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Q.1 What are your current research interests and what drew you to that particular area?

My research interests are in economic theory. Economic theory is generally some sort of formal analysis and by formal analysis, I mean analysis within the scope of some model where different agents interact.

If you study mathematics, you'll study Pythagoras theorem which is so many thousand years old. But everything you read about Economics is very recent. A lot of time was spent in the 30s and 40s by economists like Marshall and Samuelson, developing this competitive model in which the agents took their environment as given and looked at the implications of that. But the other great development which took place in the history of not just Economics but generally in the history of ideas was this incredible book by Neumann and Morgenstern called **the Theory of Games and Economic Behaviour in 1944**. It laid down a basic model to allow for the analysis of this kind of multi-agent interaction. This could be chess, this could be tennis, this could be an oligopoly, etc.

They wrote something like that which obviously was of great interest to economists and this work was then refined by economists like **John Nash** and **Lloyd Shapley**. But it was only in the 1980s that the formal analysis of game theory reached the discipline of economics as it were. And it brought profound changes to the study of economics. If you went to the graduate study of Economics in 1965 or 1975, it would be completely different from what you would see in 1985 and 1995. People started studying these enormous, new, powerful tools of game theory.

When I went to graduate school, it was in the 1980s when all of these developments were just taking place, there were lots of people who were very excited by these things. There were a couple of people who were at the Delhi School of Economics who were a couple of years ahead of me, who were also graduates and they were all very excited. So when I went there, they said that I must learn this amazing new stuff, on this huge range of issues. So that's how I got into it.

The first kind of problem that I got interested in, on which I wrote my thesis on, is called "Implementation". It sounds bizarre, but it won a guy a Nobel prize. The best example of that is the biblical story of King Solomon. So King Solomon is a figure in the Old Testament, a king who is known for his wisdom and his judgment, Solomonic judgment. So what's the famous story about Solomon? There are two women who come to him, both claiming to be the mother of a child. So the question is that Solomon has to make a decision about who the child belongs to. So Solomon tells to cut the child in half whereupon the true mother concedes. Then Solomon says, "I know who the real mother is now, give the baby to her." So this is a classic problem of what is called **Implementation Theory**. Imagine that there are **two states** of the world as it were. One in which the **woman 1** is the real mother, and the other in which **woman 2** is the true mother and there are three options before Solomon - give the child to woman one, let's call it **option A**; **option B** is giving it to women two; **option C** is to cut the child in half. So formally, the question is, what does Solomon want to do?

He has this objective function which says that in each state, give it to the right mother. So in state one give it to woman one, in-state two give it to woman two, so that's his

objective function. But what's the difficulty? The difficulty is that he doesn't know which state it is, but the two women know what state it is, they know who the true mother is and who the imposter is, but Solomon doesn't know. So is there a way for him to get these women to make certain announcements, do certain things, such that when you look at the equilibrium of the game, called the **Nash equilibrium** of the game, then **that does exactly what his objective function is**.

Solomon played a trick, which unfortunately game theorists are not allowed to play. What he did is like the income tax authorities saying that okay, I know that some of you have undeclared incomes, if you announce your real income, I'll give you a big bonus. Then, you announce your real income but then they say oh no, now we've changed the game, so now I'm going to take away your income and send you to jail for fifty years. So I've changed the rules of the game. You thought the rules were of a certain way and then I changed it. So Solomon said he was going to cut the baby, but he didn't do it, he changed the *rules*. So formally, we can show that we cannot do what Solomon did, that the Solomonic thing is actually impossible.

So part of the stuff I wrote in my thesis was, what if you could flip coins and do certain things, so on so forth. So anyway, those were the kinds of things, issues that I got involved in. Even now, the sorts of things that I'm interested in is about voting models. One of my main areas of interest is called Strategic Voting where agents have private information about their ranking and they realize that they can manipulate it, and use it to their advantage. The question is what can you achieve under such circumstances.

I also have some interest in certain things like auctions. In auctions, you pay for things but again your valuation is private information. If I have to sell an object, I want to make the most money from it. And again, what's the best way for me to sell the object in order to maximize my expected revenue is a **classic question in mechanism design**. These are some of the areas I am interested in.

Q.2 Sir, the Condorcet Jury's theorem assumes to rule out insincere voter behavior. But in practice, insincere voting does take place. Are there insights from game theory that you think can be used to model or influence voter behavior in such situations?

Condorcet had two basic contributions, one of them was the jury's theorem. There is something else that Condorcet did which is very important if we follow the arguments of Brexit, for example. So let me explain the second contribution first. Condorcet paradox is that the majority of voting can lead to cycles. So suppose I have three proposals, **A, B, and C**. And suppose there are three agents **1, 2 and 3**. So agent 1 likes A to B to C, agent 2 likes C to A to B, and agent 3 likes B to C to A. Now let's do majority voting. Now over A-B, two guys to one would like A to B, two guys to one would like B to C and two guys to one would like C to A. So you have what's called a cycle. So every proposal that you can think of is beaten by some majority, and that's what happened in Brexit. Whatever proposal people put, a majority defeated it.

The Condorcet jury theorem is about a different model of preferences. So the model of preferences in a jury model is that, imagine there's a person that is brought for trial.

The jury is trying to make a decision as to whether they should acquit or punish the guy. Now all the agents have the same preferences, which is either to acquit if the guy is innocent or to punish if the guy is guilty. Everybody wants the same thing, they're not biased or vindictive people. The thing is that everybody receives a private signal about whether the guy is guilty or not, it's just your reading of the guy. If I'm the guy at the dock, maybe when I'm asked certain questions, I start twitching or something, and you notice it and say that I've got a signal that this guy is guilty or that he's innocent.

Now the question is, Condorcet said, how can we ensure that the right thing happens? Each of us has to vote to convict guilty or not guilty, and how are we going to aggregate these verdicts? Condorcet said that the best way to aggregate these is by the majority voting rule. Let everyone say guilty or not guilty, and count the number of these votes and then whichever is more, we'll go with that. Why is that, it's because of what's called the '**Wisdom of the Crowd**'. Everybody is getting some partial information and the best way to aggregate that information is to use everybody's information because everybody is observing something. So he assumes sincere behavior.

There are complications where, for strategic reasons, you may ignore the signal that you've got. I'll give you an example of why that might happen. But generally, if you're sincere, then he's just trying to justify the wisdom of the crowd. You might say that that's a powerful argument for why democracy is good and why authoritarianism is bad. Authoritarianism is where decisions are made by one or a small group of people. What happens is that you cannot observe, you ignore the signals that everybody else has received about whether something is good or bad. So if there's a policy, whether it's good or bad depends on the signals that everybody receives. But in authoritarianism, because of the way it is, it centralizes this, and you just don't ask other people. Not taking their opinion into account makes it more likely that you'll be wrong, so you get it wrong. So it's better to ask everybody and it's more likely that you'll get it right. That's Condorcet.

But you're right, there are problems with insincere behavior, why is that? The problem is that, imagine, for example, what's the jury rule, for instance in the U.S., that there are twelve guys and to convict, everybody has to say, convict, it has to be unanimous. Now I have received a signal that the guy is guilty, and I'm thinking what should I say-- suppose you get the signal that the guy is innocent, when is it that my vote is going to matter? If the eleven other guys say that the guy is guilty and I say that no he's not guilty. What is the probability that eleven guys have received one signal and that I have received the opposite signal? You can see that it's completely sensible to think that I've been mistaken that I've got the wrong signal, that the guy is actually innocent. So what will you do? You'll ignore your signal and vote guilty because your vote matters only in the case that everybody else says guilty and you're saying not guilty and the probability that you've received a correct signal in that eventuality, or the condition of that event, is very low. You're more likely to assume that you've got it wrong, that you've just received a bad signal, so you say let me just ignore it, and let's just go for guilty. So everybody does it and the guy gets convicted. This is the strategic problem that Condorcet assumed away.

There's a big literature around all this. So if you get into research, you can get into the depth of it, reading thirty papers of exploring various aspects of just this question, you know, should I be truthful, etc.

Q.3 Sir, how has been your experience, teaching for more than three years?

Teaching and research are different things although they're connected. So teaching is, you understand something only when you teach it. When you try to explain something to somebody, you'll have to confront any gaps in your argument, which otherwise you might not be aware of. So it's fabulous. I can't recommend it highly enough. It's nice to be always, to deal with people, with young people with fresh ideas. Research is always fantastic, you know, enormous freedom to travel, to collaborate with people from all parts of the world. I've written papers with people from every part of the world. So it's all a fabulous experience, you'll find it hard to replicate it in any other area of life. It's the least bureaucratic set up that you'll ever be in. In my almost how many years, nobody has told me that you have to do this, you have to do that, except for minor responsibilities. So I think it could be very exciting.

Q.4 Sir, how common is it for the government to have game theorists for designing a policy?

I would say that India is not a country where expert opinion is valued very highly in general. It's a country where we have a long tradition of people from the civil services and so on making decisions on a riot field and deciding how to price tea, they're known to do everything. That's our tradition. And I do think that, compared to other advanced or industrialized countries, India falls behind. But, on the other hand, India is a very poor country. In relation to other countries with India's per capita income, India may well do better.

So I suppose the government can and should use more expert opinion, but in many cases, people are very wary of experts because they think that experts are biased, they're just very suspicious. So just to be a guy on the street is supposed to be good enough.

Q.5 In your work, "Fair and Lovely", you discuss a large literature on the problem of dividing resources when agents differ in their preferences over these resources. Of the models discussed, which one do you think can be most instrumental in dividing the task of pollution cleanup among countries?

There is a whole literature on what's called "fairness". It's a fascinating area. I can give you several examples, from antiquity, of what are the principles of fairness, etc. There's nothing special about the pollution problem. I mean if you ask me, what's special about the pollution problem perhaps is, you know on a range of issues, relating to what's verifiable, observable, etc. But what's interesting about fairness is how rich the problem is.

Here's a fairness problem, this is a problem of what's called **bankruptcy**. You die and you have creditors. What you owed dying is more than your estate. Again, this is a

problem of antiquity. This comes from one of the oldest problems in, I think this is from the ancient Greeks, what's called the problem of the contested garment. So there are two people, there is one garment and one guy claims all of it, and the other person claims half of it. So what's the right way to divide it, so here are two solutions. One is the Aristotelian solution, Aristotle believed in proportions. He said that by demand, the guy who wants the whole thing, his demand is twice that of the other guy, so you must do it in terms of $\frac{2}{3}$ to $\frac{1}{3}$. So one guy gets 66.6% and the other guy gets 33.3%. But the other solution or there are many solutions which are equally, again this is a solution which is from antiquity. One guy has given up half, he wants only half. So what is contested is half. So you split that equally. It should be $\frac{3}{4}$ to $\frac{1}{4}$. And there are beautiful solutions, you know so what's a bankruptcy problem. The bankruptcy problem consists of $n+1$ numbers. What are the n numbers? The amount that each creditor wants and the last number is the estate. So the sum of these numbers has to be greater than the estate. Given this, a solution tells you how you split the estate. And again, there are these fabulous solutions which tell you how you do that.

Here's an application. Suppose there are a number of people below a well-known poverty line of a hundred rupees per day. And there a whole bunch of people who are below the poverty line and you have a total amount of money to distribute to these people, but there isn't enough money to bring everyone above the poverty line. And the other thing is, you don't want to give anybody more than the poverty line. How should you distribute it? So the bankruptcy problem will give you different ways to do it. If you're a bureaucrat, then one of the things that you might be very tempted to do is to look at the guys who are just a little bit above the poverty line and push as many of the above. The solution would be to find people who you can cheaply move up. But for instance the equal gains solution, the $\frac{3}{4}$ to $\frac{1}{4}$ solution would be that you start from the bottom. And it's like, you start from the bottom and raise it to the second-highest and then you start raising this until you come to the third-highest and then push them all up as far as you can. That would be another way to do it. Or what I'm saying is that the theory of fairness is an incredibly rich theory. Fairness is something that a lot of computer scientists are interested in and in finding efficient algorithms for doing these things.

Q.6 Sir, at Miranda House, many of us want to pursue our Masters or Ph.D. outside India. How was your experience when you were pursuing it abroad, and your experience in academia?

I finished my Masters a long time ago, so we really didn't have that many choices. Now there are more choices. But generally, about research, there's much to recommend in research which is, the life of contemplation, rather than a life of doing things. There are enormous, enormous freedoms in research, you can do whatever you want to do, you make your own agendas, you can be ambitious, ambitious not in terms of making money, but in terms of making your contribution to the world of ideas, which is far more substantial. And it lasts longer than any other thing that you might be able to achieve in material terms. So if you just like thinking and wondering about things and learning about things, then I think it's a clear choice.

But it's not for everybody, because people like to see a connection between what they think and something which happens. So if you're such a person, who says, "I have this great idea, it must be used," then I'm afraid academics is not necessarily going to be the most satisfying place for you. Because most of the stuff, almost all of it is mostly about exploring, understanding, and moving on. It's not like big things have happened. Solomon's problems were not, it was not that the Bible was changed because a bunch of game theorists decided something in 1980 or 1990. There are enormous attractions for academic life if I might say, basically in terms of the complete freedom to do and think as you choose which you'll never get anywhere else. So if you're an ambitious person, intellectual, then yeah, I would recommend the field.

It's not easy as well because academics have no hierarchies, so age will not buy you anything. If you're wrong, you're wrong. Even if a twelve-year-old kid can show that you're wrong, you have to swallow your pride and accept that this guy is smarter than me, he has a better argument than me. Just accept it and move on. It's a matter of personality. It's not that there are some people who are very smart and there are some people who are not so smart and all that, I think those things are much less clear. What is important is how much passion and love you have for something, whether you really want to do it and you feel like you're going to die unless you get the answer to that question. If you're that kind of person, then I think that you might consider academics.

Dr. Arunava Sen is a game-theorist and a professor loved by his students at ISI Delhi. We encourage you to look at his work <https://www.isid.ac.in/~asen/cv.html>

