PRINCIPLES OF BEHAVIORAL ECONOMICS

Prof. Sujata Kar

Department of Management Studies
IIT Roorkee

Week 45

Lecture 45

Hello, welcome back to the course on Principles of Behavioral Economics. This is lecture 45. Now we are discussing intertemporal choice models, and in the previous modules, we have introduced the concept of intertemporal choice models. We also covered the contributions from neoclassical economics, such as the discounted utility model. Today, we will discuss the features of the discounted utility model.

There are several features of the DUM that need to be examined, as they relate to the implicit psychological assumptions underlying the model. First, integration of new alternatives with existing plans. Second, utility independence. Third, consumption independence. Fourth, stationary instantaneous utility.

Fifth, stationary discounting. Sixth, constant discounting. Seventh, independence of discounting from consumption. Eighth, diminishing marginal utility and positive time preference.

So these are the features that we are going to discuss next. Beginning with the first one: integration of new alternatives with existing plans. It is a common assumption in most decision or choice situations relating to the standard model that people evaluate new alternatives by integrating them with existing plans. So if we go back to the life cycle hypothesis, then you remember we say that if additional wealth comes, it is integrated with the existing wealth and then again divided across all the periods

one expects to survive or live, and then accordingly, consumption is decided. So this is the basic idea behind the integration of new alternatives with existing plans. This means that if a person is offered a prospect A, say, investing $10,000 now to gain $15,000 in 3 years, the effects of this prospect on the person's whole consumption profile must be considered. Thus, if the person currently has the consumption profile,

say ct to small t to capital T, any periods, then they must estimate their new consumption profile if they were to accept prospect A, for example, ct prime to c capital T prime. So basically, there is additional wealth that has been incorporated, and how it is going to change your consumption pattern is given by this new profile. Prospect A would then be accepted if the utility generated by this new profile is greater than the utility generated by the existing or old profile. Although this approach may seem logical from a normative point of view—meaning that people should want to integrate new alternatives to maximize welfare.

However, this places unrealistic demands on people's mental capacities. We actually cannot predict or foresee the future so well that we would be integrating all such possible income or additional wealth into our existing wealth and then decide how much to consume. So, this is basically placing unrealistic demands on our mental abilities. People may not have well-formed consumption profiles relating to all future periods, and they may be unable or unwilling

to reformulate such plans every time new prospects are encountered. The second one is utility independence. It is assumed in the DUM, that is, the discounted utility model, that it is simply the sum of all the discounted future utilities which is relevant in terms of making intertemporal choices. So, if you remember the expression we have the total utility is equal to the first period utilities are denoted by U1,

then the second period discounted utility, then the third period discounted utility and so on. So, the sum of all the future stream of utilities discounted. This ignores the possibility that the distribution of utilities over time may be relevant. As we shall see, people may prefer a flat or rising utility profile to a falling one, or a pattern of dispersion of utilities rather than a concentrated pattern.

So, basically, how I am expecting the utility or the flow of utility in the future. It might have a particular distribution that the DUM does not actually talk about. A related assumption is consumption independence. So what is consumption independence? It is assumed in the DUM that a person's welfare in any time period is independent of consumption in any other period.

This means that preferences over consumption profiles are not affected by the nature of consumption in periods where consumption is identical in two periods. I'm going to give you an example shortly. It is therefore analogous to the independence axiom in expected utility theory. For example, consumption independence says that one's preference between

an Italian and Thai restaurant on any night should not depend on whether one had Italian last night, nor whether one expects to have it tomorrow.

So basically, the idea is that my past decisions may impact my current or future decisions. So if I'm offered a meal in a restaurant, say a Chinese restaurant, and if I had it just the night before or yesterday night, then I would like to have it after a couple of days if that is allowed. And if I am forced to have it immediately, maybe my satisfaction or utility would be somewhat less than if I had been allowed to have the meal after a certain period of time. So my past preferences or my past experience, of course, impact my present situation or preference choices, which is not taken into consideration in the DUM.

It should be noted that neither Samuelson nor Koopmans proposed that this assumption had either normative or descriptive validity. This gives rise to various anomalies in the model, which we will see later. The fourth one is stationary instantaneous utility. The DUM generally assumes that the instantaneous utility function is constant over time, meaning that the same activity yields the same utility in the future as it does now. So, the instantaneous utility function means the utility is generated by a functional form which is

given by or a result of what I'm doing currently. So, suppose I am reading a book, the satisfaction that I am getting from it is my instantaneous utility. Now, it is quite possible that what I prefer to do today or the kind of satisfaction that I obtain from some activity today won't be the same after one week, after one month, or maybe after several years. The assumption is that it remains constant in DUM.

But it's not necessary that it will remain constant. For example, if activity A is expected to yield 20 utils (the unit of measurement of utility) in 3 years' time, the current utility of A, which can be written as U0A, will be discounted to about 15 utils at a 10% discount rate. So, I apply a 10% discount rate. 20 is supposed to come in 3 years' time.

So, that is why I have 1 plus 0.1 raised to the power 3, which would be roughly identically equal to or approximately equal to 15. However, it is assumed that the utility of A in 3 years' time, that is U3A, will still be 20 utils. So, if it is 20 today, then it is 20 after 3 years also. This implies that people's preferences do not change over time, which is an obviously unrealistic assumption. For instance,

Youngsters are very fond of going to movies. They go to watch movies in groups of friends and all. But as we age—consider a person in his 40s, 50s, 60s, or 70s— their preferences for going to movies in groups or alone would be much, much lesser, which implies that the

utility from watching a movie has substantially decreased over time. It's not the same, but then DUM assumes that it remains constant over time.

Evidence suggests that people tend to exaggerate the degree to which their future preferences will resemble their current ones, a phenomenon referred to as projection bias. So when I am in my 20s and very fond of watching movies, going to movies with friends, I would think that even when I am in my 40s or 50s, my preferences for going to movies with friends would be the same, but that need not be the case, so I am suffering from or will be suffering from projection bias which we have already discussed in the previous module. Thus, we may expect to like the music trending today in 20 years because we like it now very much, but then we may find in 20 years' time that we can't even stand it.

The fifth feature that we are going to discuss is stationary discounting. It is assumed in the DUM that people use the same discount rate over their lifespan. Suppose A consumes C in each period. So, C is the amount of consumption. Then, in addition to C, the decision-maker is given the choice of consuming an additional X at time t.

Or an additional X prime at time T prime. Now, X prime is greater than X, which means it's a larger quantity. So, alongside my consumption, I am offered at time period T another consumption of, say, 1000 rupees—it's easy to measure. And then, this is in period t, and in period t prime, which is greater than period t—if period t is tomorrow, then t prime could be the day after tomorrow, and I am offered an amount like 1500.

So, the amount is larger, and the time period is later. Alongside my existing consumption, these are offered to me. A will choose X at time t.

$$\sum_{i \neq t} \delta^i u(c) + \delta^t u(c + x) > \sum_{i \neq t'} \delta^i u(c) + \delta^{t'} u(c + x')$$

What is happening here is that I am first summing up all the consumption—present as well as future—excluding time t. And then, for time t, I have utility from C plus X. And then, it is, of course, multiplied by the discount factor delta raised to the power t. A will choose X at time t if this is greater than this.

And what is this? This actually includes all consumption that would be coming forward as well as the present consumption summed up excluding the consumption in period t'. And then this is the consumption in period t prime multiplied by its discounting factor or the

consumption in period t prime discounted to the present. So, this is also present value considering t prime or consumption in t prime. This is also present value of consumption considering the option of consuming c plus x in time t. So, if this is greater then A will choose x at time t. This will be the case if delta t prime u c plus delta t u c plus x is greater than delta t u c plus delta t prime u c plus x prime.

$$\delta^{t'} u(c) + \delta^{t} u(c + x) > \delta^{t} u(c) + \delta^{t'} u(c + x')$$

So, what does it say? They simply say that we are retaining this, right. And if you compare these two terms, this term and this term, then the only difference between them is that here t prime is included and t is not included.

Here t is included and t prime is not included, right? So, since all the other terms are the same, I can cancel the rest of the terms. Retain delta t prime uc plus this exact term is greater than delta t u c. The rest of the terms are cancelled. Plus delta t prime u c plus x. So if this holds, then this holds.

And then A will choose x at time t. Now this expression we had derived in the last slide.

$$\delta^{t'-t} < \frac{u(c+x)-u(c)}{u(c+x')-u(c)} \qquad \delta^{t'} u(c) + \delta^{t} u(c + x) > \delta^{t} u(c) + \delta^{t'} u(c + x')$$

So now this expression can be reorganized like this. So, what we are simply doing is that taking u c to this side, taking delta raised to the power t common, then we will be having u c plus x minus u c, this term. And then we are taking this to the other side. So, we have delta t prime multiplied by u c plus x bar minus u c, right.

And then when we have both the terms on one side, then we will have delta t prime, delta raised to the power t prime minus divided by delta raised to the power t, which can be written as delta t prime minus delta t. This is true for any value of t and t prime. The long t prime and t is constant. Thus the choice between x or x prime depends on the interval of time that passes between the two possible dates of consumption

that is t prime and t and not the point in time when x could be consumed. This property of DUM is called the stationarity property. Now let us take a small example.

$$\delta^7 < \frac{[u(c + x) - u(c)]}{[u(c + x') - u(c)]}$$

Suppose that the decision maker could choose x at time 0 and x prime at time 7. So she will choose to consume at time 0. If delta 7, which is basically the difference between t prime and t. Here this is 7 minus 0 equals to 7. So delta raised to the power of 7 is less than this expression. If this is so, then the individual will choose to consume x at time 0. If this is the case, then she would also choose x if given the choice of x at time period 257 or x prime at time period 257 plus 7, 264. So again, you see that it does not matter whether it is 7, 0, or say, 37 minus 30, or say, 264 minus 257.

What are the time periods? The time periods themselves do not matter. What matters is the difference between the two time periods. The longer it is 7, then delta raised to the power of 7. If less than this expression, then the individual will choose to consume in period 0.

We will prefer x over x'. However, she may choose x'. If given the choice between x at 257 or x prime at time period 260. Now see, if it is 260 and 257, then t prime minus t is equal to 3. So when the time period is different, then of course her choices can be very different.

$$\delta^{260-257}[u(c + x') - u(c)] = \delta^3 u(c + x') - u(c) > \delta^{264-257}[u(c + x') - u(c)] = \delta^7[u(c + x') - u(c)].$$

So here, if she chooses x prime over x, then this implies that 260 minus 257 uc plus x prime minus uc, which is equal to delta raised to the power 3 uc plus x prime minus uc. This is greater than delta raised to the power 7. Multiplied by uc plus x prime minus uc. So basically, delta raised to the power 7. So here, delta raised to the power 3 multiplied by the difference in consumption.

Is greater than delta raised to the power 7 multiplied by the difference in consumption, and that's why she preferred to choose to consume x prime instead of x. Thus, the choice between x or x prime depends on the interval of time that passes between the two possible dates of consumption. I am just repeating it, which is like t prime minus t and not the point

in time when x could be consumed. In this case, period 257. If preferences display stationarity, then the choice between two potential consumption bundles does not depend on the time they are offered, only upon the interval between possible consumption dates.

So this is basically the concept of stationary discounting. In contrast, there is considerable evidence that discounting rates vary according to age. For example, Mischel and Metzner have found that willingness to delay gratification increases with age. Implying that older people have a lower discount rate. However, the relationship between discounting and age appears to be a complex one.

In an experimental study of respondents between the ages of 19 and 89, it was found that older people discount more than younger ones and that middle-aged people discount less than either group. Similar results were found and confirmed by another study in 2002. A more detailed study in 2013 introduced two further parameters into the relationship between discounting and age: i.e., cognitive ability or impairment, and gain or loss. Their conclusions suggest an even more complex situation, since they found that both cognitive impairment and losses versus gains are relevant to discount rates.

For gains, they found that middle-aged subjects discount at the same rate as older impaired subjects, while older unimpaired subjects discount at a lower rate than either of them. The picture is somewhat different for losses. In this case, middle-aged subjects discount at the same rate as older unimpaired subjects, while older impaired subjects discount at a higher rate than either of them. Thus, it appears that older impaired subjects discount both future gains and future losses more highly than unimpaired subjects.

It should be noted however that this is not irrational given the shorter expected lifespan and lower quality of life of such subjects. Now here I would just like to clarify one thing what is meant by when we are talking about discounting at a higher rate or a lower rate for example when we say older impaired subjects discount at a higher rate than either of them. So, in order to explain that I'll just give a small example suppose I ask you what would you like to have? Would you like to have 100 rupees today or tomorrow? So my first question is that you want to have 100 rupees today or tomorrow.

So suppose somebody says that I want to have it today, which implies that 100 rupees today is not equal to 100 rupees tomorrow. The preference is strictly in favor of 100 rupees today. Now, if I ask that individual, how much would you like to receive in order to be indifferent between 100 rupees today and 100 rupees tomorrow? Suppose that individual says, 'Either you give me 100 rupees today or you give me 110 rupees tomorrow.'

So, for that individual, 100 today is equivalent to 110 tomorrow. This implies that he actually has a discount rate of 10%, because 110 divided by 1 plus 0.1 equals 100. Now, suppose another individual says, 'No, I want 100 today, or if you want to delay it, I want 120 tomorrow.' So, for that individual, 100 today is equal to 120 tomorrow, which means he has a discount rate of 0.2.

This individual is actually applying or discounting the future at a higher rate—a higher discounting rate. These kinds of individuals are said to be more impatient. A patient individual will have a smaller discount rate, in the sense that someone is still willing to wait. The larger the discount rate, the more impatient the individual is. And this is what is implied by a higher discount rate or a lower discount rate.

Next, we talk about constant discounting. The DUM assumes that at any period of time, the same discount rate is applied to all future periods. In mathematical terms, this means that given the discount function—that is, the discount function we already introduced in the previous modules. At time period t, the same per-period discount rate rho is applied to all the periods in the future. So, your discount rate remains constant.

Now, a closely related concept is that of stable discounting, which also has the same implication. Consider the problem of choosing between two consumption profiles. These are the two consumption profiles. You can see that current-period consumption remains at C1 because we are in the current period. We are beginning with the current period as 1, period 1.

$$c = \{c_1, c_2, c_3\} \qquad \& \qquad c' = \{c_1, c'_2, c'_3\}$$

And in the future, the consumption profiles are going to change. The consumption, or the amount you consume in periods 2 and 3, is different. In the first period, the person would strictly prefer C if the utility from consumption in the first period, plus the utility from consumption in the second period discounted to the present value, and the utility from consumption in the third period, again discounted to the present value, is greater than similarly C, the present consumption and consumption in periods 2 and 3 discounted to the present value.

Now, here you note that we are not using delta raised to the power of 2 or delta raised to the power of 3 because all we want to show is whether The delta, or you know that delta, is equal to 1 plus 1 upon 1 plus rho. So if delta is constant, rho is constant, or if rho is

constant, delta is constant. So we want to check whether rho and delta are constant or not, and that is why we did not mention delta raised to the power 2. Because if we mention delta raised to the power 2, that automatically assumes that rho and delta are constant.

$$u(c_1) + \delta_2 u(c_2) + \delta_3 u(c_3) > u(c_1) + \delta_2 u(c'_2) + \delta_3 u(c'_3)$$

$$\frac{\delta_3}{\delta_2}[u(c_3) - u(c'_3)] > [u(c'_2) - u(c_2)] \qquad (1)$$

Now, from this expression, we can always write this expression where basically we have changed terms and arrived at this expression where delta 3 divided by delta 2 multiplied by the difference in the consumption in the third period is greater than the difference in the consumption in the second period. So this is happening if the person prefers profile C. In the second period, the person would strictly prefer C if and only if again that is I have arrived in the second period. Now, the second period is my current period.

$$u(c_2) + \delta_2 u(c_3) > u(c'_2) + \delta_2 u(c'_3)$$

$$\delta_2[u(c_3) - u(c'_3)] > [u(c'_2) - u(c_2)]$$

I am consuming UCT multiplied by delta UC3, which is basically the consumption in the next period discounted by this discount factor, and again that is greater than the alternative profile. So, if this is greater than the alternative profile, then I will be preferring consumption profile C. Now, again rearranging terms, I would be getting delta 2 multiplied by the difference in the consumption in period 3 greater than the consumption in period 2. Now, equation 1, equation 1 is reproduced here for ready reference, and 2, this is this equation, are always consistent for delta 3 equals to delta 2 square.

Now you can see that this term and this term are the same. The right-hand side is also the same. So, we will have both of them valid if this equals this, which implies delta 3 upon delta 2 equals delta 2. That is, delta 3 equals delta 2 squared. So, if utility in period 3 is discounted by the square of the discount factor applied to period 2, then preferences will always be constant.

And the decision-maker will never regret the decisions she made in the previous period. If this equality does not hold, then we cannot guarantee consistent decision-making across time periods. Therefore, this condition ensures time-consistent preferences since the standard model views time-consistent preferences as rational and inconsistent preferences as irrational. This feature of the DUM is often perceived as legitimate. However, there is plentiful empirical evidence that discount rates are not constant over time but rather tend to decline.

Inconsistent time preferences have been widely observed. This evidence and alternative models of accommodating it will be seen later. It should also be noted at this stage that constant discounting is not a sufficient condition for consistent time preferences to exist. Stationary discounting is also necessary.

If discounting is not stationary, then in the following time period, that is t plus 1, one may observe a different but still constant discount function, which is like this.

$$D_{t+1}(k) = \left[\frac{1}{1+\rho'}\right] k \qquad \text{where } \rho' \neq \rho$$

Here we have 1 upon 1 plus rho prime. This is raised to the power k, where rho prime is not equal to rho. For example, the evidence in the study with older people mentioned above suggests that as people enter middle age, rho prime becomes less than rho. As I was trying to say, a smaller value of rho implies that we tend to become more patient.

In this situation, discounting is constant in both periods t and t plus 1. But the discount rate changes with the passage of time. The consequence of this is that once again, time preferences will be inconsistent. So next, we talk about the seventh feature: independence of discounting from consumption. Another assumption of the DUM is that all forms of consumption are discounted at the same rate.

Without this assumption, it is impossible to reduce the discount rate to a single parameter or to talk about a uniform time preference. As Frederick, Loewenstein, and O'Donoghue put it, we need to label time preference according to the object being delayed, like banana time preference, vacation time preference, and so on. So what they say is that for each and every good or service that we consume, we might have a very different time preference in terms of delaying things or prepolling things. There is indeed evidence that different products are discounted at different rates and even that different attributes of products are discounted differently.

A 2004 study found that perceived effort and perceived price are discounted differently. Do-it-yourself products involve effort in terms of consumption and appear more attractive when the purchase is planned for some time in the future. When the purchase is immediate, such products appear less attractive, implying that perceived effort is discounted more heavily than price. Once again, the consequence is that preferences are inconsistent over time. And finally, the last feature is diminishing marginal utility and positive time preferences.

Although these two features are not essential elements of the DUM, in practice, most analyses involving intertemporal choice assume that both conditions exist. In actuality, both elements predate the DUM, since Fisher in 1930 emphasized the importance of each of them in his indifference curve analysis approach. Indifference curves generally require the assumption of diminishing marginal utility or concave utility functions. These things we discussed while discussing the DUM. The implication of this condition is that it might cause people to delay consumption until later time periods.

For example, when we eat a delicious and generously portioned meal, we may prefer to leave some of it for the next day or, if at a restaurant, take the remaining portion home in a doggy bag. It should be noted that this effect of diminishing marginal utility operates in the opposite direction of the normal direction of time preference because generally, we say that we have diminishing marginal utility with respect to time preference also. So if I just had a meal, despite how delicious it is, I would not actually prefer to have it in the next mealtime because my marginal utility is diminishing.

But when we carry the leftovers home or save something for the next time, then this actually violates the assumption of diminishing marginal utility. Normally, time preference is positive, meaning that people apply a positive discount rate to future utilities. For this reason, many economists have not been happy with Fisher's approach on the grounds that

it confounds the effect of diminishing marginal utility with pure time preference. However, we shall see later that it is very difficult to define the term 'pure time preference' since there are, in reality, a number of confounding factors all the time, not just the phenomenon of diminishing marginal utility.

With this, I conclude this module on the features of DUM. In the next module, we will discuss the anomalies observed in the applications or in the context of DUM. Thank you.