	Stock 2
Stock 1	$x_1^2 \sigma_1^2$	$x_1 x_2 \sigma_{12}$ $= x_1 x_2 \rho_{12} \sigma_1 \sigma_2$
Stock 2	$x_1 x_2 \sigma_{12}$ $= x_1 x_2 \rho_{12} \sigma_1 \sigma_2$	$x_2^2 \sigma_2^2$

The risk of the portfolio is the sum of the boxes, note the  $\rho$  is the correlation coefficient. For portfolio of more stocks, just similar process.

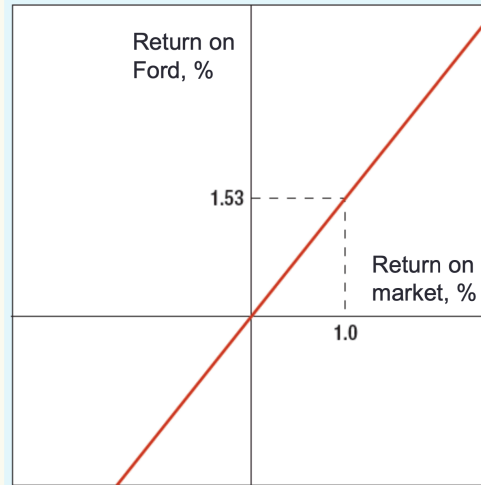
## 1.4 How Individual Securities Affect Portfolio Risk

*The risk of a well-diversified portfolio depends on the market risk of the securities included in the portfolio.*

### 1.4.1 Market Risk Is Measured by Beta

If you want to know the contribution of an individual security to the risk of a well diversified portfolio, you need to measure its *market risk*, and that boils down to measuring how sensitive it is to market movements. This sensitivity is called **beta**  $\beta$ .

- Return on stock changes on average by 1.53% for each additional 1% change in market return
- Beta = 1.53



### 1.4.2 Calculating Beta

#### **Definition 1: Beta**

A statistician would define the beta of stock  $i$  as

$$\beta_i = \frac{\sigma_{im}}{\sigma_m^2}$$

,where the  $\sigma_{im}$  is the covariance of the stock and the market, the  $\sigma_m^2$  is the variance of the market.

## 1.5 Diversification and Value Additivity