Hi everyone, my name is Jonathan Clarke, I'm an associate professor

in the finance group at the Scheller College of Business, and I'm gonna be

teaching the investing analytics portion of the data analytics in business course.

I wanted to take a minute to tell you a little bit about myself and

what were gonna be covering.

So for a brief bio, my PhD is in finance from the University of Pittsburgh.

My research is in the intersection of investment banking, and also

the behavior of professional investors like security analyst sell side analyst.

I've published in a number of premier academic journals including the Journal of

finance, Journal of financial economics and management science.

I've been named to the Poets and

Quants 2018 list of Top 50 Undergraduate Business Professors.

I also teach actively at the NBA level and won the 2009 and 2013,

MBA corps Professor of the Year award.

And lastly, I serve on the editorial board of the Financial Review and

also on the board of the Eastern Finance Association.

In addition, I've taught executive education courses for

a number of companies ranging from Bank of America,

Coca Cola, Georgia Pacific to Lockheed Martin.

During our time together, I'm going to introduce the use of analytics and

investing.

And this discussion is going to be broken into three main parts, measuring risk and

return for both individual stocks and for mutual funds.

We're gonna talk a little bit about measuring risk adjusted performance and

market efficiency.

And as a final step, we're gonna talk about the factors that drive returns.

These topics I think will be a of interest to anybody that's

has an interest in pursuing a career in finance.

Or even anybody that's saving for retirement and

wants to know something about how to invest their money.

So I look forward to helping you learn this material.

Thanks.

[MUSIC]

Welcome everybody to this lesson in the investing analytics portion of

the data analytics and business course.

Today what we're gonna focus on is simple and compound returns, which are obviously

very important for understanding how our investments are performing over time.

The objectives for this lesson are that I want you to be able to understand

simple and compound returns, and be able to use R to calculate the values for

simple and compounded returns for a given asset.

So one of the big lessons I hope you take out of the investing analytics portion of

this course is that analytics play a crucial role in investing.

We typically observe prices of various assets over time, and

we need tools and techniques to describe the data and

ultimately predict maybe where prices are heading.

And so consider this case and consider the chart on this slide.

It shows you data on one of the world's largest mutual funds.

In between 1980 and 2018,

its share price rose from $11.26 to $132.08.

And that raises the question of how good was this performance?

And throughout the next several lessons,

we're gonna come back and revisit this mutual fund's performance.

And we're gonna look at ways to quantify both this fund's return,

and also how risky this fund was.

And I'm gonna start off with a very simple example.

A return is really just the percentage change in the stock price from

one period to the next.

So let's suppose that we have the following data.

Monthly data on stock prices.

So in April 2019, the stock price was $15, and

by May 2019, the stock price had gone up to $17.

So what's our return?

Well in this case we take $17, minus the previous month's price of $15,

we divide by $15, and we get that the return is 13.33%.

So that's a simple enough calculation.

But in finance, we really have to worry about a couple of other events that can

complicate this calculation.

We have to worry about stock splits and dividends, in the general expression

we have for calculating our return is to calculate the return and period t.

We take the stock price p sub t, adjust for any stock splits via

the split factor that's f of t, we add back in any dividend that was paid,

we divide by the previous period's price and we subtract off one.

And that will allow us to calculate a return in any situation.

If you're not familiar with stock splits, the reason why we need to adjust for

them is they're really just a cosmetic event.

So let's assume that a company has 1000 shares outstanding and

the price is currently $20.

Well in this case, the total size of the company,

of the market value of the company is $20,000.

It's a 1000 shares times the $20 stock price.

Now suppose this company does a stock split,

suppose they do a 2 for 1 stock split, well in this case,

there will now be 2000 shares outstanding and the price will be 10 bucks a share.

But if you take the 2000 shares outstanding times the $10 a share,

the market value is still $20,000, that is the stock price.

The stock split really hasn't changed anything.

So let's take a look at how this works in practice.

And so what you're looking at is stock price data for Charles Schwab,

now I found four months, way back in 1991,

where Charles Schwab experienced both a dividend and a stock split.

And I want to show you how we adjust for that, so

let's take October 1991 as an example.

Charles Schwab stock price was $37.75.

They paid a six cent dividend.

So we're going to add those two numbers together.

And then we're going to divide by the September 1991 price of $31.25.

We subtract off 1, we get that Charles Schwab had a really good month,

their return was 20.99%.

So let's go to November 1991.

Now November 1991, there were no dividends, no stock splits.

So we don't really have to worry about that, and to calculate a return in this

case, we just take the $32.75 in November,

and we divide by $37.75, the October price, subtract off one.

And it wasn't such a good month for

Charles Schwab, their return was a negative 13.25%.

Now when we get to December 1991, Charles Schwab stock price is $30.375.

And if we compare that to November, it looks like the stock went down,

it looks like in experienced a negative return.

But the important thing to notice here is that Charles Schwab had a stock split,

they did a 3 for 2 stocks split, and we need to adjust for that.

And the way we adjust for that is we take the price of $30.375, and

we multiply it by the split factor, the split

factor is always the top number divided by the bottom number in the stock split.

So a 3 for 2 stock split gives us a split factor of 1.5.

And when we take 1.5 and multiply it by 30.375.

That basically tells us what Charles Schwab's stock price would have been in

December if they hadn't split the stock.

And so once we do that, once we take $30.375 multiplied by the 1.5

split factor and divide it by November's stock price of $32.75 and

subtract off one, we get that Charles Schwab actually had an excellent month.

Their stock return was 39.12% for that month.

And so this slide really shows you the adjustments you need to make to

calculate returns.

We need to adjust for both dividends and stock splits.

And they have a meaningful impact on the returns that we calculate.

Now, if you look at this chart, it really tells us.

Here's how Charles Schwab did in October.

Here's how it did in November.

Here's how it did in December.

But a lot of times as an investor, we want to know if I invested in Charles Schwab at

the beginning of September, how much money or what would my return have been,

if I held the investment through the end of December.

And to calculate that, we need to know how to compound returns.

We typically hold assets over multiple periods, and

sometimes we want to know what our total return is over the entire period.

And that's what the compound return tells us,

the compound return represents the cumulative effect

that a series of gains or losses has on the original investment over time.

So to calculate the compound return, what we do is we take one plus the return in

the first period, times one plus the return in the second period.

And we keep on doing that over however many periods we have.

And then we subtract off one, and that tells us the compound return.

And so to calculate the compound return for Charles Schwab,

what we do is we take 1 plus 20.99% times 1 plus negative

13.25% times 1 plus 39.12%, we subtract off 1.

And over this time period, Charles Schwab had excellent performance,

its compound return was 46%.

So simple and compound returns are both Informative to us,

and compound returns are especially Informative because they tell us

the experience of an investor over time.

And what their gain has been since they started with an investment.

We can calculate compound returns very easily in R.

Now you have sample code and a sample data set posted on canvas where you can try out

calculating compound returns, and you can see the code on the screen here as well.

Before starting out, it's very helpful to look three packages into R.

Performance analytics is a really great package for

working with stock price data, it has lots of useful features.

And we're gonna come back to that package over our upcoming lessons.

XTS is a really helpful package for working with time series data and

creating a time series dataset.

And we have time series data here because we're working with stock returns over

time.

And the lubridate package in R is really helpful for creating dates and

manipulating dates.

So I'm going to load those three packages into R and

the input data set that you have, it really just has three columns,

it has a date The price of the fund,

and the return on the overall stock market.

And what this code does initially is it takes that input data set and

converts it into a time series package.

And once we've done that, once we prepped the data, then we can really calculate

the performance of this fund, we can calculate the compound return.

We can calculate the compound return

very easily in R using the return.cumulative function.

So with this function, the first argument, I point to is the fund return and

when I said geometric equal to true, that compounds returns for us.

And if you do that, in this case, the cumulative return for this fund is 141.58.

And that implies that the fund has increased 14,158% since 1980.

If you want to create a chart of the compound return over time,

we can also do that.

And the function here in R is just chart.Cum.Returns.

And again the first argument that we feed to this function is the return that we're

interested in.

And we'll also set geometric equal to true.

And again, you can see that this fund has had truly

outstanding performance since 1980.

So to summarize this lesson, returns allow us to understand how our investment is

growing over time, and simple returns and compound returns are informative.

And compound returns in particular tell us how our investment

has performed over a time period.

And that's really useful for us to gauge how our investment or

how our wealth has grown over time.

In the next lesson, we're gonna look at the riskiness of returns.

We can't just look at returns in isolation,

we need to understand how risky the returns are.

And that's what we'll tackle in the next lesson.

[MUSIC]

In the previous lesson, we saw how to calculate both simple and

compound returns.

But we can't look at just returns in isolation.

We need to understand something about the risk that we're taking with our

investment.

And that's what we're gonna look at in this lesson,

we're gonna look at different ways to measure risk.

And so at the end of this lesson, you should be able to calculate various

measures of risk including standard deviation, beta, r squared and

draw down and they each tell us something about how risky our investment has been.

And that's gonna be critical,

as we think about investing in different asset classes.

So when we think about return,

it's important to recognize that both risk and return matter.

Investors care about how much prices, how much returns fluctuate.

They care about volatility.

They care about how much they stand to gain or lose.

And so when we think about investment, some investments have very low risk or

sometimes even no risk.

If you think about treasury bonds in this case, they generally tend to be very safe.

Some investments though are very high risk.

You can think about investing in technology companies or pharmaceutical

companies where there's a lot of risk, a lot of uncertainty about payoffs.

And we want some way to quantify risk, and so

our first basic measure of thinking about risk is we can

just calculate the standard deviation of returns.

So the standard deviation really just tells us something about how far away we

are from the mean on average.

And so the standard deviation you can see the formula,

but it really tells us how far we are away from the mean.

So intuitively, what you wanna think about here is that a higher

standard deviation indicates a higher level of risk.

So the chart shows you different distributions,

one with a standard deviation of one.

One with a standard deviation of 1.5 and 1 with a standard deviation of 2.

And you can see the range of outcomes is much higher for

when the standard deviation is 2.

Now when we think about standard deviation, we like to think about

that as being a really good measure of the total risk of a stock or a mutual fund.

So standard deviation is total risk and that total risk has two components to it.

It has a firm specific component and it has a market wide component.

And what I mean by that is firm specific,

you can think about that is good or bad news about the firm.

Maybe the firm has a product recall.

Maybe there's a lawsuit.

Maybe they missed earnings.

Those are sort of firm specific events.

But they're also market wide events.

There's overall news about the economy that can affect the stock.

There can be news about interest rate movements,

there can be news about the likelihood of a recession.

And what we can do is we can actually take that measure of standard deviation

that measure of total risk.

And we can separate it out into a firms specific component,

and then to a market wide component.

And to understand how to do this, or how were gonna do this,

it’s important to note that as we hold more stocks in a portfolio the firm

specific risk starts to disappear and what we're left with is is market risk.

And so what this chart shows you on the x-axis

we have the number of stocks in our portfolio and

it goes from 1 to up to 50 or 100, or could be even 300.

And on the y-axis, we have standard deviation.

And the important thing to note is that as we add stocks to our portfolio,

the standard deviation falls up to a certain point.

As we go from one stock to two stocks or two stocks to three stocks,

the standard deviation falls a lot.

But as we go from 50 stocks to 100 stocks,

the standard deviation doesn't fall as much.

And so what's going on here is that as we move from one stock to two stocks,

to three stocks that firm specific risk is being diversified away.

Some news about a firm might be positive.

Some news about another firm and our portfolio might be negative, and

that just kind of washes out.

So as we add stocks to our portfolio, all we're left with is market risk.

It's the risk that cannot be diversified away.

It's that risk of a recession, that risk of an interest rate change.

Those big macro economic factors.

And so what we want to do, or what we can do, is we can decompose risk for

a firm-specific component and a market wide component.

And we can do that by estimating a fairly simple linear regression model.

The regression model is a simple regression where the dependent

variable is just the return or the fund we're interested in.

And the independent variable is just the return on a broad stock index.

Think like the S&P 500 or the Vanguard Total Stock Market Index.

And beta, the coefficient on the market return that's a measure of a stock

sensitivity to the overall market and we can use that as a measure of risk as well.

Now when we run this regression we'll also get a measure of the goodness of fit the R

squared.

And that tells us the percentage of the funds performance that occurs as a result

of the market.

Sometimes we can also use this as a measure of risk.

A higher R squared means the fund is more closely correlated

with the overall market.

So we can use beta from the previous regression is a measure of risk.

And the important thing to recognize is that higher betas represent high

market risk or high exposure to market risk.

And when we look at betas it's important to understand a couple of key items.

A risk free asset will have a beta equal to zero.

The overall stock market will have a beta equal to 1.

And we typically see the companies will have betas of one extreme pretty

close to 0 and at the other extreme, sometimes as high as 2 or even 3.

So the chart below here shows you the beta is estimated over the last five years for

various companies.

So Apple is obviously one of the world's biggest companies.

And they are also slightly riskier than then average, right?

They are a tech company, and Apple's beta is 1.21.

So it's slightly riskier than the overall stock market.

Clorox makes a lot of household staple products.

These are products that you demand in both good times and in recessions.

So they're a fairly safe company, they're fairly recession proof.

And the beta for Clorox is 0.27 indicating that

it's much lower risk than the overall stock market.

Bristol-Myers Squibb, a pharmaceutical company.

They have slightly higher risk than the overall market their beta is 1.37.

And Netflix is very popular company certainly,

but they also have very high risk and Netflix beta is 1.81.

So another measure of risk that we can look at is the drawdown of an asset.

And to think about the drawdown of an asset we first need

to define the high-water mark.

And the high-water mark of an asset is just a highest price

a fund has achieved in the past.

And with drawdown basically what that shows us,

is it shows us the cumulative losses since losses have started.

And so the way that we calculate this is we take the high watermark,

we subtract off the current price of the asset and we divide by the high watermark.

And really what this measure gives us, really what drawdown tells us,

is it tells us what is the peak to trough decline in our investment.

And so if you look at the chart here, you can see the peak,

that's our high watermark.

And you can see where we bottomed out on January 15th, in this particular chart.

And so that peak-to-trough decline that's draw down, and

that can tell us something about how risky the firm is as well.

So let's see how to calculate some of these measures in r,

and it's pretty straightforward.

It will start by calculating the mean and standard deviation of returns.

We'll use the same file that you use previously.

And as a first pass we'll calculate mean and standard deviation, and

we can do this very easily.

We can use the table.Stats function.

And then to the table.Stats function we'll just point in this mutual funds return.

And so when you do that, what you see is that the arithmetic

mean return per month for this fund has been 0.65%.

And the standard deviation of returns for this fund has been 4.65% per month.

Now we can use this same data set to also estimate beta and R squared.

And so we're just running a simple linear regression model here.

And so we can use the LM function in R.

And the format of our regression is we're gonna use the funds

return the ContraRet here.

And we're gonna regress that on the Market.Return.

And what you see on this screen is the summary data from that regression.

And the first thing we're interested in is the coefficient on the Market.Return,

that's out beta.

And so the beta of this fund is about 0.9 which indicates that it's

less risky than the market, less risky than your average doc.

The other key output to look at from this regression is the adjusted R squared.

And the adjusted R squared here is 0.8313.

And that tells me that this funds movements are pretty highly

correlated with the overall market.

We can plot the draw downs very easily in R and

there are two key functions to be aware of here.

The first is the chart.Drawdown function.

And to execute this function you just feed in the funds returns.

And you can see the picture of the drawdowns historically for

this mutual fund.

And there were five big episodes to pay attention to.

The first one occurred in the early 1980s.

The second one occurred in the mid 1980s.

The third one occurred in 1987 when we had a big stock market crash.

The next major drawdown occurred in the early 2000s.

That's of course when the dot com bubble burst, and the largest draw down

occurred in the financial crisis starting in 2007 running through about 2009.

So the chart.Drawdown function gives you a great visualization of when

the biggest drawdown have occurred.

If you want specific detail data on the drawdown you can create this

table form using the table.Drawdown function.

And in this particular case, I've told the the function to show

me the five largest drawdowns for this particular fund.

So if you look at the largest one, it started on November 2007.

That's where this fund reached its high watermark.

The trough occurred February 2009, and it wasn't until 2012,

February of 2012, when this fund ultimately recovered.

So from peak-to-trough,

this fund fell 46%, or a little over 46%.

That decline occur over 16 months and

it took another 36 months for the fund to fully recover.

So the entire episode from peak-to-trough to recovery

lasted 52 months or about four and a half years.

The second largest event occurred in 1987.

So in this particular event in September 1987,

the trough was reached in November 1987.

The decline was 34% and

here recovery didn't occur until April 1989.

So the total length of this episode was 20 months it took three

months to reach the trough.

And it took it never another 17 months until recovery.

And draw down is a really useful way to think about risk as well.

It somewhat telling us about the largest declines we've experienced in the past.

So the main summary of this lesson is really just we can't look at returns,

returns are part of the story.

We also need to look at measures of risk.

And the easiest way to think about risk is to just look

at the standard deviation of returns.

And that's a good way to think about total risk.

But we can dive a little deeper into that measure of total risk.

And we can think about how much of that total risk is due to

sensitivity to the overall market.

And that's what beta tells us about.

And then we can also look at some other measures, of course,

we can look at drawdown, we can look at R squared and

those help give us a more complete picture of how much risk the fund is exposed to.

[MUSIC]

So now that we know something about risk and return, and how to measure risk and

return, I think it's helpful at this point to look at

the historical performance of different asset classes.

And look at their returns and their risk, and see what lessons we can glean

from the historical record of different asset classes.

So at the end of this lesson, I want you to be able to

understand the performance of different asset classes in the US over time.

And I want you to observe that over time there is a relation between risk and

return.

And that's gonna be important as we go forward

in our investing analytics lessons.

So for this particular lesson, we're gonna focus on four asset classes.

We're gonna focus on small cap stocks, so

these are really small companies that are traded on US exchanges.

A lot on these companies you wouldn't even have heard of,

they could be small new startups.

And we're gonna look at the smallest 30% of stocks traded on US exchanges.

We're gonna look at the performance of large cap stocks,

these are companies you have heard of, these are companies like Apple and Amazon.

And so we're gonna look at performance of the largest 30% of stocks

traded on US exchanges.

We're also gonna look at the performance of US Treasury debt.

And when we do this, we'll look at Treasury bills,

this is very short-term debt, it's generally very safe.

And we're also gonna look at Treasury bonds.

These bonds have longer maturities, these maturities go out to 30 years.

And as a benchmark, we're also gonna consider the rate of inflation.

And this chart is one of my favorite charts in all of finance.

It shows you the value of $1 invested in different asset classes.

It shows you the value of that $1 if you invested in 1927 and

just held the asset through 2018.

And by way of comparison, $1 in 1927,

it's comparable to about $14 in 2018.

And the really interesting thing about this chart is $1 invested in small cap

stocks in the beginning of 1927 would have grown to pretty close to $27,000 by 2018.

The performance of that $1 invested in in large cap stocks,

it's still impressive, but it's a lot less than $27,000.

You can see here that $1 invested in treasury bonds would have grown

to be worth nearly $100.

And that $1 invested in treasury bills, short-term government bonds,

would have grown to be slightly more than the rate of inflation.

And when I look at this chart, there are a whole bunch of interesting takeaways that

I see that are present here.

The first one is, if you invest your money and let it compound over

a very long period of time, it's gonna grow into an enormous sum.

So that $1 in small cap stocks growing into $27,000, that's a huge, huge gain.

That's one lesson I take away.

The other lesson I take away is that there does seem to be a relation between risk

and return in this chart.

Small cap stocks have generated the highest return over time, but

they've also had episodes where they've fallen quite a bit.

That $1 invested in small cap stocks, by the time the Great Depression

rolled around, that $1 would have been worth about $0.30.

So that's a pretty steep decline.

But if you were patient with small cap stocks,

over time, they would've generated big returns.

Small cap stocks are generally viewed as riskier than large cap stocks.

So large cap stocks haven't generated as high of a return as small cap stocks.

And bonds and bills are relatively safe, and they've generated a much lower return.

So when I look at this chart, one of the big takeaways is that

there does seem to be a relation between risk and return.

And we can expand on that by looking at the range of returns that we

typically see by asset classes.

And so if we look at small cap stocks,

there have been years where small cap stocks had fallen by over 50%.

And there have been years where they've gone up over 100%.

If you look at large cap stocks, the range of values is much narrower.

There have been periods where large cap stocks have fallen by over 40%.

But the most large cap stocks have risen in any one year has been about 50%.

And you can see inflation bills and bonds, they are much, much narrower ranges.

We have a better sense of where those values are gonna lie in a given year.

Now, we can look at some basic measures that we saw before.

We can look at the average return, average yearly return for

these different asset classes, and we can look at standard deviations as well.

And if you look at small cap stocks, yes,

they've had the highest average annual return of 16.46%.

But the standard deviation is quite large, 33.27%.

Large cap stocks, they've had a lower return, about 11.2%.

But their standard deviation is lower, 19.28%.

And if you look at bills, they've had a mean return of 3.37% and

a standard deviation of 3.17%.

So again, I hope this chart sort of reinforces that there is

a relationship between the return you get on the asset and the risk.

So the summary from this lesson is really just that risk and return are linked.

Over time riskier assets have generated higher returns.

However, those riskier assets have higher year to year variations.

And this risk return tradeoff is something we

are going to explore in the next lesson.

Thanks.

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