Data Analytics in Business

Investing Analytics

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Simple and Compound Returns

Lesson Objectives

At the end of this lesson, you should be able to:

- Understand simple and compound returns
- Use R to calculate these values for a given asset

Analytics Plays a Big Role in Investing

- We typically observe prices of various assets over time and need tools and techniques to describe the data and predict where prices might be going
- Consider this case, which is one of the world's largest mutual finds
  - Between 1980 and 2018, its share price rose from $11.26 to $132.08
- How good was this performance?
  - We can use analytics provide insights into this question

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A Simple Return as a Starting Point

A return is just the percentage change in the stock price from one period to the next

Let's suppose that we have the following data. What is the monthly stock return?

Date	Stock Price
April 2019	$15
May 2019	$17

The stock return is equal to ($17 - $15) /$15 = 13.33%

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A Caveat on Calculating Returns

- In practice, we need to adjust for stock splits and dividends when calculating the return
- The general expression for a return is $r_t = \frac{p_t f_t + d_t}{p_{t-1}}$ -1 where p is the price; f is an adjustment factor for stock splits; and d is the dividend
- Note that stock splits are largely cosmetic events
  - Suppose a company has 1000 shares outstanding and a current price of $20. The total market value of the firm is $20,000. Now suppose the company does a 2 for 1 split. There will be 2000 shares outstanding and the price will be $10. However, the market value is still $20,000

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Example: Calculating Stock Returns for Charles Schwab

Date	Price	Dividend	Stock Split	Return
September 1991	31.125			
October 1991	37.750	$0.06		=(37.750 + 0.06) / 31.25 - 1 = 20.99%
November 1991	32.750			=(32.750) / 37.750 - 1 = -13.25%
December 1991	30.375		3 for 2	=(30.375 * 1.5 / 32.750) - 1 = 39.12%

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Compounded Returns

- We typically hold assets for multiple periods and would like to know our total return over this period
  - The compound return represents the cumulative effect that a series of gains or losses has on an original investment over a period of time
- Compound return = $(r_1 + 1) \times (r_2 + 1) \times \cdots \times (r_n + 1) - 1$
- What's the compounded for Charles Schwab?
  - Compounded Return = (1+.2099)*(1-0.1325)*(1+0.3912) -1= 46%

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Compound Returns: Illustrative Example in R

- We can easily calculate simple and compound returns in R:
  - The code is posted on Canvas
  - Before starting, load the PerformanceAnalytics, xts, and lubridate packages into R
  - Load the contrafund.csv dataset into R. The data has three columns:
    - Date, ContraPrc, and the Market Return
  - Lastly, we need to turn contrafund.csv into a time series (xts) file

```
R code

library(PerformanceAnalytics)
library(xts)
library(lubridate)

# load data and create an xts dataset
fund<-read.csv("contrafund.csv")
fund$Date<-mdy(fund$Date)
fund2<-fund[order(fund$Date),]

#create an xts dataset
All.dat<-xts(fund2[,-
1],order.by=fund2[,1],)
```

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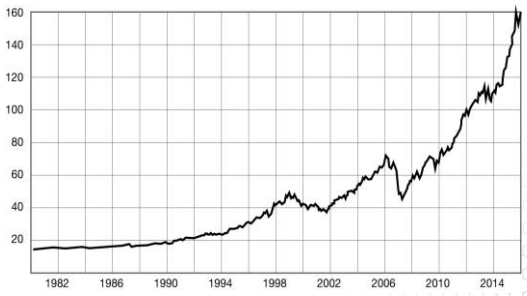
Calculate the Compounded Return

- The function here is Return.cumulative(All.dat$ContraRet, geometric = TRUE)
- The cumulative return is 141.58 implying that the Contrafund has increased 14,158% since 1980!
- We can also look at the compounded return over time using the chart.CumReturns functions:

  chart.CumReturns(All.dat$ContraRet, wealth.index = FALSE, geometric = TRUE)



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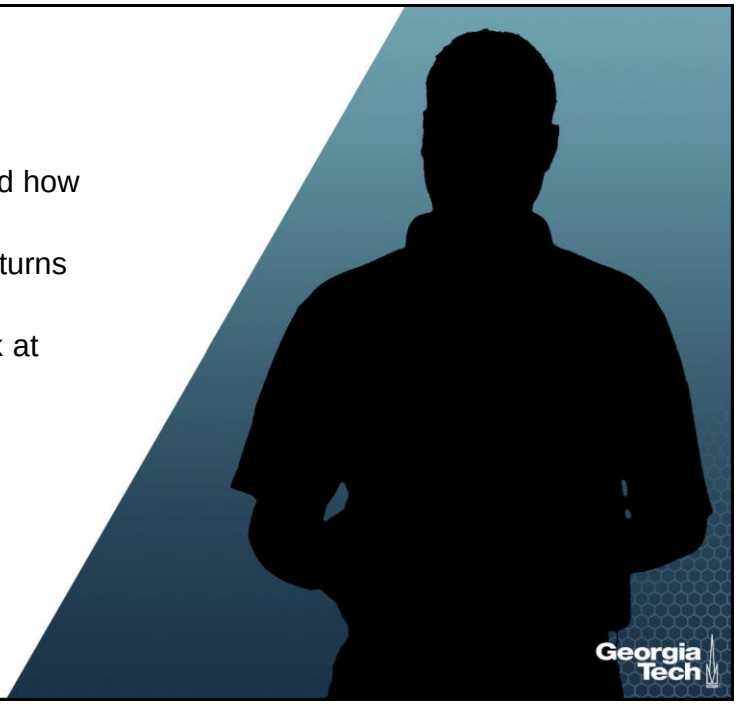
Summary

1. Returns allow us to understand how our investments are growing
2. Both simple and compound returns are informative
3. In the next lesson, we will look at the riskiness of the returns



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Measuring Risk

Lesson Objectives

At the end of this lesson, you should be able to:

- Calculate various measures of risk, including:
  - Standard deviation
  - Beta
  - R^2
  - Drawdown

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Risk *and* Return Matter When Investing

- The risk of the investment also matters
- Investors care about:
  - How much prices will fluctuate (i.e., volatility)
  - The amount of money that they stand to gain or lose

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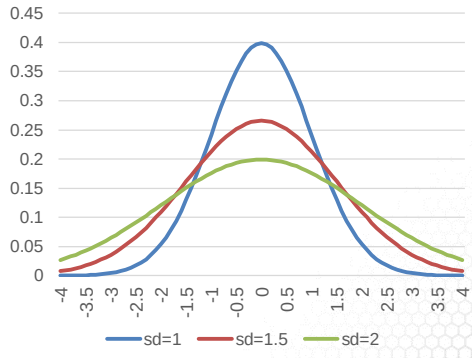
Standard Deviation of Returns

- Standard deviation (SD) measures variation by looking at how far observations are from the mean
  - It's calculated as:

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

- Intuitively, a higher standard deviation indicates a higher level of risk



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Think of Standard Deviation as Total Risk

Total risk has a firm specific and a market wide component:

- Firm specific – good or bad news about the firm
  - A product recall
  - Lawsuit
- Market wide – news about the overall economy
  - Interest rate movements
  - Recession likelihood

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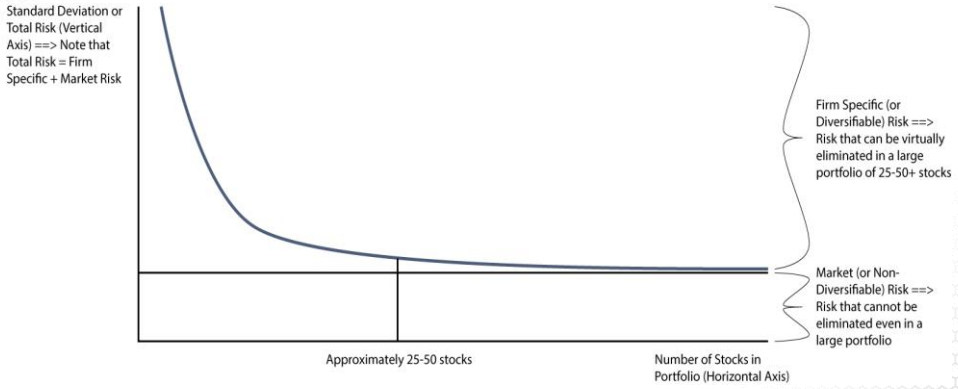
As We Hold More Stocks in Our Portfolio, the Firm-Specific Risk Disappears



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Decompose Risk into Firm-Specific Component and Market-Wide Component

- We can estimate the following regression model:

  $$r_i = \alpha + \beta r_m + \varepsilon$$

  - Where r_m is the return on a broad stock index portfolio, like the S&P 500
  - β is a measure of a stock's sensitivity to overall market movements
- We use the goodness of fit measure, R^2 , from the above regression as a measure of the percentage of the fund's performance that occurs as a result of the market
- Higher R^2 means the fund is more closely correlated with the market

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Interpreting Beta

Higher betas represent high market risk

- A risk free asset has a $\beta = 0$ and the overall stock market has a $\beta = 1$

Company	β
Apple	1.21
Clorox	0.27
Bristol-Myers Squibb	1.37
Netflix	1.81

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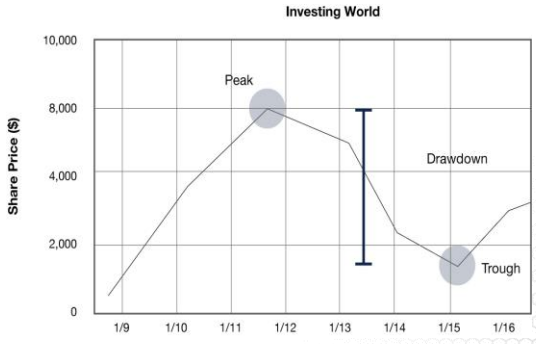
High-Water Mark and Drawdown

- A high-water mark (HWM) is the highest price a fund has achieved in the past
- Drawdown (DD) is the cumulative loss since losses started:
  - $DD_t = \frac{(HWM_t - P_t)}{HWM_t}$
- In other words, drawdown measures the peak-to-trough decline in your investment



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Estimating Mean Return and Standard Deviation

- We will again use the contrafund.csv file and use the same packages as the returns example
- To calculate standard deviation, we can use the table.Stats function
  - table.Stats(All.dat$ContraRet)
  - It's worth noting that the arithmetic mean return is 0.65% and the standard deviation is 4.65% *per month*

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Estimating Beta and R^2

- We can estimate Beta and R^2 via a simple linear model:

  Mod1=lm(ContraRet~Market.Return,= All.dat) summary(mod1)

- The summary regression output is to the right
  - Beta is the coefficient on Market.Return and is 0.9004 indicating that this fund is less risky than average
  - The Adj. R^2 is 0.8313 indicating that this fund is correlated with the overall market

Call:
lm(formula = ContraRet ~ Market.Return, data = All.dat)

Residuals:

Min	IQ	Median	3Q	Max
-0.087523	-0.009502	0.001399	0.010316	0.060957

Coefficients:

	Estimate	Std. Error	t value	Pr (> | t |)
(Intercept)	0.0025419	0.0008485	2.996	0.00288
Market.Return	0.9004602	0.0188912	47.666	< 2e-16

Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01776 on 460 degress of freedom
Multiple R-squared: 0.8316,
Adjusted R-squared: 0.8313
F-statistic: 2272 on 1 and 460 DF
p-value: < 2.2e-16

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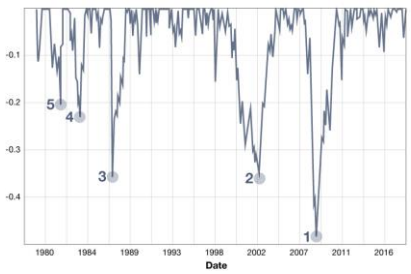
Drawdown

We can plot the drawdowns and show the five largest draw downs using the following functions:

chart.Drawdown(All.dat$ContraRet)

table.Drawdowns(All.dat$ContraRet,top=5,digits=4)



	From	Trough	To	Depth	Length	Trough	Recovery
1	2007-11-30	2009-02-28	2012-02-29	-0.4634	52	16	36
2	1987-09-30	1987-11-30	1989-04-30	-0.3416	20	3	17
3	2000-04-30	2003-02-28	2004-11-30	-0.3324	56	35	21
4	1983-05-31	1984-07-31	1985-03-31	-0.2214	23	15	8
5	1981-06-30	1982-07-31	1982-10-31	-0.1952	17	14	3

- Notice that the largest drawdown occurred between 2007-11-30 and 2009-2-28. The Contra Fund fell 46.34% from its peak. It took 16 months to reach bottom and 36 months to recover. The total episode lasted 52 months

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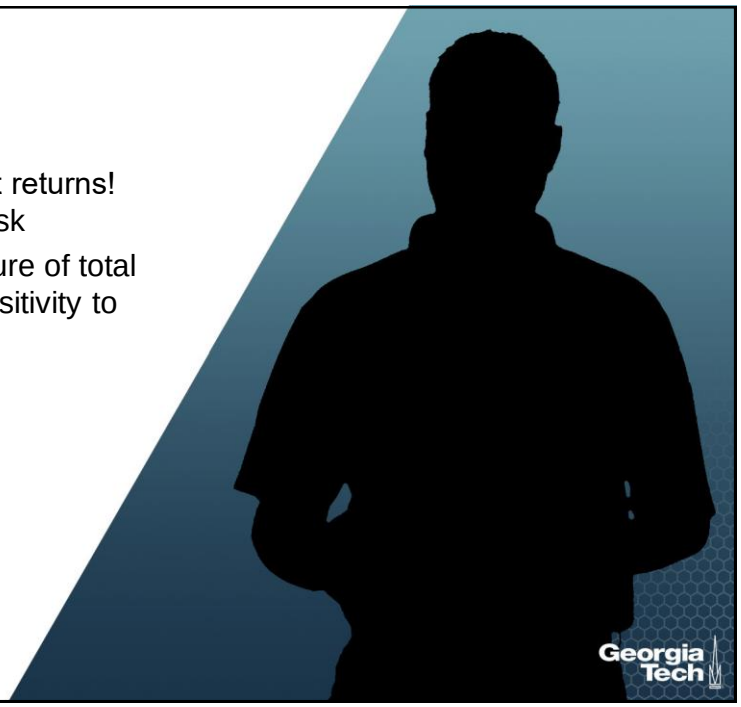
Summary

1. It's not sufficient to look at just returns! We also need a measure of risk
2. Standard deviation is a measure of total risk, while beta measures sensitivity to market movements



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Historical Returns

Lesson Objectives

At the end of this lesson, you should be able to:

- Understand the performance of different asset classes in the U.S. over time
- Observe the relation between risk and return over time

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Asset Classes

For this lesson, we will focus on four asset classes:

1. Small cap stocks: The smallest 30% of stocks traded on U.S exchanges
2. Large cap stocks: The largest 30% of stocks traded on U.S exchanges
3. Treasury Bills: Short-term U.S. Treasury debt
4. Treasury Bonds: Long-term U.S Treasury debt

For benchmark purposes, we will also consider the rate of inflation

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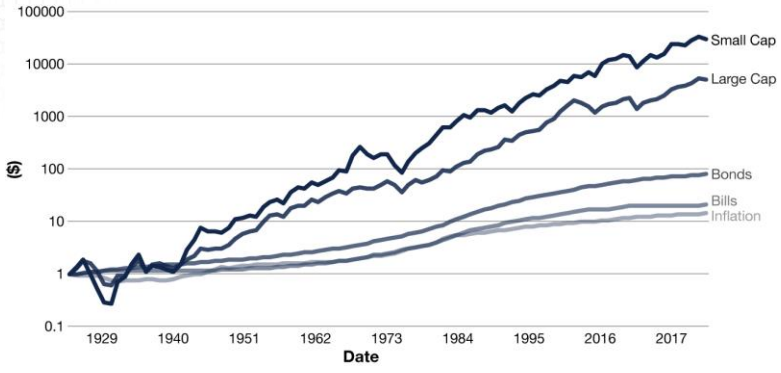
The Value of $1 Invested in Different Asset Classes, 1927 to 2018



- $1 invested in small cap stocks in the beginning of 1927 would have grown to $26,829.83 by 2018

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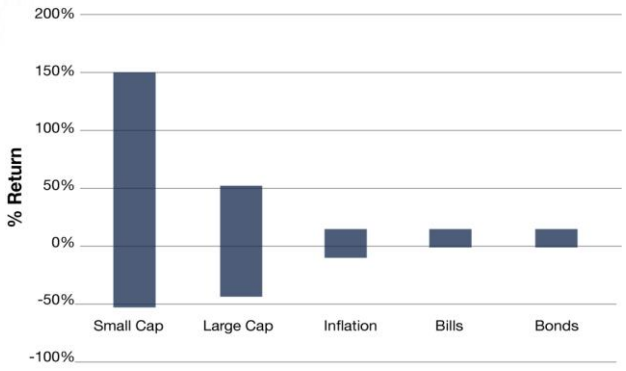
However, the risk is very different

The chart shows the range of annual returns by asset class. Stocks are much riskier than government Treasury Bills and bonds



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Risk versus return for different asset classes

Riskier investments have a higher average annual return, but also a higher standard deviation

	Std. Deviation	Mean
Small Cap	33.27%	16.46%
Large Cap	19.28%	11.20%
Inflation	3.80%	3.10%
Bills	3.17%	3.37%
Bonds	2.80%	4.96%

This chart shows the Average return and standard deviation over the 1927 to 2018 time period

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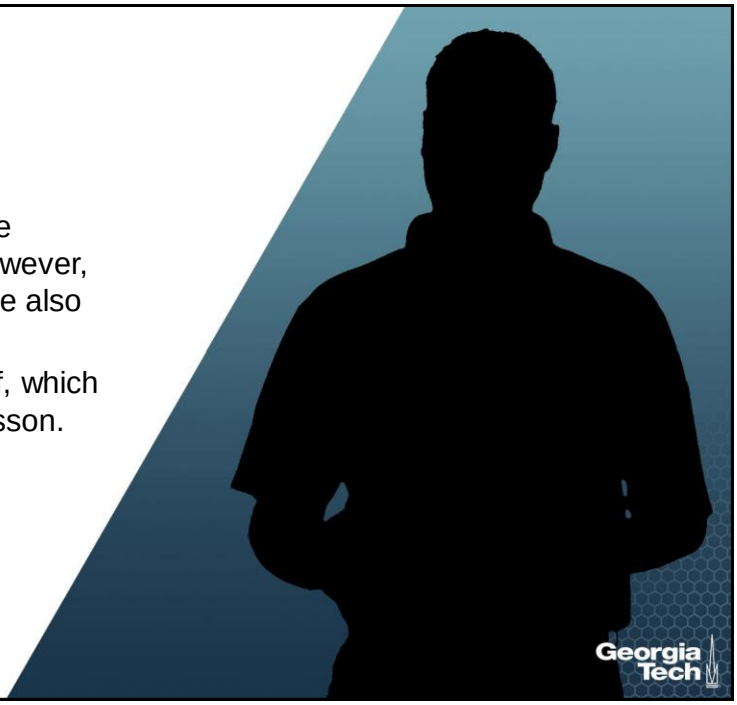
Summary

1. Risk and return are linked.
2. Over time, riskier assets have generated higher returns. However, the year-to-year variations are also larger.
3. This is the risk/return tradeoff, which we will discuss in the next lesson.



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