In previous lessons we've seen how to measure the risk and return of an asset.

We've talked about how to measure that assets abnormal performance.

And we've talked a bit about market efficiency.

In this lesson, we're going to talk about the factors that researchers have

identified that seem to drive stock returns.

And so at the end of this lesson, I want you to be able to describe those factors.

And there really five big ones that seem to have stood the test of time.

There's the size effect, the value effect, momentum,

profitability and volatility or the low risk effect it's sometimes called.

So we're going to step through these factors and

see how they relate to returns.

Over the last 50 years researchers have searched for

factors that drive stock returns.

And this is really difficult work,

because some of these anomalies that have been identified,

some of these patterns and stock returns could just be the result of random chance.

Or they could be the result of data mining.

And so what we're gonna do in this lesson is look at those factors that have

stood the test of time.

An understanding something about these factors

can actually make you a better investor.

And I should put in one word of warning here or caveat.

Our view on this is constantly evolving.

Throughout much of the 1970s and the 1980s when we thought about what drove return.

We thought that a pretty high fraction of that return was driven by

data, by market risk and some was due to firm specific factors.

Today our view is a bit different as in we still have that market risk.

We still have those firm specific factor.

But now we think that returns are driven by some of these other effects by value,

momentum, size, quality volatility.

And that's what we're going to talk about in this lesson.

So the first one I want to talk about is the size effect.

And this effect was discovered back in 1981.

And the effect is that smaller firms

tend to have higher returns than larger firms on average.

And so, here, when I say size, size is measured via market capitalization.

Market capitalization is just price, time, shares outstanding.

And so, let me use Apple as an example.

Apple has a price of about $176 a share.

They also have about 4,6 billion shares outstanding.

And so when we look at Apple's market capitalization or

market cap, it's over $800 billion.

So Apple is one of the largest companies in the world.

Now at the opposite end of the spectrum,

there are a lot of really small companies that are traded in the US.

These companies might have market caps of hundred million 200 million,

they're relatively small.

And so the size effect was identified back in 1981 by Banz is actually pretty large.

Small cap stocks have outperform large cap stocks by about 3% a year since 1927.

And so what you're looking at in this particular chart is

the return to small cap stocks minus the return to large cap stocks over time.

And my data here the data here goes back to 1927 and runs through the end of 2018.

In what you observe, it doesn't work 100% of the time.

But over time, in the majority of the time periods small

cap stocks generate a higher return than the large cap stocks.

The next big effect that was documented in the stock prices is the value effect.

And the value effect is that inexpensive stocks tend to outperform

expensive stocks.

And this effect was documented in 1993, an influential 1993 paper by Fama and French.

But it's been around for longer than that.

Warren Buffett would be a value investor, for example.

When we look at how we calculate a stocks expensiveness, its really calculated by

looking at the book value of a company's assets relative to the market value.

So when the book value is low relative to the market value, and

we have a low book to market ratio, that implies that the stock is expensive.

And sometimes we will call that a growth stock or glamour stock.

When the book value of assets is high relative to the market value,

that implies that the stock is inexpensive.

And we call that a value stock.

And here again the value effect is really quite large value stocks have outperformed

growth stocks by about 4.67% per year on average.

And it doesn't work all of the time or across all years.

But it does work in the majority of the years.

So this particular chart shows the annual return to

high book to market stocks minus the return to low book to market stocks.

It shows this performance from 1927 to the end of 2018.

And again, what you see is that over time value stocks tend to perform well.

The return is greater than zero, and a big majority of the years examine.

The momentum effect is one of the most puzzling effects that we see

in the stock market.

It's tough to tell a story where the momentum effect is consistent with

market efficiency.

It seems like there's a behavioural explanation at the heart of momentum.

But the momentum effect is really just the tendency of stocks that

have performed well over the past year to continue to perform well.

Or to put it another way past winning stocks tend to outperform past

losing stocks.

This was a result that was initially published by Jegadeesh and

Titman back in 1992.

And it is one of the most studied effects in all of finance,

and that's because the effect is so large.

Past winners tend to outperform past losers by about 9.23% per year.

Now that's significantly larger than the value effect.

That's significantly larger than the size effect.

That's substantial, substantial outperformance.

And here's what the momentum effect looks like on a yearly basis since 1927.

And so what this chart shows you is the annual return

to winning stocks Minus the return to losing stocks.

All right, so anything greater than zero on this chart indicates that high momentum

stocks have outperformed, that winning stocks have out perform losing stocks.

And you can see that over the vast majority of the years examine

high momentum stocks have outperformed.

Now, what you'll also see when you look at this chart is that momentum effect

generally performs very, very well.

But there are some periods where it comes crashing down.

In particular, 2009 was a terrible year for the momentum effect.

The momentum effect has also had some other bad years at 1975.

For example, but over time,

it's generally performed exceptionally, exceptionally well.

The profitability effect is a more recent effect that recently

researchers have examined.

And this is the tendency for profitable stocks to outperform on profitable stocks.

And one of the first big papers to look at the profitability effect was Fama and

French in 2015.

And what they found is stocks with really strong operating performance, that it

really performed well, tend to outperform those with weak operating performance.

And the performance here is also significant.

It's about 3.2% per year, and

here's what the profitability effect looks like since 1964.

The data doesn't go quite as far back in this example.

But here you can see the performance of the profitability effect since 1964.

Again, anything above zero on this particular chart indicates that

profitable stocks, those with robust operating performance

have outperformed those with poor operating performance.

And again, in the majority of cases, those stocks with robust operating

performance have outperformed those that have performed poorly.

The last effect is also a more recent effect.

And I would call this the volatility effect or the risk effect, and really what

this effect says is low beta stocks tend to outperform high beta stocks.

Low-risk stocks tend to outperform high-risk stocks.

And this effect was most recently popularized by Frazzini and

Pederson in 2014.

And they coined this term and this factor the betting against beta factor.

And this effect is also really quite large since 1980

the effect is about 12.2% per year.

So it's on par with the momentum effect in terms of In terms of size.

And here you can see the betting against beta strategy by year since 1980.

Again, it doesn't work every year.

But in the majority of cases, and in this case, the vast majority of cases,

the betting against beta strategy works really well.

So these effects that we've talked about the value effect,

the momentum effect, the size effect.

They can make us better investors and they're important for investors.

We can use these factors these drivers of return to

construct better portfolios for investors.

For example, we could construct a small cap portfolio for investors.

We can use these factors to tell what's driven of funds historical performance.

And in fact, you'll see that investment professionals are now

focusing on what I would call the smart beta revolution.

They're constructing mutual funds.

They're constructing investment vehicles.

They rely on the value effect, the momentum effect, the profitability effect.

And those can be important for you as you save for retirement and

they can be important for investors going forward.

So in summary, prior academic research has uncovered a number of

fundamental factors that drive stock returns.

And the five big ones that seem to have stood the test of time

are the size effect, the value effect, the momentum effect.

The profitability effect, and the low risk or the volatility effect.

Now some of these factors might be driven by rational effects,

small stocks might be riskier than large cap stocks.

And we might expect small cap stocks to have a higher return.

But some of these are difficult to reconcile with market efficiency.

Momentum, for example, it's difficult to tell a rational story about why

high-momentum stocks might out-perform low-momentum stocks.

Now that you know a little bit about these factors, we can use these factors to

tell why a fund or why an investment has performed the way it has.

We can decompose a return and see if it loads on any of these different factors.

And that's what we're gonna do in the next lesson.

[MUSIC]

[SOUND]

In the last lesson, we saw the different factors that drive stock returns.

And we talked about value, momentum, low-risk investing, for example.

In this lesson,

we're gonna see how we can decompose an asset's return into those factors.

We're gonna talk about how to interpret factor regressions.

And so, at the end of this lesson, you should be able to run factor regressions

in R, you should be able to interpret the output of factor regressions, and

you should be able to describe applications of factor investing.

So from the previous lesson,

there are a number of factors that drive stock returns.

There's the traditional market factor, the beta of the stock.

There's the size effect that small stocks tend to

generate higher returns than large cap stocks,

there is the value effect that inexpensive stocks outperform expensive stocks.

There is the momentum effect that stocks that have performed well in the previous

year continue to perform well, there's the the quality factor, or the profitability

factor where high quality stocks, highly profitable stocks tend to outperform.

And then, there's the low risk factor where stocks with low betas have

traditionally generated higher returns than those stocks with high betas.

And so, if I were to summarize these factors, what this chart shows,

is it shows you the factor, it shows you the notation,

I'm going to use when talking about these factors.

So is the size of fact, I'm gonna notate that with SMB, small, minus, big.

The value of fact, I'm gonna call that HML, high, minus, low, book values.

The momentum of fact, I'm just gonna abbreviate that by MOM.

The risk effect, that's from a paper published in 2014.

By for Leise and Peterson that coins the term betting against the beta.

So I'm gonna to call that the BAB effect.

And then, there's the quality effect, which that term was coined in

a paper by Asness Frazzini and Pederson, called The Quality Minus Junk Factor.

And what you see on the last column of this chart,

is the magnitude of the effect.

And these are on a per month basis.

So you could roughly annualized these by just multiplying by 12.

But the size of fact is, gone down a magnitude in more recent years,

but it's about 0.12% per month.

The value of factor is almost twice as big, 0.27% per month.

Momentum is a large effect, 0.59% per month.

And then, you can see that the risk and quality affects our 0.48% per month,

and the quality of fact is is larger here.

So when we estimate factor regression model,

it's really just a linear regression.

The dependent variable, which in this case, is our mutual fund, again,

we're gonna look at that mutual funds excess return above the risk free rate.

So that's gonna be our dependent variable.

And the factors are going to be the independent variables.

So the typical specification is just really a linear regression.

And in the equation on this side, you can see that our funds,

the excess return is the dependent variable.

You can see that I have those factors from the previous slide as the independent

variables.

And this is a regression specification that I can estimate, pretty easily in R.

So how do we interpret these factors?

The coefficient on these factors from the regression,

tell us a lot of good information.

So a positive coefficient on SMB indicates that the fund is tilted towards small cap

stocks, for example.

A positive coefficient on HML indicates that the fund is tilted towards

value stocks.

A positive coefficient on MOM, the momentum factor,

indicates that the fund is tilted towards high momentum stocks.

A positive coefficient on QMJ

tells us that the fund is tilted towards profitable stocks.

And a positive coefficient on BAB

indicates that the fund is tilted towards safe or low-risk stocks.

And the intercept from this regression,

tells us something about the skill of the fund manager.

So a positive and significant coefficient is gonna indicate that the fund

manager has outperformed the market, and negative insignificant

coefficient is going to indicate that the fund manager has underperform the market.

So we can do this, we can do this for our fund.

And this data is on canvas.

And so, what you have for our fund is monthly data.

In the first column of the data, you have the date.

In the second column of data, you have the funds access return.

And then, you have our factors,

you have the the market factor, SMB, HML, MOM, QMJ and BAB,

and we have this on a monthly level from 1982 to 2018.

And so, now, we're really in this position where we can

say something about what drove our funds performance.

So if you remember this mutual fund that we've worked with in our lessons,

has exhibited fantastic performance, the mutual fund had a high sharp ratio.

It outperformed its benchmark, here, you can see the funds performance.

That's the black line relative to the overall market.

That's the red line, and the performance has just been exceptional over time.

But why is it been so good?

That's what factor regressions allow us to look into.

And so, I'll show you how to do this in R, just a couple of notes.

I like to use the Stargazer library to display linear regression in R.

It has a nice interface, and the data looks really good in this package,

so you can see in the code below, I load in the the data,

and I load the stargazer package, and then,

I just run a series of regressions, the dependent variable is always my

funds access return, and the independent variables are just the different factors.

And I start off with just a simple traditional one factor model.

And I'm gonna work my way up to

a six factor model where I include all of the factors that we've talked about.

And then, in the last line of this code,

just uses the stargazer package to output the regression output.

This chart shows the output from the regression.

And so, I've run four different models.

And I've included different factors in these regression.

So in the first column,

I just include the excess market return as an independent variable.

And that coefficient of 0.901 tells me that the beta of the stock is about 0.901.

And the constant term, the intercept term is significantly positive,

it's 0.002 or 0.2% per month.

And that seems to indicate that this fund manager has skill,

they're outperforming what's expected.

And column 2, I've added the size factor and the value factor.

And this doesn't change things too much.

The coefficient on the market excess return has fallen 2.885.

So it's decreased slightly, but not by a huge amount.

The constant term is still positive and significant.

It has roughly the same magnitude, 0.2% per month.

The coefficient on SMB, 0.048, it's marginally significant at the 10% level.

And that indicates the the fund has exposure to small cap stocks.

Now, in column 3, I've added the momentum of fact, and this does have a big impact.

The coefficient on the market access return doesn't change much again.

It's 0.913, and that's highly statistically significant.

The coefficient on SMB and HML are no longer statistically significant.

The coefficient on the momentum is highly statistically significant, 0.132.

And that indicates that this fund tends to have exposure to high momentum stocks.

And in fact, if you looked at the intercept from this regression,

it's no longer statistically significant.

So that tells me the one of the reasons why this fund has performed so well,

historically, is because it's picked, and

because it's loaded heavily on high momentum stocks.

And the fourth column, I've added the betting against beta factor.

I've added the quality factor, the QMJ factor.

And you can see here that the betting against beta factor is positive,

and highly statistically significant, as well.

And that the performance, the constant, which measures the performance of the fund

managers, again, no longer statistically significant.

If we look at the last column, that column four,

it really tells me something about what's driven the fund's performance over time.

And there are four coefficients that are significant.

The market excess return variable is 0.914.

And that tells me that the fund has a market beta 0.914, so

slightly less risky than average.

The HML factor is negative and significant, so that tells me that

the fund is tilted away from value stocks and more towards the glamour stocks.

The momentum factor is positive and highly statistically significant.

Its coefficient is 0.096.

And that tells me that the fund is tilted heavily towards high momentum stocks.

And the last factor that's significant, is the betting against beta, the BAB factor.

And that tells me that the fund is tilted towards safe stocks.

So now, we can really say why this fund has performed so well, historically.

It's performed so well, historically,

because it's picked, safe stocks with high momentum.

And once we adjust for those two factors, the intercept, the constant term,

is no longer statistically significant.

So again, the takeaways from the factor regression, or the factor regression

framework allows us to uncover the driving forces behind this funds performance,

but it works more generally for any asset.

And this fund, again, performed well,

because of its high exposure to high momentum stocks and low risk stocks.

So as a final note about these factors, and these factor regression,

I do wanna point out that factor investing is becoming extremely popular, Blackrock,

Fidelity, Invesco, Vanguard, they're all active in the factor investing space.

Blackrock recently estimated that by 2022,

approximately, $3.4 trillion will be invested in factor based strategies.

And I wanted to put two words of caution to

factor investing and going forward.

One is that as investors invest more money into these factors,

the performance might start to dissipate.

So it's that story we talked about with market efficiency,

that as people start to exploit anomalies, those anomalies start to disappear.

The other caveat, a word of caution, is that each of these factors that we've

talked about, has experienced prolonged periods of underperformance,

they don't work 100% of the time.

And sometimes, they can underperform for several years on,

and that's important to bear in mind if you pursue a factor investing strategy,

is some of these factors you need patience.

So let me give you an example of the underperformance between 2009 and 2018.

The average annual premium on value stocks was actually negative.

It was negative 2.33%,

that is value stocks over this 10 year period underperformed.

So if you look at recent headlines,

there's been talk that the value premium is dead, it's no longer there.

But the important thing to note is between 1927 and 2008,

the average premium on value stocks was 5.52%.

However, the standard deviation was also really large,

the standard deviation of this effect was 14.35%.

So it's really consequently not that unusual that we would observe

this level of underperformance for an extended period of time.

Given the high standard deviation of the strategy, this is entirely possible.

So the main point is you may need to be patient with some of these factors.

So the summary for this lesson is that factor regressions allow us to

understand the drivers of funds performance.

And we can actually decompose and

say something about why a fund performed the way that it did.

And the intercept from these factor regressions tell us something about

the fund manager skill.

And those can be very, very useful things to know as you go to invest.

[SOUND]

In this lesson,

I wanna present some concluding thoughts about what we've accomplished in

the investing analytics portion of the Data Analytics in Business course.

So the first thing I hope you take away from my portion of this course is that

analytics plays a big role in financing and investing.

We deal with lots of data sets,

lots of big data sets that capture a stocks return.

That capture elements of a firms performance from

the accounting statements.

We even tried capture investors sentiment.

And what we typically do a lot of is trying to tie together

these different data sets and say something about where stock prices and

where stock returns are headed.

We've really covered three core concepts in our three modules.

And the first one it was really quantifying prices in financial markets

and we saw how to calculate returns, and

how to calculate standard deviation and beta.

And the second module, we saw how to identify superior performance and

we talked a little bit about Sharpe ratios about Jensen's Alpha.

And then we talked about transaction cost.

And whether or not markets are efficient, some of the reasons they might be

efficient, and some of the evidence against market efficiency.

And in the last module, we really saw how we can

identify the driving forces behind a firm stock returns.

So to go with each of these points and a little bit more detail,

the big things I hope you take away from topic one are that we have ways

to quantify and think about stock and mutual fund prices.

We generally start off by calculating simple and compound returns.

But then we talked about standard deviation, beta, R squared, drawdown,

all of these factors help us think about how the fund or

stock has performed over time.

In module 2, we again looked at ways to identify superior performance.

There are really four things we did here.

Simplest one was just to compare our fund or

our asset classes performance to an appropriate benchmark.

And then we talked about to reward to risk ratio is the Sharpe ratio and

the Treynor ratio.

For each of these ratios, the numerator is the reward.

It's an excess return.

And the denominator is some measure of risk,

with the Sharpe ratio its standard deviation.

With the Treynor ratio it was beta.

And then lastly, we talked about Jensen's Alpha which is really just a simple linear

regression model.

The one big thing I hope you take forward with you is that a lot of these measures,

you will see again.

You'll see these measures when examining your own portfolio.

So I went through and looked at some of the leading mutual fund companies,

and almost all of them in their prospectus for

different funds show the value of say $10,000 invested over time.

And so when you typically look at a mutual fund perspective,

you should see a chart that looks like the one below where it compares value of

$10,000 invested over time versus some bench mark.

So the blue line here is the fund, the red line is the market, and

here we can tell that this fund has performed very well.

If you dig a little bit deeper into the data just about all mutual fund companies

will also tell you some of the statistics that we've talked about in this course.

And this particular case our fund has a beta 0.9, the R squared is about 0.83,

the Sharpe ratio is about 0.65, which is which is pretty high.

That's an annual Sharpe ratio.

And then the standard deviation is 16.1% per year.

So hopefully now as a result of the data analytics lessons that

we've talked about as applied to finance you'll have a better understanding for

what these statistics mean.

What these statistics mean and hopefully that will make you a better investor.

With topic three we identify the main drivers of return.

So we looked at the size effect, the value, the momentum,

the profitability effect, and the volatility or low-risk effect.

And, again, I think you'll likely see some of these topics again in the future.

And so there's no shortage of funds that tries to exploit these factors.

And so I pulled some recent examples,

there's the iShares Edge MCI USA quality factor.

There's the AQR large cap momentum style factor.

There's the vanguard small cap and x.

There's the fidelity large cap value index.

I hope as a result of our lessons,

you'll have a better sense of what these factors are and

what these funds are trying to accomplish by investing in these types of stocks.

I will say in our lessons, we've just really covered the basics.

And if you are interested in pursuing this topic further,

there are a couple of text I would like to recommend.

One is Efficiently Inefficient: How Smart Money Invests and

Market Prices are Determined.

The author Lasse Pederson.

He is a world renowned academic.

And he's also consulted and

it has one foot in the investing world and the book is fantastic.

Again, the other great book is Asset Management,

A Systematic Approach to Factor Investing, which goes into a lot of detail on

the different factors that we've talked about is by Andrew Ang.

Also an accomplished academic and practitioner as well.

And so both books are written by industry leaders and both books will develop some

of these concepts that we've talked about in more detail.

And might be useful if you have an interest in this topic going forward.

If I were to summarize my portion of the data analytics for business course,

it would be that analytical methods play a big role in investing.

Analytics allow us to measure risk return to think about performance.

Analytics allows us to understand the drivers of asset classes and performance.

And these are incredibly important things to know about as investors and

they can make us better investors.

Thanks for your time.

[MUSIC]