Discounting the Future

Suppose, hypothetically (or perhaps not), that you really like Big Macs. Now, suppose that I was going to give you a Big Mac right now. If you are hungry, then you will be happy since I am giving you something that: (a) sates your hunger; and (b) tastes yummy. And I'm giving it to you right now. No waiting.

Now, suppose that I told you that I would give you the same Big Mac, but one hour from now. Assume that I just bought the Big Mac and I'm going to let it sit in my car for the next hour. How happy are you *right now* about the prospect of getting this particular Big Mac in one hour? Well, maybe it will get a little bit cold, and maybe in the meantime you would eat something else to satisfy your hunger, but in one hour it will seem like pretty much the same Big Mac.

Now suppose that I buy a Big Mac right now, but I'm going to wait until tomorrow (24 hours from now) to give it to you. How happy are you *right now* about this Big Mac that you will get tomorrow? Probably less so - first of all, you are hungry *now*. Sure, you will be hungry again tomorrow, but will that Big Mac taste quite as good after sitting in my car for a day? Probably not.

Now, (really, we're almost to the point), suppose that I buy a Big Mac right now but I'm going to wait six months to give it to you. How happy are you right now about this Big Mac that will sit in my car for six months before being given to you? What will happen to that Big Mac between now and six months from now? Will it still even be recognizable as a Big Mac? I won't even mention the special sauce…

On the other hand, it's a Big Mac. Why is it any different to you whether you get it now, a day from now, or six months from now? Basically, there are three reasons:

1. Physical depreciation: After six months or even maybe one day, that Big Mac won't be as tasty as it is right now because it's a perishable product. This is the same thing as "inflation" when we talk about money. Inflation depreciates the purchasing power of a fixed quantity of money.
2. Impatience: If you are hungry, then you want the Big Mac right now, not sometime in the future. Even if I told you that I would buy you a fresh Big Mac six months from now, that's not a very meaningful promise at this moment in time. Remember, you are hungry *now*!!!
3. Opportunity cost: If I make you wait an hour for the Big Mac, then you have to be hungry for an hour. On the other hand, you could also eat something else right now instead of having to wait an hour for the Big Mac. Whatever you chose not to eat right now in order to wait for the Big Mac reflects an "opportunity cost" that you have foregone.

Evidently, the same Big Mac (whether it will be fresh or had sat in my car for some unfathomable period of time) is worth less to you if you get it in the future than if you get it now. The process of measuring how fast that Big Mac loses value to you, relative to its value right now, is called discounting. The particular method of discounting that we will cover in this lesson is known as "exponential discounting" because of the assumption that something loses value at a constant *rate* (percent per year) over time. An alternative discounting method that we won't cover, but you can look at in your spare time, is known as "hyperbolic discounting." Wikipedia has a nice article on hyperbolic discounting. [1]

Before we can dive in, we need some terminology:

- ***PV*** = Present Value, i.e., the value of something today (or what something in the future is worth to you in today's terms). The present value is sometimes called the "principal" (as in the case of a loan).
- ***FV(t)*** = Future Value of something at time ***t***. This time ***t*** is usually defined relative to the present day, and usually (but not always, so be careful) in years. So ***t*** = 5 would mean five years from this year.
- ***r*** = Discount rate, in percentage terms. This is also usually defined on an annual basis but does not need to be. So a value of ***r*** = 0.05 would be a discount rate of 5% per year. In the case of a loan, ***r*** is equivalent to the annual interest rate.

Suppose that you were to put some amount ***PV*** in a simple investment vehicle, like a bank account, that paid back your money plus a rate of return ***r*** every year. The future value of that amount in one year (***t***=1) would be:

$$FV\,(1) \;=\; PV\,(1+r) \;=\; PV \;+\; r \times PV$$

If you kept your money in the account for another year, in that second year you would earn a rate of return ***r*** on all the money that was in your account the first year:

$$FV\,(2) \;=\; [PV \;+\; r \times PV] \;\times\; (1+r) \;=\; PV(1+r)^2$$

Note that you have effectively earned interest in the second year on the interest that you earned in the first year. This phenomenon is called "compounding." Since interest is calculated once per year in this model, we call this "annual compounding."

There is a detailed section in the "Have We Caught Your Interest" reading that discusses compounding at intervals more frequent than annually, all the way up to continuous compounding. Please read this section carefully, although in this class we will use annual compounding almost exclusively.

Going back to our little bank account, more generally, in year ***t*** the future value of the investment that you make today is:

$$FV\,(t) \;=\; PV(1+r)^t$$

This equation is an indifference condition - it says that you would be equally happy getting some amount of money ***PV*** right now, or $FV\,(t) \;=\; PV(1+r)^t$ if you had to wait ***t*** years to get your money. The factor $(1+r)^t$ just measures your opportunity cost for having to wait ***t*** years.

Now, we will flip the equation on its head. Suppose that you were promised some amount of money ***FV(t)*** in year ***t***, sometime in the future. What is that promise of future wealth worth to you today? In other words, what would you need to be paid today in order to be equally happy between getting money today and getting the amount ***FV(t)*** in the future? We can find this by manipulating the previous equation to solve for ***PV***. Dividing both sides by $1/(1+r)^t$, we get:

$$PV = \frac{FV(t)}{(1+r)^t}$$

Assuming that **r** is greater than zero, this means that the value in the present of some amount of money that you are going to get in the future is lower than the face value of that amount of money. In other words, you would be willing to accept less money right now in exchange for not needing to wait to get it. This is sensible, if you think about it. First, people are impatient. Second, there is an opportunity cost to waiting. If I got some amount ***PV*** right now (rather than some larger amount ***FV(t)*** in the future), then I could take that amount **PV** and do something with it that might increase its worth t years from now.

The term $1/(1+r)^t$ is known as the "discount factor" and it measures how quickly something has declined in value between now and ***t*** periods from now.

Here are two examples that illustrate the mechanics of discounting.

Example #1: Suppose that ***r*** = 0.04 (4%), ***t***=20. The discount factor is equal to:

$$1/(1.04)^{20} = \ 0.46$$

Thus, ***PV*** = 0.46×***FV***. What this says is that the present value is less than half of the future value after 20 years.

Example #2: Now suppose that ***t*** = 100. The discount factor is equal to:

$$1/(1.04)^{100} = \ 0.02$$

Thus, ***PV*** = 0.02×***FV***. What this says is that the present value is only 2% of the future value.

These two examples, although simple and without much context, illustrate two important properties of exponential discounting. First, at any positive discount rate, if you go far enough into the future, then the future is worthless and you would never consider it when making decisions in the present. Second, the higher the discount rate, the faster the future becomes worthless *relative to the present*. Remember that the discount rate does not determine whether one thing will be worth more or less in the future than another thing. It only measures the value of something in the future relative to that same thing in the present (like a Big Mac six months from now versus the exact same Big Mac today).

There is almost nothing that puts students to sleep faster than the discount rate. Frankly, it's a dry topic. But the discount rate is actually front and center - in some ways, much more so than any science - in the debate over climate change and how societies should respond. The reason for the controversy is simple - if the worst impacts of climate change are going to be felt even two generations from now, then unless we use a discount rate of zero or near zero (meaning that we value the future exactly as much as the present) it is difficult to justify large and costly climate-related interventions in the present, in order to yield substantial benefits far in the future. But such a low discount rate flies in the face of what economists actually know about preferences that people seem to have for happiness now versus happiness (or wealth) in the future. If you are really interested in this topic from the perspective of climate change, Grist has a nice piece that was published recently [2]. Since our focus in this course is on commodity markets and business decisions, we'll find (in the next couple of lessons) that there is a logical way to determine the "right" discount rate for those types of decisions.

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Links:
[1] http://en.wikipedia.org/wiki/Hyperbolic_discounting
[2] http://grist.org/article/discount-rates-a-boring-thing-you-should-know-about-with-otters/