

Decision Making Under Uncertainty
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Lecture – 02
Examples of Managing Uncertainty and Making Decisions

Next, we will talk about examples to manage uncertainty and making decisions. So, the course is about - Decision Making Under Uncertainty. So, we will look at some common examples in day to day life.

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Decision-Making in One's Education

- ▶ During schooling one has to make several decisions
 - ▶ Which school to attend? There are pros and cons for various options
 - ▶ Should we go to science stream, commerce, or arts?
 - ▶ Would it be a good idea to invest time and money studying for an entrance exam?
 - ▶ Should we be taking private tuition lessons to do well in school?
- ▶ At college time there are many decisions (before and after)
 - ▶ Which college to attend, what field, and which electives?
 - ▶ Should we get a job after undergraduate studies or get an advanced degree?
 - ▶ Should one venture into a start-up by becoming an entrepreneur?
- ▶ How would you go about making these decisions?
 - ▶ What are the uncertainties involved?
 - ▶ What criteria would you use to decide among alternatives?

So, first example that we would like to talk about is decision making in one's education. Now, think about yourself when you were in school. Those of you that are not in school, your parents had to make decisions such as, which school should I put my child, okay. There are pros and cons you can imagine. Some schools might be close to your house; there may be other schools that are better but further away. Should we put in the one that is closer or should we put in that is further away? Also, there is lot of uncertainty. If you think about it, the school maybe highly ranked right now. We do not know how it will be 12 years from now. So, that is another thing to consider. We also don't know what the child's interests are going to be. So, should we put in a school that caters a lot to sports? Should we put a school that caters a lot of cultural activities or something that is heavily into academics? So, those are types of decisions that we make as individuals.

Now, another decision we make as we go through, may be when we go to 10th class, is to split into going into the science stream, commerce or arts. I know most of us pretty much like to do what our friends and our neighbors and everybody that we know does. But, think about it. A lot of us pay a lot of attention to what is the right thing to do. And, this is a very difficult decision. And, we need to think about how best to make a decision as to what stream to take - the science or commerce or arts. Now, another thing that impacts a lot of people is - should we spend time and money studying for an entrance exam? Now, this is another interesting decision to make. Think of the IIT JEE exam. Now, if you want to pass that exam, you are looking at investing a significant amount of time, may be 4 years of your life, and a lot of money going to tuition. Now, is this all a good thing to do? Of course, if you don't do that, you are not going to enter; that is the assumption. I do know of people who have entered without going through any of these tuitions. But, think about it; that is a decision we need to make.

Another decision is - should we be taking private lessons/tuitions while going to school? That's a decision to make and again it's an issue of money that you lose right now for possibly much nicer future. The decision to be made is - should I keep the money and have a good time or should I save the money by investing in a child's tuitions? So, that is another decision that we all make in terms of education.

Another decision that we make is at college, which I presume most of you listening to this are going to be in. So, before going to college, we need to make a decision on which college should I attend, what field should to specialize - mechanical engineering or electrical engineering or a completely different field, maybe a class in management. What electives to take? I have 3 or 4 electives to choose from. What class to take? How do you make these decisions? That is something to think about. There is a lot of uncertainty, right. So, what are the uncertainty here? Well, you don't know how your future is going to pan out; you really don't know what you are passionate about; you probably don't have a good idea what you are good at and what you are not good at. In those situations, it is hard to make these decisions. There are lot of uncertainties in terms of how things would pan out. For example, I have a lot of friends that did and went through an engineering program. But, they do not do any engineering in life right now. So, those are things to think about. So, there is a lot of environmental changes between now and maybe, 10 or 20 years from now. So, these are decisions to be made under tremendous amount of uncertainty. Now, another question -

should we go ahead and take up a job or should we get an advanced degree, a masters degree or a PhD degree? That's a decision to be made because your life could be very different depending on how you make that decision.

Another thing is - should we become an entrepreneur? That's a risky decision. Now, we take a risk in becoming entrepreneur. Our venture could be very successful, which is what we hope to, when we take up these positions. So, we could also go into something that may not. So, there is a certain amount of risk but there are certain tremendous pay offs if you become an entrepreneur. Now, the question that we want to ask is - how do you go about making these decisions? We want to make decisions so that we are somewhat conservative; we want to have a wonderful life, a happy life. Usually, these are criteria that are used to make these decisions.

And, we also talked about some of the uncertainties involved. We talked about things could pan out, how the environment could change, how life could change as we go along. We could get married to somebody else who has a very different plan and things could be very different from when you actually have to make the decision. Also, what criteria would you use? There are whole bunch of criteria. Towards the end of this topic, we will look at a set of criteria that one uses.

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The slide is titled "Managing Risk and Uncertainty in Supply Chains". It contains a bulleted list of points with several handwritten annotations in red ink. The annotations include circles around "Supply Chains", "Dell Computers", "pool risk and manage uncertainty", and "operational costs", and underlines under "operational costs" and "ability to manage uncertainty". A handwritten diagram at the top right shows "Supplier" and "Retailer" with an arrow pointing from Supplier to Retailer, and "buy" written below it. Another handwritten diagram at the bottom right shows a central box labeled "More" with three arrows pointing outwards. In the bottom right corner, there is a video inset of a man in a blue shirt speaking.

Managing Risk and Uncertainty in Supply Chains

- ▶ One of the biggest supply chain success stories is that of Dell Computers
 - ▶ There were so many different computer configurations possible that it became risky to carry inventory in retail outlets
 - ▶ Dell directly interfaced with customers and allowed them to customize their computers and have them shipped
 - ▶ It allowed Dell to understand the needs and demands of their customers
 - ▶ It also allowed Dell to only carry raw materials and as orders came in, they would put together a computer and ship
 - ▶ This way they could pool risk and manage uncertainty
- ▶ When there is a lot of variability, uncertainty and risk involved, companies pool risk by carrying inventory in regional warehouses
- ▶ Having more information throughout the supply chain significantly reduces operational costs and ability to manage uncertainty

Now, let me move on to the second example. In the second example, we are looking at somewhat more industrial setting, a supply chain setting. If you are not familiar, a supply

chain is one in which there are products that are supplied to a retailer. You have a retailer/store/shop who gets items from a supplier. It comes to a retailer and then, customers come and buy from the retailer.

So, one of the retailers or one of the supply chains success stories is that of Dell computers. Dell is a very well-known computer company in the US. And, they were the first to innovate in a certain way that completely changed a lot of things that we do today. We are talking about the early 1990s where there were several computer companies. There were HP, Compaq to name a few and they were all selling computers.

What they were doing is, they were putting these computers in different stores and whoever came they came and they pick the computer they want. However, there are so many different computer configurations possible; some might want a certain type of configuration like a hard disk or a RAM or a they may have preference for storage.

So, there are so many things that are possible. Now, you cannot take all these various combinations and store different computers catering to individuals. In fact, it becomes hard to even predict how many people would like what type of computer. So, one thing that Dell did very smartly is to say - we will have an online platform where you could pick what type of processor you would like, what type of storage you would like and then they would put together and customize the computer for you.

Now, when they customize the computer and ship it, there is a down side. You cannot get your computer within zero time. You really are going to look at, waiting for a week to get a computer. So, that's the risk that they took - will customers be happy to configure the computer of their choice trading off some time to get their machines in their house?

So, that was the risk that they took but they had some side benefits. Dell was able to understand what various customers are going to need; they understood what are going to be their demands; they understood what are going to be the needs of various companies.

And turns out, Dell was also able to carry raw materials and when the orders came in, they put together computers and shipped it. Now, this is an extremely important thing. Now, instead of carrying finished goods, what Dell ended up doing is they just carried raw materials. So, they carried a whole bunch of storage units; they carried a whole bunch of

processors. So, they had the little motherboard and then, they had a little box and then, they would keep putting stuff in, depending on what the customer asked for.

Some people wanted a certain type of speakers and then, they put the appropriate audio and video devices and so on. So, they really did a great job of just carrying the raw materials and customizing a computer. This way, they were able to do what is called pooling risk and were able to manage the uncertainty in terms of what the customer demands would be and so on.



Now, what happens when there is tremendous amount of variability, uncertainty and risk? We go onto define what is variability, uncertainty and risk in the next set of topics. But, let's say when all this is there, companies are going to be carrying some inventory at regional warehouses. So, instead of having these multiple retailers holding inventory, they will put the inventory in a warehouse and then, depending on where the demands are, they would go ahead and satisfy those demands from a central warehouse. So, this is very commonly done by a lot of companies. Now, if you have more information throughout your supply chain, you could significantly reduce what is called operational cost and you could also manage uncertainty.

Now, think of the following: a lot of times when there is an unfortunate situation like a cyclone, you want to know, how much there is in store. You want to know - should I carry a little bit more supplies expecting a major cyclone to hit or I do know we have enough; you don't even know what the inventory levels are, for lot of your items in your store. Having that information significantly improves customer satisfaction and performance.

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Decisions in Personal Health

- ▶ Your body has "sensors" that will let you know if you are sick
- ▶ Say your symptoms are fever, runny nose, stuffy ears and light cough
- ▶ You are also feeling quite fatigued and want to stay home for the day
- ▶ You need to make a decision whether to see a doctor or not, and whether to stay home or not
- ▶ Some of us would stay home (probably get some home remedies), and see what happens in a day but not go to a doctor right away
- ▶ If symptoms get worse, then we would see a doctor the next day
- ▶ It could be a viral or a bacterial infection, or it could be just an allergy or something nasty like influenza (notice uncertainty)
- ▶ The doctor's office may be able to determine which one, but many times they would just prescribe antibiotics (another decision)
- ▶ The decision to see a doctor and stay at home could depend on our history of feeling this way in the past
- ▶ The doctor could use a test (somewhat unreliable) but frequently rely on what other patients were diagnosed



Okay, we have seen two examples. Now, let's look at a third example. Now, we are back to a personal individual level where we are looking at personal health. This is a favorite topic among a lot of people. Whenever you walk, people are always asking – “What do you eat to look so thin?”, “I am sorry to see the way you are”, “What are some of the things that you do?”, “What kind of exercises you do?”, etc. So, personal health is a big deal.

Now, we have sensors in our body. For example, your eyes can sense what is going on outside, your ears can sense sounds, your tongue can sense tastes and then, you can smell with your nose, you can feel with your skin. So, turns that a body has all the sensors. Now, these sensors basically carry information. If we had a 6th sense, that will be a new sense (nuisance!).

Let's now worry about the 5 senses that we have. Let us look at an example where you have some type of symptoms such as you are unwell, you have fever, you can feel it, you have a runny nose, you cannot smell, you have stuffy ears, you cannot hear and you have a light cough. And, let's say you are in that situation and you are thinking – “Well, I am really tired. I am so fatigued. Maybe, I should just stay home for the day”. That is what you are thinking in your mind.

And, you are thinking – “should I have to make this decision?”, “should I go see a doctor or maybe, I will just stay home”. In fact, there are two decisions here - should I see a doctor or not, and should I stay home or not. So, these are two decisions you have to make.

Some of us would prefer to just stay home and get some home remedies. We do this a lot. We probably don't want to see the doctor right away. We will see what happens tomorrow. So today, I will stay home, will not go to work or will not go to school and tomorrow, I will see. If I get worse, I will go see a doctor. This is common. Some of us tend to see the doctor right away and then go from there. So, that is typically how one goes about making these decisions.

Now, the situation itself has a lot of uncertainty. We don't know what is causing this. A lot of things have these symptoms - the symptoms of fever, runny nose, stuffy ears and light cough. It could be a viral or a bacterial infection; it could just be an allergy. So, there is really no problem but you are around with pollen and something like that. Or it could be something really rough like an influenza which is commonly called flu. And, there is some uncertainty there. So, notice the uncertainty there. We don't even know what is causing these symptoms. Say you go to a doctor's office. The doctor will probably be able to figure out what we have. Now, there is tremendous amount of uncertainty there. All the devices they use are not 100 percent guaranteed.

So, for the most part, they are able to determine quite well what is wrong. And, if it is a bacterial infection, they would give you an antibiotic and this is another decision that they have to make. So, first decision is, they have to figure out what is it that is causing your condition; second decision is what medication to give you.

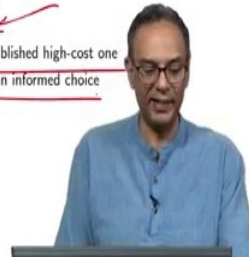
Now, turns out, that there is also this issue of history. That is also an important thing to consider. Whether we see a doctor and stay at home depends on how we felt like this – “Oh! I had this last year exactly the same time; it must be allergies” or you are thinking, “I have never felt like this before, I have to better go see a doctor”. So, your decision could depend on your historical experiences.

Now, the test that the doctor uses is somewhat unreliable. This day and age, that's not so much the case. But, the doctor also sometimes uses what other patients experience -there is a flu going around in town. So, maybe this is flu. So, doctor uses that information in order to make their decisions. Notice how we use historical information and habits and so on to make our decisions going forward.

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Managing Risk in Financial Investments

- ▶ Using the salaries we get, we try and satisfy our wants and needs
- ▶ We try and set aside some moneys for near term expenses for the family, for health (if any), for a home for a vehicle, etc.
- ▶ We also set aside money for retirement and this can take many forms
- ▶ The first decision to be made is how much to set aside
- ▶ The second decision is what to invest in using the amount set aside
- ▶ The decisions depend on factors such as life expectancy, retirement age and future wants/needs
- ▶ Assuming that is characterizable, we are ready to make investment decisions
- ▶ For that it is important to assess risk and personality
- ▶ It is also important to study various stocks before deciding where to invest
- ▶ In addition whether to do this on ones own, get a low cost broker, or an established high-cost one
- ▶ One typically reads a lot, collects data, does some analysis and then makes an informed choice



Now, the fourth example that we are going to look at is making decisions under situations such as personal finance. Personal finance is something that is extraordinarily important, extremely difficult decision because we are making decisions for something that is going to happen much later in life. Those of you that are in college or school right now, this is not yet your situation. But, if you talk to people who are working, this is something that they are concerned about; they are trying to save money so that they could live a happy life once they are retired. Sometimes, people are looking at saving a little bit and taking care of their wants and needs as they go as well as after they retire.

So, what we do typically is, we setup some money aside so that we make sure that once we grow older, we can use the money in, say there is a health situation or an education situation or when we want to buy a house or when we want to buy a vehicle. So, how much you set aside now? That's not an easy one. And also, you want to set aside some money for retirements and this is extraordinarily complicated in some sense and I think a lot of us fret a lot about this.

Now, the first question is - how much money to set aside for retirement? And then, the second question is - once you set aside that money, what kind of investments do I need to make? Should I invest in stocks and bonds and so on? Or should I invest in gold perhaps? Should I invest in house? There are many ways to invest money going into retirement.

Now, lot of uncertainty is there - how long are you going to live, what age you are going to retire, I don't know what I am going to need when I grow old. So, those kinds of decisions have to be made now based on some of the uncertain events into the future.

Now, what should the decision be assuming that these things are characterizable. Now, I am not saying that is easy, but a lot of financial institutions make you or want you to make those assumptions and then, ask you to make investment decisions. So, investment decisions are typically based on how you characterize a life expectancy when you expect to retire and what your wants and needs are in the future.

So, it is really important for you to assess your personality and risk. Some people are risk taking; they like to take risk. Some people's personality is such that they don't want to do that. So, your decisions are also depending a little bit on your personality.

So, one thing the people do, those that are investing in stocks, is to you would study the stocks, look at historical performances of the stock and how was it. In fact, one of the investment 101 lessons is to study a stock for 1 full year and see how it grows so that you understand what is going on before you invest which one to go for.

Now, another decision you need to make is - should you go with a low-cost broker or should I go with a high-cost established broker? So, you are thinking about who do you pick to be your investment broker.

So, the whole thing is the following. There are many steps and you do this for every single type of decision. This is an example where it is easy to articulate. You read which is sometimes called "do your research" and then, you collect data, the some of the analytics that we were talking about. So, you are doing a whole bunch of analysis and then, you do some type predictive analysis and then, you make some prescriptive analysis such as making a decision.

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The slide is titled "Decision-Making in Sports" and contains the following bullet points:

- ▶ There are a lot of decisions to be made in sports
 - ▶ Selecting the set of players and captain
 - ▶ Choosing the playing team (versus substitutes)
 - ▶ What to do if you win the toss
 - ▶ In cricket, you have to decide the batting order, the bowler and field placement
 - ▶ In football (soccer) penalty shootouts, which side should a goalie jump
- ▶ Some decisions are dependent on what the other team does (it is a game after all) but there are important strategic decisions
- ▶ Haven't we all criticized poor decisions in our favorite sports?
- ▶ The notion of "playbook" is from sports and gets used in other areas
- ▶ Teams nowadays collect a large amount of data to make excellent decisions in sports (read *Moneyball* by Michael Lewis)

The slide also features an NPTEL logo in the bottom left corner and a video inset of a man in a blue shirt speaking in the bottom right corner.

Last but not the least, decision making in sports. Now, this is a favorite topic among a lot of people. I understand that some people in the audience may not be interested in sports. I will give a lot of sports example throughout the course, but I will keep that to somewhat of a minimum.

So, there are lot of decisions we need to make in sports. I know all of us get really excited when there is a cricket match. In fact, today when as we are recording, there is a test match going on between India and Australia, this is day 2 of that match.

Now, turns out some of the decisions we need to make is - who should be the players, who should be the captain, etc. Well, the decision on the captain happens way before going to a tour. But, once you are in a tour, you also need to decide who are the players that you want to send. You also want to figure out who should be the playing 11 if it is cricket, or for other games, who should be the team and who should be playing as a substitute. Now, that's another decision to be made. Then, the toss. You put a toss and then decide what to do. Should you, in cricket, bat first or ball first? So, that's a decision that you need to make.

There are other decisions in a game of cricket. You have to decide the batting order. Now, those of you that are not familiar with cricket and you know baseball for example, in the same situation, you need to decide the batting order. And in cricket, you have to make a lot more decisions such as who is a bowler in every single over; in baseball, you kind of decide who the pitcher is and then, you could get a relief pitcher and so on. Now, you also need to

decide field placement. Now, this is not something that they do in baseball, but in cricket, you have to decide where you need to put which fielder.

In soccer or football as some of us call, you have to decide which side of goal you should jump. Now, these decisions both in cricket and in football, is made with tremendous amount of statistics.

Now, I don't know if you have seen when you look at a football match, there is a penalty shootout in the end. The goalie usually does not have enough time to see when the ball is coming and jump on one side. Typically, what the goalie does is, as the kicker is coming in and kicking the ball, the goalie jumps to one side. Now, that's the decision the goalie needs to make because he or she needs to take a chance and needs to know, most likely this person is going to kick it to the left and I am just jumping to the left and many times, they are lucky.

Now, turns out that that decision based on prior information is kind of a decision we are talking about in this course. Now, some decisions are also dependent on what the other person does. For example, this is a game after all; now, many situations that is not too crucial. There is a whole field of game theory where they analyze how to do some things based on what the other person does as well. Now, we will not go too much into game theory, but I will just touch upon that topic once more in this course.

Now, we all know how much we criticize poor decisions in our favorite sports. So, we are like, why did he bring this guy to bowl the last over. I mean those are decisions that we always talk amongst with our families or friends when we watch a game on TV.

Now, the other thing is now, sports actually uses a whole bunch of decision making under uncertainty. In fact, people use the word "playbook" and by "playbook", what we mean is in fact, is a strategy; that is a word that has come from sports. People working in companies also have a playbook. That's the way they do things.

Now, I would highly recommend to those of you are interested in sports to read this book called Moneyball by Michael Lewis. And, this book talks about baseball but, it is not so baseball oriented. After all it is about how we make decisions in sports. I would highly recommend that. I do want to stop by saying one important point though.

A lot of times, we as spectators end up criticizing decisions after something happened. Now, this is a very important distinction. You make a decision given the information that you have. You cannot make a decision in hindsight. You can't say that was a poor decision based on the outcome. For example, in cricket, the batting team needs to score 15 runs in the last over and you brought in a particular bowler; you are thinking that this is a great decision and make that call right there. You can't say after losing the game, that was a bad decision as you do not go back. That is an important aspect in decision making under uncertainty. Having said that, it brings us to the end of this lecture.

Thank you.