Lecture – 09
Criteria, Objectives and Setting for Decisions

Okay. So, we spent some time talking about characterizing random variables such as writing down the random variables form, discrete, continuous, expected value, variances, sums of random variables, central limit theorem; these all we will use a lot in this course. Another very important aspect that I want to touch upon by, before we complete this topic is what are the criteria for making these decisions, what are the objectives, what are the settings. So, these are things we will talk about in the next few slides. The treatment is not going to be mathematical, alright.

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So, what are the optimization criteria? So, we talked about the characterization of uncertainty. So now, we talked about uncertainty, the course about decision making under uncertainty; so, we spend a little bit of time talking about making decisions. To do that, it is important to figure out what criteria you are going to use to optimize.

Now there is a wonderful book. If you have not read this, I would highly recommend it; this is a book called "The Goal". The Goal is written by a person by the name of Eliyahu

Goldratt. And, Goldratt's book is an amazing book. I would highly recommend to anybody interested in a topic like this.

Essentially, Goldratt says that the main criteria for any company, especially if it is a for-profit business, is to maximize the amount of money that is made. While this is extremely important, sometimes it's not easy to translate the effect of the alternate decisions; what is the effect of these alternate decisions on what monetary values?

Now, let me give you an example. Let's say you are a company that produces computers or something like that. And then, you are saying now, maybe I should try a few alternatives such as going online. Let's take the example that Dell did. It's not clear to them going online, how much of an improvement and monetary value they are going to get. So, they might use some other alternative ways of actually measuring things. So, one does several criteria as a combination; we will see some of that a little bit later.

But, let's look at a simple example. So, let's say you are a dentist as an example and you open up an office to practice dentistry; now, you have two choices both of which are extraordinarily reasonable. The first choice is, you provide phenomenal care for a small number of patients. So, you take a small number of patients; they are all extremely happy; you provide great care and if you ask them, they will say - I have never met a dentist like you. On the other hand, there are a gazillion people outside who are dying to have you as their doctor or their dentist, but you are not available to them. Now, your alternative option is to provide good enough care for a large number of patients. So, that means you are not providing phenomenal care, but I am providing something that would pass in each test; but it is not phenomenal. So, that's your choice. Now, when it comes to making money, it is possible that both are equally good. It's not clear which one would be better. And, that's what I was trying to say here. It is not clear sometimes; you may want to maximize amount of money you make, but it's not clear which decision is going to result in better monetary values. So, there are those kinds of caveats to be careful about.

Now, the question is, what do the decisions mean in terms of some other metrics that we are all probably very interested. If you start a dentist office, you want to be sure that you want to have a lot of impact on people; you want to make sure that you stay profitable; you want to stay self-satisfied. For example, we are talking about this same course in NPTEL. NPTEL is a way of making sure that everybody has access to good education. So therefore, what they are

saying is – Well! Let's try and cater to a larger audience impacting more people. I, for example, definitely signed up to do this because it gives a lot of self-satisfaction. So, one does not normally do everything necessarily for the sake of profit, but there are also other things like impact and satisfaction, alright.

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We need to talk about the other optimization criteria, especially for not-for-profit like universities and academic institutions as well as governmental organizations. And, many times businesses also use these as a proxy for money. Now, let me take an example. Let's take an example of educational institution. Now, we are usually trading off between cost, quality of the product like if you are a company and making a product or the quality of care if you are healthcare or you know a service, the timeliness - how much on time things are and the availability. So, these are other metrics that one typically uses. So now, coming back to our educational institution, that is typically not-for-profit. A good objective would be to maximize the quality of students graduating. Now, I firmly believe that is a very good objective which is to maximize, what students are graduating out of the university. Now, one could achieve that objective. How does one do that? One could achieve that objective by being extremely restrictive in terms of admission. This is what a lot of times is done in a place like IIT; extraordinarily restrictive in terms of who they admit.

Another option would be to spend a whole lot of money and increase a lot of resources which is what the government is doing right now. In India, they are building a lot of IITs; they are

spending a lot of money improving the resources. That's another way to do this. So, that could be something that you could want to do. Now, the actions could also change when your aims are different and your constraints are different. So, it is very crucial to pick the right objective. That is why I kind of said, it is important to know what are you trying, what is your aim, what are you trying to maximize, or minimize if it is a cost? And, their actions could really depend on what aims you have as well as what your constraints are.
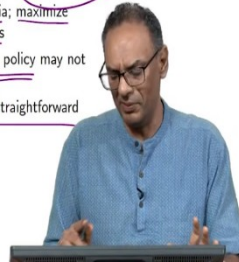
Now, this is a fact of life. It is very difficult to provide all of the following: you cannot give low cost and high quality and highly timely stuff as well as high availability; it's not possible, something has to give in especially when you have constrained resources. Now, take this NPTEL course for example. This course for sure, is low cost for the people who are taking the course. For sure, it is highly timely and that means, you can view it anytime; yes, you have to start at the beginning of a semester. But other than that, it is somewhat timely. You do not wait a whole lot. There are other courses which are even more timely. High availability - nobody stops you from taking it; you can go ahead and take it. Now, quality is the question. I do know that if you were face to face in a classroom, the quality would be higher than what is provided here; but we are trying our level best.

Now, there are many such examples in life that you could think about. For example, the dentist office was trying to keep it at low cost, high quality and highly timely, but not highly available. That is because it is very difficult to get an appointment, if you want to keep your costs low and quality high. That means, your times are all going to be taken. And, you also want to be timely, that means everybody who starts an appointment at a certain time will get their appointment. You got everything in there. Then, your availability is going to get hit because you are not going to be able to schedule everybody inside. Like that, you can think of multiple examples where three out of the four can be satisfied, but the fourth is going to be incredibly hard, alright. Now, that is not terribly crucial for this course. I just wanted to mention that as a comment.

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Now, once we establish the criteria, we also have to figure out what is the objective. Now, we talked about the expected value. That is a very common objective and a common objective is to maximize the expected benefit or minimize the expected loss. But is maximizing the expected value appropriate for a one-time decision? What I mean by that is, you make a decision exactly once. Why would you do the best on average? Would you not be thinking about something else? For example, you could think of maximizing the worst-case benefit or you could take the most likely benefit and maximize that. You could also minimize what is called a regret. Now, minimizing regret is rare for a company unless one is the CEO; you are probably more likely to do minimize regret when you are talking about individuals making decisions. We will talk about all these things in the next topic of one-time decisions which will be topic two. We will go over all this. What should be there? What should be the criteria to use for one-time decisions? Should it be maximize the expected value? What are the other options?

Now, if you are doing repeated decisions, it does make sense to use the expected value because you are repeating day after day after day; so, on an average, things average out. So, that's the reason it is a not a bad idea at all to use expected value in the situation made of repeating a decision. You could also look at other risk measures. There is something called cVaR, Conditional Value at Risk which is very popular. There are things like that that you may be able to find online.

Now, there is another thing that is important too. Who do you want to maximize? Many times, your population is very important like we saw in the case of the dentist. Now, if your population is, you are providing excellent care for a small number of your patients, you are providing terrible care for the people who are not your patients, that means, they are not even getting to see you. So, on the other hand, you have to be sure that you have clearly identified your population. So, your objective could be - I want to maximize my sales in India, I want to maximize the quality of students among those that graduate. So, we are not saying we are going to look at all the students, but only those who graduate. We are not concerned about the people who do not graduate and their quality because you are not going to get a degree from our school, alright. We also we talked about quality of the patients, alright.

Another thing that we want to say is the issue of what is the best decision that is socially optimal. What is good for everybody may not be good for an individual. There are many such examples that we could think about. And now, it is important for us to worry about how do we do as an individual. Now, many of these topics fall more under the game theory side which we will not get into. However, many times, you are really mad at the government for making a decision. However, if you think about it, they are not trying to make your life best, but they are trying to say - what is best for the population as a whole. And that's the reason you have things like the democracy, because you do want to see what works for everybody taken in an aggregate way. So, these are good things to remember in life for sure. Our course will fortunately won't go into some of these nitty-gritties, but we will keep our objectives very straightforward.

Types of Decisions

- One time, few times and multiple times
- Finite horizon versus infinite horizon
- Centralized versus distributed decisions
- Strategic, tactical and operational decisions
- Simple and suboptimal versus complex and optimal
- Nested decisions, contingencies and reevaluation
- Multi-players: Games, auctions and competitions

The last slide in this set of topics is what types of decisions. So, there are multiple types of decisions that one can consider. So, we talked a little bit about one-time decisions and multiple time decisions. For example, if you think about the cricket example, there is something between, called few times.

So, let's say you are playing a 20-20 match; then, 20 times you have to make a decision on who's going to bowl as a captain. So, that's a few times decision; it is not a lot; it is also not one time. But a one-time decision where you toss a coin and win the toss, which would mean I am deciding to bat or I am deciding to bowl; so, that is a one-time decision.

And, there are also some other multiple decisions where the decisions are a lot. Say if you are looking at a ball by ball in a test match, you decide on where you want to bowl as a bowler; it could be something that is a multiple type of a decision.

Now, let's look at the next example which is a finite horizon versus infinite horizon. They are kind of related to the previous topic. A finite horizon would mean, I have a few decision points where decisions need to be made. And, the infinite horizon is a case where this goes on and on forever. Now, you would wonder – "We all have a finite life. Why would I ever be interested in infinite horizon?". Well, turns out that the results mathematically actually are very appealing in the infinite case; you kind of get very nice results and that's why a lot of people study infrared horizon. Basically, that means, it is multiple times done over a very long period of time.

Then, there is an issue of centralized versus distributed decisions; in supply chain, this is extremely common. That means, do you want to make decisions about inventories in a centralized fashion or a distributed fashion? Now, many times, you do not have enough information to make distributed decisions at the central level. However, the centralized decisions tend to be on a companywide level and generally more optimal. Now, there are tradeoffs and we want to think about how one can go about doing things like that.

Now, another aspect that is important and somewhat related to centralized and distributed; centralized and distributed is space related, time oriented would be strategic, tactical and operational decisions. Strategic decision is a decision that you make usually one time or once in a while. For example, do I want to install a wind farm in my village? So, that's a strategic decision. Then, I make tactical decisions such as who do I write contracts in terms of taking the wind farm energy and try to talk to, yearly contracts I might make with a utility company; that's a tactical decision. And then, I had to make operational decisions, like every day, how do I buy power and how much power do I sell, and what the market price is, you are going to get the market price; you need to make several decision about the operations on a date, on an hourly or a secondly basis. So, that is the strategic, tactical and operational decisions.

Now, you also have this issue and a lot of companies that I speak with and consult, they tell me something very interesting. As a researcher, I tend to build some very complex models that gives me the optimal solutions. But many times, companies are interested in simple, may be suboptimal solutions. And, that is very understandable because as a person who is not into research, you may not have full appreciation for or full understanding of what it takes to make those decisions. So, you want a simple solution that you could quickly think, "Yeah! That makes sense". So, there is that issue as well. So, it is not that everybody really wants the optimal solution. If there is something that is reasonably close, a lot of people are very happy.

Now, another important part is this issue of nested decisions. We will see a little bit of these in our course, especially in the very next topic, where you make one decision and then, based on that, your next decision follows and then, a contingency plan. Let me give you an example.

Let's say, you are doing pizza delivery and you want to decide what all pizzas to put into a particular delivery scooter. Essentially, once you decide to take off the scooter, that is your first decision saying, "I think I am going now and dropping off my pizzas". Then, you are

asking, what is a nested decision; what order do I go and deliver the pizzas? So, that is a secondary decision. So, the first decision is what all pizzas I am going to deliver, the secondary decision is what way do I go? Then, I could think of a contingency plan if something changes along the way. For example, there is traffic and then, I want to change my plan and I don't want to go this route; I want to go through a different way. You might also want to reevaluate as you are driving and then, you come back closer to your restaurant and then, the your manager calls you and says, "Hey! Can you pick up a couple more pizzas, anyway you are close by?". You might want to do that and reevaluate your decision; so, we do this a lot of times. And finally, I do want to say one other thing. We almost the entire course except in one situation, will talk about why there is only one player. But at times, you might be in situations where there are multiple players and you want to come up with strategies and these fall under what is called "game". Game theory is what is used to solve when there are multiple players. We will touch upon this in one topic, but mostly we will not be in this situation. But I do want to say that a lot of people work on this topic of games or even auctions; there can multiple players in an auction or even competition. So, these are things where you have to make a decision, understanding or thinking about what others we will do. This is like playing chess or football. Things where you think about what the other person would do, in order for you to make a decision; you adapt quite a bit as you go along. So, that is another level of decision making which we would not do for the most part of in this course. So, this brings us to the end of topic 1.

Thank you.