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4/21

Scribe Notes

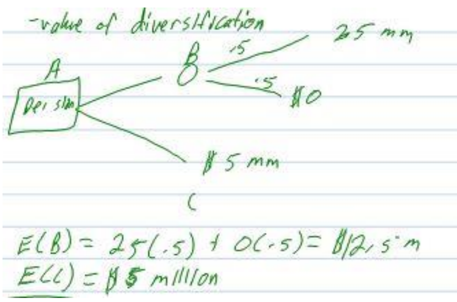
- Homework for this week is due Wednesday
- Capstone hw due next Wednesday is worth 3 hw grades

<u>Main Goals of Class</u>

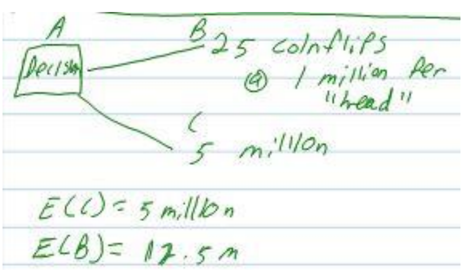
1) Monte Carlo Simulation
    a) Bootstrap resampling- important technique in quantifying uncertainty in portfolio allocation
2) Value of diversification

<u>Coin flip Examples</u>

First scenario-



Second scenario:



The second scenario has the same expected values for nodes B and C; however, it has much lower risk because the variance between outcomes is smaller and there are more independent events involved in the outcome. This applies to portfolio allocation because assets with the same expected values but lower variance are considered safer choices.

We reviewed the lesson from Wednesday using the steps outlined in MonteCarloIntro.R script.

1. First, a riskless asset (compound interest problem)

```
Horizon = 40
ReturnAvg = 0.05

Wealth = 100
# Sweep through each year and update the value of wealth
for(year in 1:Horizon) {
    ThisReturn = ReturnAvg
```

```
        Wealth = Wealth * (1 + ThisReturn)
    }
    Wealth
```

2. Now a risky asset with a positive expected return

```
    ReturnAvg = 0.05
    ReturnSD = 0.05
    Horizon = 40

    Wealth = 100
    # Sweep through each year and update the value of wealth
    for(year in 1:Horizon) {
        # Generate a random return
        ThisReturn = rnorm(1, ReturnAvg, ReturnSD)

        # Update wealth
        Wealth = Wealth * (1 + ThisReturn)
    }
    Wealth
```

These lines represent one simulated investment projection. Now we do 1000 repeated simulations to understand the distribution of terminal wealth using this asset.

```
    ReturnAvg = 0.1
    ReturnSD = 0.15
    Horizon = 40
    sim1 = do(1000)*{
        Wealth = 100
        # Sweep through each year and update the value of wealth
        for(year in 1:Horizon) {
            # Generate a random return
            ThisReturn = rnorm(1, ReturnAvg, ReturnSD)

            # Update wealth
            Wealth = Wealth * (1 + ThisReturn)
        }
        # Output the value of wealth for each simulated scenario
        Wealth
    }
    hist(sim1$result,30)
```

Problems with this assumption: ThisReturn = rnorm(1, ReturnAvg, ReturnSD)

- asset classes are never normally distributed ➔ This leads to systematically underestimating the uncertainty in your investment

- This only considers one asset class

Bootstrap re-sampling

You can correct 2 problems with naïve Monte Carlo Simulations:

1) What to do with huge # of assets?
   a) There is a very complicated correlation structure that is difficult to describe with math models/ distributions.
2) The failure of simple (parametric) distributional assumptions, like normality

"Solution" = bootstrapping

- Let the data themselves stand in for the population
- What would it be like to have a portfolio 50/50 bonds and stocks
- Over the next year, what if every day was a sample from the joint distribution of the returns of that portfolio.
- Pretend that observed set of returns is the population, and that future returns will be draws from the same joint distribution of asset returns

Strategy: resample the "rows" of our past returns matrix

- Use this resampled return to simulate a portfolio's future performance

	Asset 1	Asset 2	Asset 3	Asset D
Day 1	+1 %	-2%	+2%	+3.1%
Day 2	etc	etc	etc	etc
Day N	etc	etc	etc	etc

- This whole list of returns can be thought of as a draw of the joint distribution of these D random variables
- Doesn't require explicit modeling

Using Portfolio.R

- Import closing price data from yahoo servers
- Express each day's return as an implied interest rate in a matrix
- The joint distributions of these stocks cannot be described by normal distributions
- Use bootstrapping rather than sampling from a normal distribution
- Sample a random return from the empirical joint distribution
- This simulates a random day
  - return.today = resample(myreturns, 1, orig.ids=FALSE)
  - # Update the value of your holdings
  - holdings = holdings + holdings*return.today
  - # Compute your new total wealth
  - totalwealth = sum(holdings)

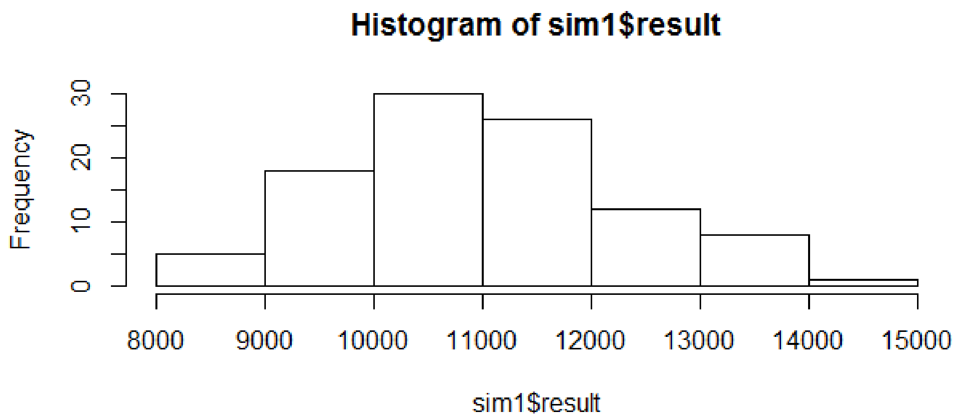
Now loop over a whole trading year

```
totalwealth = 10000
weights = c(0.2, 0.2, 0.2, 0.2, 0.2)
holdings = weights * totalwealth
wealthtracker = rep(0, 250) # Set up a placeholder to track total wealth
for(today in 1:250) {
	return.today = resample(myreturns, 1, orig.ids=FALSE)
	holdings = holdings + holdings*return.today
	totalwealth = sum(holdings)
	wealthtracker[today] = totalwealth
}
totalwealth
plot(wealthtracker)
```

- Plots of the daily returns of a particular stock over time show that there is no clear predictive relationship between daily returns. (Oracle used in class example)
  - There is a small average positive daily return
  - Stock price doubles over 5 years
- Efficient market hypothesis—value of the stock tomorrow is unpredictable using the value of the stock today. The market builds in all useful information that can be used to forecast future performance of the asset; therefore, it must be unpredictable.
- We've looped over a whole trading year
- Simulate 100 possible years
  - Simulate a year, which involves 250 samples
  - Do 100 times

```
sim1 = do(100)*{
	totalwealth = 10000
	weights = c(0.2, 0.2, 0.2, 0.2, 0.2)
	holdings = weights * totalwealth
	wealthtracker = rep(0, 250) # Set up a placeholder to track total wealth
	for(today in 1:250) {
		return.today = resample(myreturns, 1, orig.ids=FALSE)
		holdings = holdings + holdings*return.today
		totalwealth = sum(holdings)
		wealthtracker[today] = totalwealth
	}
	totalwealth
}
```

```
hist(sim1$result)
```



<u>Using Montecarlotips.R</u>

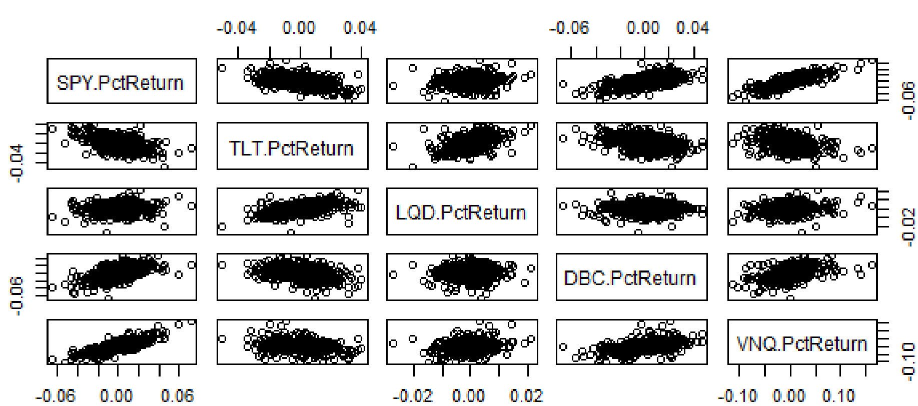
- Build scenarios out of random events
- Use conditional statements

```
x = rnorm(1, mean=0, sd=1)
if(x > 0) {y = 1} else {y = -1}

# You can also split these statements across multiple lines,
# as long as the 'else' is on the same line as the trailing brace from 'if'
x = rnorm(1, mean=0, sd=1)
if(x > 0) {
  y = 1
} else {
  y = -1
}
Y
```

<u>Diversification.R</u>

- Using "SPY", "TLT", "LQD", "DBC", "VNQ" ETFs that reflect 5 broad asset classes
- Joint distribution of the 5 ETFs



Activity at the end of class (continued on 4/23):

- Make 2 portfolios
  - 1) 50% stocks/ 50% real estate
  - 2) 50 % commodities / 50 % government bonds
- What do returns look like over time?
- What is the histogram of the possible distribution of returns after 1 year in the first portfolio and how does it compare to that of the second portfolio?