Video 1 - Time Value of Money: Calculating Present and Future Value

The following is a supplementary transcript for tutorial videos from

https://blogs.ubc.ca/financefundamentals/

Hello everyone, today we are going to be discussing the time value of money. This is an important concept to understand, whether you are in a finance course right now, or use money to do things like buy food and pay your bills. So first, we will look at what time value is, and why it is so important to understand. Next, we will look at how we can calculate it. First, by solving for the future value of a single sum you invest today; and then, by calculating the present value of a single sum you receive in the future by applying the same logic; and lastly, we will look at how easy it is to do all of this in Excel.

Video at 00:38

What is time value of money? First, answer this question for me. If you could choose between me giving you $100 today and $100 one year from now, which would you pick? Probably now, right? There are a few reasons for that: first, if you had the money today, you could invest it in an asparagus farm that is going to make you lots of money, or start your own asparagus farm that is going to make lots of money. Even just having that money sit in a bank account is going to earn you some interest. Or you could buy a dog that is going to bring you lots of happiness this year. The point is, if you wait a year to receive that money, you are going to miss out on all the opportunities to benefit from spending it on things this year. Essentially, there is an opportunity cost to let that money sit idle instead of using it on other projects. When you factor in that opportunity cost, you are going to want to be compensated for all the potential profits or enjoyment that you are missing out on. This is called the time value of money.

Video at 01:37

But there are two other reasons why you might want the money today rather than later. First, you don't even know me, and by this time next year, I could have changed my name and made off to Mexico. But even in a real investment, there is always a risk that the market is going to crash or the company is going to go out of business, and you will lose all or part of your investment. So, when we factor in that risk, $100 today and $100 in a year certainly are not worth the same amount. Let's say that there is a 10% chance that I don't pay you back. Your expected value is $100 * 9% = $90, which is less than if the investment was an assured thing at

These resources were created by the Sauder Finance Fundamentals TLEF Team under the terms of the CC-BY-NC-SA license at https://blogs.ubc.ca/financefundamentals/.

$100. But even if the expected values are the same, most people will prefer a less risky investment. They would require an additional return on risky investments.

Video at 02:25
And lastly, even if I could guarantee that I will pay you back, a little something called inflation is going to mean that $100 in a year is worth less in real terms than $100 today. A typical inflation rate is around 2%, so prices are rising around 2% each year. This means that if today's $100 buys you 100 loaves of bread, in one year, you might only be able to buy 98. I don't know about you but I prefer the option with more bread.

Video at 02:53
We just learned that risk, inflation, and opportunity cost contribute to the return you will require on an investment. So, we should factor these in when we are making financial decisions. We can do this by discounting our future cash flows to their value in today's dollars. This way, we can compare apples to apples, or today's dollars with today's dollars, in order to make a decision that maximizes our value in today's terms.

Video at 03:16
So how do we discount our future cash flows? It depends on a few key factors. First, we need to know our interest rate, which is the amount that we earn, expressed as a percentage of our investment over a given time period. This rate factors in our risk, inflation, and opportunity cost. You will also hear it referred to as cost of capital, discount rate, or required rate of return. So, how far away is the future? We express time in intervals known as “periods” and can refer to our total number of periods as "n". A period can be any length of time, like a month, a quarter, or a year. For example, if interest is compounded every quarter, then 1 quarter = 1 period. If the annual interest rate is 12%, then our interest rate for the period is 3%

$$quarterly\ interest\ rate = \frac{12\%\ annual\ rate}{4\ compounding\ periods\ or\ 4\ quarters} = 3\%$$

Compounding just means that whatever interest you earn is added to your investment for next period. So, you are earning interest on your initial amount plus any interest that you have earned in the past. The more interest is compounded, the faster your investment grows. For this video, we will assume that interest is compounded annually. Let's apply these concepts to a simple example:

These resources were created by the Sauder Finance Fundamentals TLEF Team under the terms of the CC-BY-NC-SA license at https://blogs.ubc.ca/financefundamentals/.

Video at 04:25

Suppose I have invested $2,000 in my uncle's acappella group for five years. They will pay me 8% interest annually to compensate me for my risk for inflation and for my inability to use the funds for other things like buying avocados. After one year, my investment is worth what it was worth before plus the 8% I earned or

$$\textit{investment in a year} = \$2,000 \textit{ invested} + \$2000 \times 0.08 \textit{ interest earned}$$

$$\textit{investment in a year} = \$2,000 \times 1.08 = \$2,160$$

Video at 04:59

Then, next year I earn 8% on $2,160, as it is compounded annually, which is

$$\textit{investment after another year} = \$2,160 \times 1.08 = \$2,332.80$$

Then, next year, I can multiply last year's value by 1.08 to get the new value of my investment. We can calculate the value of the $2000 after five years as

$$\textit{investment after 5 years} = \$2,000 \times 1.08 \times 1.08 \times 1.08 \times 1.08 \times 1.08$$

$$\textit{investment after 5 years} = \$2,000 \times 1.08^5 = \$2,938.66$$

Video at 05:34

Thus, in five years the money will be worth

$$\textit{investment after 5 years} = \textit{initial amount} \times (1 + \textit{interest rate})^n$$

This gives us the formula to calculate the future value of an investment.

$$\textit{future value} = \textit{present value} \times (1 + \textit{interest rate})^{\textit{number of periods}}$$

Expressing amounts of money also known as cash flows in terms of future dollars is called compounding.

Video at 05:55

What if we already know how much our investment will be worth in the future? Suppose a man in a turtleneck tells you that, if you buy a share in his tech company, it will be worth $500 in three years. But we know that $500 in three years is worth less than if you had it today due to the time value of money. So, you probably would not want to pay $500 for it today. How much is it actually worth in today's dollars? We can work backwards from the future value formula we have created to solve for the present value. This technique is called discounting.

These resources were created by the Sauder Finance Fundamentals TLEF Team under the terms of the CC-BY-NC-SA license at https://blogs.ubc.ca/financefundamentals/.

Video at 06:25

Let's say the next best use of our money is to invest it in a music company that pays 5% per year; thus, the present value of the $500 we get from the share is whatever we would have to invest *now* to earn $500 at 5% interest, which we will use as our cost of capital.

Video at 06:41

Rather than multiplying $500 by 1.05, like we would to get future value, we go backwards to get the past value by dividing by 1.05 for each year. This tells us what times 1.05^3 will give us a future value of $500.

$$future\ value\ = present\ value \times (1 + interest\ rate)^{number\ of\ periods}$$

$$\$500\ = present\ value \times (1 + 0.05)^3$$

In this way we can arrange our future value formula to solve for present value.

$$present\ \ value\ = future\ \ value \div (1 + interest\ rate)^{number\ of\ periods}$$

Thus the present value of the share is $431.92 ($\frac{\$500}{1.05^3} = \$500 \times 1.05^{-3}$)

Video at 07:10

We can manipulate this formula to solve for “t” (which refers to time, and is sometimes used interchangeably with “n” for the number of periods) or “r” (the interest rate) the same way we solved for a future value using the rules of algebra. Solving for “r” tells us the return on our investment. Solving for “n” (or “t”) tells us how many periods it will take to earn this return.

Video at 07:33

Lastly, I am going to go over how to quickly solve for present value and future value using Excel. Let's use the PV and FV formulas to check our answers from the previous questions. Let's type “=FV” into any cell, this stands for “future value”. It first asks us for our interest rate (which is 8%), followed by the number of compounding periods (which is 5 for the five years that you are investing in the acapella group). Payment refers to a fixed payment we receive at the end of every period. We will see examples of this in later videos when we talk about annuities and perpetuities. Here, we aren't paid anything until the very end, so we will put 0. Lastly, we have the present value or the value of our money today, which here, is the $2,000 that we are

These resources were created by the Sauder Finance Fundamentals TLEF Team under the terms of the CC-BY-NC-SA license at https://blogs.ubc.ca/financefundamentals/.

investing in the acapella group. There we go! In the end, we have “=FV(0.08,5,0,2000)”, which returns $2,938.66. Notice that we get the same answer we did solving it by hand.

Video at 08:29

Let's try “=PV” for present value. We will input 0.05 for our interest rate, 3 for the number of periods, 0 for the payment, and $500 for future value. In the end, we have “=PV(0.05,3,0,500)”, which returns $431.92. We get the same answer as before. Either of these methods will allow you to calculate the present or future value.

Video at 08:48

Excel has formulas to solve for your number of periods or your discount rate as well. Just type "=NPER" (you will input 0.05 for the interest rate, 0 for the payment, $431.92 for the present value, and $500 for the future value) or "=RATE" (you will input 3 for the number of periods, 0 for the payment, $431.92 for the present value, and $500 for the future value), and plug in the information you know to solve for the missing variable.

Video at 09:02

So today we went over how risk, inflation, and opportunity cost mean that $100 you receive one year from now is worth less than $100 you receive today. Then, we looked at how to solve for the present or future value of an investment, first by hand, and then using an Excel formula. Lastly, we looked at how to apply the same formula to solve for the number of periods or interest rate of an investment. Now, go try this at home!

These resources were created by the Sauder Finance Fundamentals TLEF Team under the terms of the CC-BY-NC-SA license at https://blogs.ubc.ca/financefundamentals/.