STEVEN LIPPMAN: Hey, Sheldon, good to see you.

SHELDON ROSS: Steven, nice to see you again.

STEVEN LIPPMAN: Hi. I'm Steven Lippman, professor here at the Anderson School at UCLA in Los Angeles. It's December 17, 2015. And I'm here to interview Sheldon Ross, professor at USC School of Engineering here in Los Angeles also. And I'm doing this for INFORMS.

I first met Sheldon back about 1966, when we were both graduate students at Stanford. Sheldon was in the Statistics Department, and I was in the Operations Research program. And it's a great pleasure to be here and to talk to Sheldon, one of INFORMS' outstanding scholars.

So Sheldon, how you doing?

SHELDON ROSS: I'm well Steve. It's a pleasure to see you. And it's a pleasure to be here today.

STEVEN LIPPMAN: So let's start off with a bit about your family and your educational background. And I understand you went to James Madison School in Brooklyn.

SHELDON ROSS: I did.

STEVEN LIPPMAN: With Bernie Sanders?

SHELDON ROSS: I did. So actually, I'm from Brooklyn, born and raised. I went to high school there. As Steve just mentioned, I went to James Madison. Bernie Sanders and I graduated Madison the same year. We both went on to Brooklyn College, part of the City College system of New York. Bernie left after I think one year, and went to the University of Chicago.

Actually, we probably would have been a lot closer than we are if it wasn't for one unfortunate fact, and that's we never met. I never met the guy. I never knew anything about him. I found out afterwards he was a track star there. But no, I didn't know Bernie. I missed the opportunity.

STEVEN LIPPMAN: So that was high school.

SHELDON ROSS: That was high school, basically.

STEVEN LIPPMAN: From there you went to--

SHELDON ROSS: Brooklyn College

STEVEN LIPPMAN: --Brooklyn College and got a Bachelor's Degree in mathematics.

SHELDON ROSS: That's correct. Yeah, basically, in those days in New York, the main idea was you would go to high school, and then go to college. And of course, you don't want to pay any tuition. Now, we had a wonderful system with the city colleges where tuition was $8 a year-- or $8 a semester, I think with the fees.

And so it was always sort of understood that I would go to Brooklyn College, or one of the city colleges. And I didn't really feel like traveling too far. And so Brooklyn College seemed like a very good place to go.

I mean if you were really smart, I guess you could try to get a scholarship and go to one of the Ivy League schools. But I was never-- in high school, I was a good student, but I was never that much into trying to get very good grades or anything like that. So I had good enough grades to go to Brooklyn College. And that's where I went.

STEVEN LIPPMAN: And $8 per semester?

SHELDON ROSS: It was $8. Actually, I remember my senior year, they raised from 8 to 28. And people were wondering, how am I going to afford this?

STEVEN LIPPMAN: About the same time, I was a student at UC Berkeley when the tuition was $50 per semester. Now of course, it's about $14,000 for the year-- 7,000 per semester.

SHELDON ROSS: Those were the days, I mean, on both coasts. I mean, you had the city colleges in New York. You had the University of California if you were in California.

STEVEN LIPPMAN: So you majored in math?

SHELDON ROSS: Majored in mathematics. Found out, I guess near the end of my junior year-- I didn't really have to go to work afterwards, that they had something called graduate school, which I had never known about. I assumed everyone-- basically, you went through four years. And you'd get a job maybe as an actuary. I even took the actuarial exam, and applied for a summer job one year, though I didn't get it. And then, I discovered you can actually go to graduate school.

STEVEN LIPPMAN: And that's what you did.

SHELDON ROSS: And that's what I did. I basically had no desire to go to work. You can go to school. They would pay you. I was really interested in leaving New York. In those days particularly that we're talking about, early 1960s, it was kind of a rough place. And the idea of going someplace else for school was very appealing.

STEVEN LIPPMAN: So you picked up and moved to West Lafayette.

SHELDON ROSS: I picked up and moved to West Lafayette, though that was not actually my first choice. I really wanted to go to California, which I had since - I don't remember - for the longest time I had this great image of California. And I wanted to go to California. And the University of California Berkeley was really where I wanted to be.

So I was in mathematics. I don't remember - I didn't apply to many places. I applied to Purdue, I think Cornell, and Berkeley. Purdue offered me a four year fellowship, a National Defense Education Act Fellowship. Cornell, I think, offered me a research assistantship. And Berkeley offered me nothing. Not only nothing, they did not accept me.

So I decided that, well, OK, I'd heard good things about Purdue. So I went to West Lafayette. I was from New York, big town. I decided to leave it. So I decided maybe I'll try a small town, see what it would be like.

STEVEN LIPPMAN: So you went to West Lafayette. You stayed there and got a Master's Degree in the Math Department.

SHELDON ROSS: Yes.

STEVEN LIPPMAN: So you got the foundations there.

SHELDON ROSS: Yes. Yes. Basically what happened at Purdue was I went there - from the beginning, I liked the university very much. I liked my classes, very much liked my classmates.

And I was there maybe about a month, and I remember sort of saying to myself, well, you've got to get out of here. I mean the town was very, very slow. I'm sure things have changed over the years, but coming from New York, how quickly things moved, and West Lafayette was very slow.

And then, I had discovered-- I'd taken, I guess my senior year at Brooklyn College, a class on probability. And I took a class in statistics my first semester at Purdue. And I discovered that there was a Department of Statistics.

And also that there was this other university out in northern California-- for some reason I liked northern-- which I'd never heard of a year earlier. But it turned out to be a very strong university that seem to be getting stronger all the time according to some article. And this was this Leland Stanford Junior University. And they had a statistics department.

So since Berkeley had rejected me in mathematics, and I really wanted to go to California, I decided to apply to Stanford in statistics. Fortunately, I was admitted. And I went and never left California.

STEVEN LIPPMAN: So you started Stanford in 1964 in the Statistics Department.

SHELDON ROSS: Yes.

STEVEN LIPPMAN: And you graduated four years later?

SHELDON ROSS: Yes.

STEVEN LIPPMAN: And so tell us about your four years at Stanford, and then towards the end maybe we'll segue into how you selected a thesis advisor, a crucial decision for any graduate student.

SHELDON ROSS: Yes. Well, I mean, Stanford I guess was very influential to me. It was this great intellectual place, but at the same time it had like a country club atmosphere.

STEVEN Really?

LIPPMAN:

SHELDON ROSS: Well, I think it was being out in California. There was a golf course on campus. There was a lake on campus. There were just-- you would get up, and it would be sunny outside. It just seemed like a different world.

STEVEN LIPPMAN: Idyllic.

SHELDON ROSS: It seemed very, very idyllic. Statistics, from the beginning, I enjoyed. Actually the nice thing with me, and I think in both mathematics and statistics, is that I never had initially a passion. It wasn't that I sort of loved mathematics.

And I just-- no, it was easy. It came easiest to me of all the things that I had taken. I liked it enough. But the more I went along, the more I studied, the more I got to enjoy it. And that became true also with statistics where I just got more and more interested as I went along.

But there was a problem. And the problem was that any time I was taking sort of the advanced classes, I didn't like so much that area.

And what had happened was-- going into the question about the thesis and all of that is that-- at the end of the second year at Stanford in statistics, they would have a qualifying exam. And this was a big exam. Basically, if you passed this exam, you were going to get your PhD. It might take a while, but you're going to get it. So the graduate students would throw a party at the end of the second year, those who took the exam.

And at this party which we threw, I met this one professor who I had never met before. Because he actually, even though he was in statistics, had a joint appointment with the new Operations Research Department. In fact, I'm not sure they were a department yet.

STEVEN LIPPMAN: They were not.

SHELDON ROSS: They were a division.

STEVEN LIPPMAN: Program, at that time.

SHELDON ROSS: Program. And he became the first chair. And this was Jerry Lieberman. And I had never met

Jerry before, but I met him then. And we talked. And it turned out that we had grown up in the same neighborhood. And in fact, Jerry went to James Madison High School also, a little before me. And I met him.

And then, I went off to Europe that summer-- caught a cold at some point. I was in London, and I caught a very bad cold. And I decided I'm going to come back early. So I came back. I went out to Stanford.

There was about a month before the semester began, quarter began. And I thought, gee, it might be nice if somebody would pay me some money to do something. So I went looking for people that I knew in the stat department.

And the first guy I looked for, the department chair, his name was Herb Solomon, was out of town. And then, there was a man Lincoln Moses who had been the department chair. And he was out of town. And then, I remembered Jerry.

STEVEN LIPPMAN: And that's the same guy of Hillier and Lieberman--

SHELDON ROSS: Yes.

STEVEN LIPPMAN: --that really famous OR textbook.

SHELDON ROSS: Yes. Yeah. It had not been written yet. That came a little bit later. So I knocked on Jerry Lieberman's door, and told him my story, that I had come back. And I wondered if he needed someone to do some research for him. And he said, come back tomorrow. I'll let you know. So I came back tomorrow, and it turned out that-- and he said, OK. I've decided I will hire you.

And as luck would have it, Cy Derman was visiting that summer. Cy and Jerry had done a bunch of work. And Cy was really an expert in dynamic programming. And they had written a paper in dynamic programming. And Jerry wanted me to write up a numerical example for the paper, which turned out not to be as straightforward as it sounds. And I remember so doing it, and getting involved in reading the paper, and really enjoying thinking about it, and doing that.

And at the end of the summer, Jerry asked me, how did you like it? And I said, I really like it. So it seems like a really fun area. He said, well, you want to work with me? I said, yeah, I'd love to. And so Jerry said, well, here's what you have to do. He gave me this one stack of

papers.

STEVEN LIPPMAN: So incidentally at that point, you had really chosen a dissertation advisor, and you'd kind of fallen into it.

STEVEN LIPPMAN: Yes, by chance.

STEVEN LIPPMAN: So this was not a very deliberative process?

SHELDON ROSS: Not at all. No, first of all, I had no idea what dynamic programming was beforehand, what operations research was beforehand. It was just totally random, sort of running into Jerry at that party, talking to him, finding out that he was from Brooklyn. And so I felt comfortable, even though I didn't know him, going to ask him, you know if he wanted to support me that last month. And the fact that he was working on something which I found so interesting-- so it was very random.

STEVEN LIPPMAN: And at that time of course, you didn't realize how important this decision was to choose him as your advisor. Choosing any person is for a graduate student is almost crucial. It impacts your dissertation, of course, and it impacts your future career.

SHELDON ROSS: Very much so. Very much so. As I said, Jerry told me to read. Gave me this one batch of papers, they were by Cy Derman. He said, read these papers. Gave me another batch by David Blackwell. He said, read these papers. And then, he said, the third thing you have to do is take Pete Veinott's dynamic programming class in the fall, which is where we met. If you recall, we were both in that class, a few other people--

SHELDON ROSS: I did very well in that class. It was a wonderful class. And I really totally got into the dynamic programming. And Cy suggested a problem with average cost dynamic programming, and that became my thesis.

STEVEN LIPPMAN: Wow.

SHELDON ROSS: And it really-- I mean, it's as you say about the importance of a thesis advisor. And in my case, when it came about to looking for a job, because Jerry had the joint appointment in both

operations research and statistics-- and the truth of the matter was I wanted to stay in California. And my ideal place would be to go to Berkeley. Ideally, I guess, in the stat department.

But it turned out there was an opening in operations research. So because of Jerry, I applied for that job. And luckily, I was hired.

STEVEN LIPPMAN: And by the by, I noticed-- since I saw your CV recently-- you and Jerry wrote, I believe, 14 papers.

SHELDON ROSS: Yeah. It's very interesting. Yeah, we became very friendly. I think from the beginning, Jerry treated me as a friend. It took me a little while, I think until after I got my PhD, and even there it probably took another year before I could sort of relate to Jerry as a friend. He was always sort of in my mind Professor Lieberman, even though I called him Jerry.

Jerry went off to London. I guess I'd been a Berkeley couple of years. It was probably about 1970. And Jerry was on sabbatical in London. And he said, why don't you come join me? I have research funds. Why don't you take off a quarter of Berkeley?

We were on the quarter system at the time. It's some few years later we changed to semester. And it turned out, if you taught during the summer, you could take-- you could manage to get six months off. And so I took off to go to London to work with Jerry.

And so I was working on this problem at the time, and I had a conjecture. It was called sequential assignment problem. We eventually wrote a paper. And the idea was, you had people, and jobs would come by sequentially. And you had to decide which one of your people to assign to that job.

And a job had a value. The value was x coming from some distribution. And your people had values, sort of p1 through pn if you had n people. And these were kind of the probabilities they would be able to do the job.

And so if you're assigned a p person to a x job, you have an expected return of p times x. And so the problem is to maximize the total expected return. And obviously, if the job coming in had a large enough value, you would want to assign your best person-- not obviously-- I'd say it was pretty intuitive.

STEVEN When the person finished the job, were they available to do the next?

LIPPMAN:

SHELDON ROSS: No, they're finished.

STEVEN LIPPMAN: Then they're done.

SHELDON ROSS: They're done. Once the people are assigned, that's the end of it. And so the conjecture was is that, whether or not you assign your best person to-- if you have n people who remain unassigned-- depend on the value of the job, but not the p of the person. In other words, if somebody was the best person, it didn't make a difference by how much they were the best, or exactly how good they were. The x value was larger if you had assigned them. So that was a conjecture.

And I worked on it. And Jerry and I were-- and we couldn't prove it. And so then as luck would have it, Cy Derman was also on sabbatical. And he had been skiing in Austria. And he was visiting Jerry in London.

And I had met Cy briefly that summer, since he was visiting Jerry, but we weren't at all friendly or anything. But we picked up Cy and I remember we were in a cab going to Piccadilly Circus.

And Jerry said, tell Cy your conjecture. So in the cab I explained the problem, and told Cy the conjecture. And Cy thought for a moment, he said, I don't think it's true. But if it is, Hardy's Lemma should prove it. So as luck would have it, I knew what Hardy's Lemma was.

I mean, I say as luck-- this is not like today. Today, you would go home. You would look on the internet. You know, Google Hardy's Lemma-- you have Hardy's. But back then, we didn't have that. And so if you didn't have a 101 books in, you know, your house, you wouldn't be able to figure out what Hardy's Lemma until the next day or so, or going to the library. But with a bit of luck, I knew Hardy's Lemma.

It was a very simple lemma-- if you have numbers A1 through An, B1 through Bn, and then, you want to pair them up, an A and a B. And you want to maximize the sum of the products. You should have the best A with the best B, the second best A with the second best B, very straightforward to prove it by induction, Hardy's Lemma.

And I went back. And sure enough, Hardy's Lemma worked. So Cy was indeed correct that Hardy's Lemma worked. And we wrote a paper. And that started us off.

I mean, every year for the next 10 years, I mean-- the three of us, Derman, Lieberman and Ross-- we wrote a paper together. It was a lot of fun. I think some of those papers were quite nice. Some of those papers, well, we wrote a paper.

You know, it was just kind of fun. Cy would come out to visit during summer times, visit Jerry at Stanford. I would be at Berkeley. I would go down once or twice a week. And we just had a hell of a lot of fun writing it.

STEVEN LIPPMAN: Wow.

SHELDON ROSS: Yeah.

STEVEN LIPPMAN: But I know you wrote papers with Jerry for about 20 years.

SHELDON ROSS: Oh, not quite 20. Jerry-- near the end, Jerry became more of an administrator. Jerry had a remarkable career. He was the Chair of the OR Department. And then, he had a job in the dean's office. And then, he became Dean. Jerry was the Dean of Engineering, and eventually became Provost.

STEVEN LIPPMAN: Yes.

SHELDON ROSS: And so Jerry got more and more into administrative, really important, high level administrative jobs, at Stanford. And so it was mainly those 10 years, I'd say, from 1970 and 1980. And there was probably a paper before maybe a paper or so afterwards. But those years, we did a lot of joint work together.

STEVEN LIPPMAN: And then you were at USC as a Professor in the IE and OR Department.

SHELDON ROSS: No, Berkeley.

STEVEN LIPPMAN: I mean Berkeley, sorry about that.

SHELDON ROSS: Yeah.

STEVEN LIPPMAN: And how was that time there?

SHELDON ROSS: Oh, Berkeley is a wonderful place. I mean, I had been right all along for wanting to go to University of California Berkeley. It was a magnificent place. I love being there. I loved Berkeley. I loved the fact it was close to San Francisco-- itself was a great city. And the university was wonderful.

STEVEN LIPPMAN: And you had great colleagues.

SHELDON ROSS: Colleagues were great. The department was terrific. I mean, just--

STEVEN LIPPMAN: Students were good?

SHELDON ROSS: Students were very good. Students were very good. It was just-- it really was-- I must say I never really had ever thought I would ever leave.

STEVEN LIPPMAN: But 36 years later, you decided to venture out and see a different part of California. And you accepted an offer at USC in the School of Engineering to become a Chaired professor.

SHELDON ROSS: Yes.

STEVEN LIPPMAN: And now you've been there for 11 years.

SHELDON ROSS: Yes, like, 2004. Yeah, actually, I always thought Berkeley was sort of the best place in the world to be. I mean, I really thought that.

STEVEN LIPPMAN: But something must have encouraged you to make that move.

SHELDON ROSS: Well, what happened was, I discovered there were other great places. I mean, and going from 1963 when I left New York City till 2000 or so, New York changed. And also, I think a lot of the great things about the New York are not something you can appreciate when you're college age. I mean all the great restaurants, the great cultural events, none of these things I took advantage of when I was living there.

But in later years, when I would go back, because my family was still there, so I would always visit over the years. It just seemed to get nicer and nicer, and also seemed like a much safer place than it had been back in the '60s. And I used to go to New York a lot, because I would go visit my daughter Rebecca, who was an undergraduate at Harvard. And I would actually go to New York first and see my family there. And then, I would go visit Reb at Harvard.

And I also fell in love with Cambridge and Boston. And I decided that-- and I wouldn't say maybe they were as great as Berkeley but-- there are other great places, both New York and Cambridge. And I got the idea in my mind well, gee, maybe when I got to be 60 years old, I should maybe try to go someplace else.

University of California has a very nice pension system to be quite honest about it. And so the idea of maybe retiring from there at 60, I had no intention of actually retiring, retiring, but going to teach someplace else in a great place. And I was thinking New York or Boston.

And as it happened-- and there was some contact I had in those places-- but as it happened at around that same time, I got a pamphlet in the mail from University of Southern California saying they've just received a donation by Daniel Epstein. And they are looking for someone to fill the Daniel Epstein Chair in Industrial and Systems Engineering. So on a whim, because I really had no interest in Los Angeles-- I didn't have any real positive feel for it, and it had been many years since I had visited LA-- I decided I'll apply.

And after a while, I was invited to go down and visit. I was very, very pleasantly surprised at the interesting things that were going on at USC and in the department. And also, I spent a few nights staying in a hotel in Santa Monica, which I decided was a lovely place to live. And so when they eventually made me an offer, I decided well, let me try it.

Now, I thought that they were unhappy that I was leaving at Berkeley. And I thought that if it didn't work out, I probably could go back. I figured I had probably up to maybe five years to go back if it didn't work out. But I liked it from the beginning.

I mean LA was really-- I mean, I had this image, I don't know why, that sometimes one has in Northern California that Southern California is all like, similar to maybe Orange County. It's all very, oh, I don't know, very Republican. I'm more like somebody you might expect who's from Brooklyn and from Berkeley.

And you know Los Angeles is not. Los Angeles is very diverse, with very diverse opinions,

which I enjoy very much. Los Angeles has all these cultural attractions that they're not given credit for in northern California. And it seemed like a really nice place. So I decided to come.

The other thing is, both my daughters were at a time when they didn't really need me anymore. One had graduated college. The other one's off to college. And it seemed like a very good time to maybe make a move. So I came, and it's been terrific.

STEVEN LIPPMAN: So tell me something about your students. So we talked a bit about your being a student of Jerry Lieberman.

SHELDON ROSS: Yes.

STEVEN LIPPMAN: How about your students? Because you've had some well-known students.

SHELDON ROSS: Oh, I've had some, yeah, exceptional students, I would say over the years. First at Berkeley, and now at USC. Some of the people who are probably very well known-- Mike Pinedo was a student of mine. Mike was the-- quite a few years was the -- chair in the business school, I guess the operations group in the business school at NYU. And yeah, Michael was a student. I can't remember dates. I would guess somewhere in the '80s-- probably in the early '80s or so-- of mine in Berkeley.

And he and I did some joint work, not a lot. Actually, in those days, even though you did a lot of-- I did very hands on work I think with my students, but you generally didn't write papers with them. The papers were generally their own papers.

But nowadays it seems to change a bit, that nowadays most PhD students write papers with their advisor as even part of the PhD thesis. Then, it was pretty much, you would encourage them to go off and really be able to write it themselves, so they would get the skill not only in the research, but also the writing ability which is really very, very important.

But Michael has done really well. He originally went to-- well, he went to Columbia. And then, he went to NYU.

Rhonda Righter was another student of mine. Rhonda went off to Santa Clara after getting her PhD and did really well there, and was hired back by Berkeley, my old department at Berkeley. In fact, she was the chair of the department until a couple of years ago. And she was chair for about three or five years. I don't know which one, but Rhonda's done really well and has had a

big impact.

Other students of mine-- Erol Pekoz is probably the one that I've done the most joint work with. And Erol was one of these guys-- I mean students can be a lot of work, or they can save you a lot of time. Erol was one that saved me a lot of time. I'm kind of lazy.

STEVEN LIPPMAN: Sheldon says he's lazy, but in some high 40 years since the 1968 has written over 100-- I believe it's 150 papers, and 11 books-- 13 books, 13 books. One of them is in the 11th edition?

SHELDON ROSS: Yeah.

STEVEN LIPPMAN: Another one's in the ninth edition, a couple in the fifth edition. So lazy-- I don't know.

SHELDON ROSS: Well, maybe not lazy. Well, actually, I'm pretty good when I get started working. But it's hard to get me started. And so a lot of it-- so basically there was times when you see something that people have done. You say, that really looks like it's interesting. But it's hard to force yourself into reading it.

And so Erol, I would say, Erol go off and read this and come and report to me. And he was fantastic. He would go off and read it. He would come to report to me. And his report was usually a lot clearer than the original paper.

And in that way, I remember there was-- I had him read something about something called the Azuma Inequality Martingale -- the Azuma Martingale Inequality by Blackwell. And Blackwell had a strengthening of Azuma's Martingale Inequality. And he explained it to me. And actually a week later, I wrote a little paper on it.

So that and he explained to me for the very first time Stein's methods in estimating-- not estimating-- in determining the error of Poisson approximations.

And yeah, so Erol was just really an ideal student. We've done a lot of joint work together ever since he's gone. He finished up. And Erol is now full professor at Boston University.

I had other students. Kyle Lin, who is a tenured professor at Monterrey Post-graduate School.

Let's see, I have a couple of more recent students at USC, Babak Haji, who just got his PhD, is now as a post-doc at Columbia. I expect big things out of Babak. One of the really nice things

about Babak is that when I went to Berkeley, my very first student was a man named Sabeti. Houshang Sabeti. Yeah. Actually, his name is Sabeti.

And his best friend was Rasoul Haji. And both these guys were basically finishing up when I first went to Berkeley. And Rasoul was getting his PhD with Gordon Newell, who was teaching in transportation at the time. Well, Babak, who was my student, was actually the son of Rasoul. So it was kind of nice having a second generation.

And Samim Ghamami is another one of my recent student, now works at the Federal Reserve in Washington. I expect big things over the years in Samim. So I've had a lot of very good students. I'm missing a lot of them.

STEVEN LIPPMAN: How did you pick the areas in which you did your research? I understand that you started off, and Jerry Lieberman gave you a problem. And then, that led to a lot of other problems. Now, I noticed that there was a graduate student at Stanford with you, Mark Brown. And you and he have written looks like a dozen or so papers. And they all have the word coupons in their title.

SHELDON ROSS: Yeah. Yeah, actually, Jerry led me on to dynamic programming, which from the beginning, I liked a lot. It was kind of a really a lot of fun, these sort of-- you have these problems you can generally understand. You could say, what's the optimal policy? Sort of like what you do in-- well, you did so much in dynamic programming yourself. You know that.

And so for me, there were a lot of fun problems. And so I liked from the beginning. And that was what I did my thesis on. I would say the first five years afterwards, I primarily worked in dynamic programming.

But I was always interested in probability. And so I would teach probability. I would teach probability models. And so you know, probabilistic analysis of different models was always something which also was of interest. At some point, I was asked to teach a class on simulation, some beautiful probability arguments in simulation. And so everything sort of revolved I would say about probability.

And I always liked problems. When Mark and I roomed together in graduate school-- so we were friends from graduate school. And both of us really enjoy doing probability. And I enjoy problems where you don't need a lot of technique, where you don't need a lot of sort of mathematical knowledge. But it just sort of-- well, sometimes you get a clever idea, and you can solve a problem.

And there are a lot of a kind of nice problems in probability, like coupon collecting problems. You know, you just keep on collecting coupons of different types. The classical problem is each coupon is any one of n types, equally likely to be any one of those types. How many coupons do you have to collect until you have a complete set of at least one of each sort?

STEVEN LIPPMAN: Like trading cards?

STEVEN LIPPMAN: Yes exactly like cards. Exactly like cards, like if you were to have baseball cards.

STEVEN LIPPMAN: Yes.

SHELDON ROSS: --and you wanted to get at least one of each Dodger. But like baseball cards, I mean in reality, they're not equally likely to be any one of the 26 baseball players of those days. The stars were harder to get. There were fewer of them.

And so the more realistic problem is that each of the n types has its own probability. And then, you want to know how many to get a complete set. And that's a more interesting problem, and not so trivial. There are a lot of sort of variations of it. And actually, I have written a bunch of papers on coupons, a bunch of papers on coupon collecting.

STEVEN LIPPMAN: Well, you've written a bunch of papers, as I don't know how many people would say 150 papers is a bunch. It's a gross.

But you also wrote all those books. And how did you come to mix the books with the papers? And of course, then in the end, which has had the bigger impact? Or did the books have a big impact?

So undergraduates, they know professors in schools by the textbooks. But for people who have PhDs, they're not thinking about the textbooks as much. But you clearly decided to do a lot of textbook writing.

SHELDON ROSS: Yeah, you know, I would say it's almost also by chance. At Stanford, all the exams were take-homes. And also, you had weekly problem sets. And I kind of remember, you know, writing up the solution of a problem set, or an exam problem and writing it up, and sort of reading what I had written. And it wasn't what I wanted to say, and I would sort of start all over again. And I

did that a lot. And it must have caught on, so at some point it seemed to be I got the ability to write clearer. It's an ability I didn't realize I even had.

And then what happens when I went to Berkeley, they asked me to teach a class-- well, two classes-- one was in stochastic processes, and one was related to my thesis, dynamic programming. And so what I did is I wrote up notes. And it turned out there was no real book that sort of had the material I wanted to do. And I wrote up notes.

And I asked Jerry-- Jerry Lieberman-- said, Jerry, you know, I have these notes. What do you think I should do with them? And Jerry says, well, I've just become editor of a book-- a book publishing firm ... the editor - it was Holden-Day. They since went out of business. And he said, why don't you write it up? We'll publish it as a book in the series. Jerry was the editor of the series. And I did that.

And in those days, it was real fast. I mean, actually, it seemed like to me, took me like, a week to write a chapter. And every draft was a final draft. It was very fast. And nowadays things come much, much slower. And it became like a way of life. Then a few years later, I sort of rewrote the stochastic process--

STEVEN LIPPMAN: So that first book

SHELDON ROSS: First book

STEVEN LIPPMAN: That was probability models?

SHELDON ROSS: *Applied Probability Models with Optimization Applications.* And it had some impact. And actually, more so in Europe than here. The Europeans seem to like it. And I've sort of become more well known in Europe as a result of that book. But afterwards, I sort of rewrote it. I wrote this *Introduction to Probability Models.*

And it became sort of a way of life. I went off to Columbia one year on leave. I was visiting Cy. And they all wanted me to teach a probability class. And I ended up writing and putting together notes on probability. And I eventually wrote a probability book on the notes. And it just became sort of a way of life.

Looking back, it's hard to understand how I did it. It's very hard to get started, but once I can

get started, I'm pretty good. So I started writing books. And it started to be, I would decide I would teach a class--

STEVEN LIPPMAN: So I can see that it was three papers a year and a book every three years, pretty much.

SHELDON ROSS: Yeah, I was pretty active for a while.

STEVEN LIPPMAN: That's more than pretty active.

SHELDON ROSS: But you asked a question about the research, and the books, and the impact. I was a pretty good researcher. I think I still am. I think I'm probably as good as I ever was. But I don't think I was a fantastic researcher. I think if-- I mean, some of the papers, I think, have some impact. But if I didn't do it, the world wouldn't be any different.

Well, the world wouldn't be any different if I didn't do the books either. But I think the books have more of an impact. I think the books have been used in a lot of places. I think people have appreciated them. And the style was, in some ways, unique. I think the probability model style, I think, was probabilistic in nature.

I mean going-- there have been some people well before me have written great books on probability, like William Feller. I mean, the classic book is Feller's book. But Feller's books got advanced quickly. And I think I sort of continued on with this more in the elementary style, thinking of probability as coin flipping rather than a sort of measure theory. And so I think it's had an impact.

So I'd go with the books. I would say the books have had much more impact than my papers. Which any of my papers, I think the ones that I've enjoyed the most are probably not ones that get cited very often. Although it-- you never know.

STEVEN LIPPMAN: So seeing as I'm your contemporary. And as I'm getting a little older, I'm thinking, well, maybe tonight I'll watch a TV program rather than continue to beat my head against the wall on some problem. And while I've written quite a few-- somewhere around 80 papers-- I haven't written 115, nor have I written 13 books, some of them with so many editions.

And I look to see, well, when faculty get older, their productivity tends to drop. But your's hasn't dropped at all. Perhaps it's even increased. How do you explain that?

SHELDON ROSS: OK, going to the first thing about hitting your head against the wall. One of the things is that I've never thought of myself as being the brightest guy around. I mean, I was bright. And the nice thing is that I seem to get better as I went along.

But if I couldn't solve a problem, that was OK. I mean, there were people who are smart, and if they can't solve-- it really bothers them. I was never quite that way. I mean, I would look at a problem and try to look at it maybe differently. Then, maybe sometimes come up with a clever solution. But if I didn't, OK. That's the end of it. I didn't mind dropping a problem.

Well, I think as far as productivity continuing on-- part of it of course I think is moving to USC. I mean, being at a new place, you don't want to go there and just think, well, OK, not do anything. I mean, I probably could have not done anything if I was still at Berkeley and still have been appreciated maybe for what I had done before. But I think coming to USC, you don't want to seem like you come there to retire.

STEVEN LIPPMAN: So it's rejuvenating.

SHELDON ROSS: Oh rejuv-- well, I mean motivating.

STEVEN LIPPMAN: Motivating.

SHELDON ROSS: I would say more motivating that you do want to keep on going. But I think the most important thing in my case, as it's always been, is it's still fun. For me, research is fun. I mean, I think maybe it's the sort of problems I work on.

And you can't just go by numbers. I mean I might have written 150 papers. You've written 80 papers. Your 80 papers-- you know, what's a paper? You know, you've taken one of your 80 papers, I could write that maybe as three papers.

I mean, so what's a paper? I mean how many co-authors did you have? How much work you did? You know, you can't count numbers.

But research is always kind of been, for me, fun. I have enjoyed the problems where you kind of, you say, you could sort of think about them, maybe come up with something clever, get intuition.

And my exercise is mainly walking. And I love to walk. And I love to have a problem. When I have a research problem, I love to sort of walk and pull out the problem and think about it. That makes walking fun.

When I don't have a research problem, which happens, you know, a reasonable part of the time also, you know, I walk. But I'm looking at my watch. Gee, it's only been five minutes?

But when I have a research problem, or have someone I'm talking to, it's a lot of fun. So for me research is still fun. Fortunately, teaching is still fun. You know it's just so it-- you know, I'm just keep on going.

STEVEN LIPPMAN: So here you are, nearly 50 years post-PhD.

SHELDON ROSS: That's amazing, yeah.

STEVEN LIPPMAN: And you haven't slowed down a bit. And you're intending to keep going?

SHELDON ROSS: At least another 10 years, I think.

STEVEN LIPPMAN: Another 10.

SHELDON ROSS: At least another 10, and then we'll see. Fortunately, I seem to have good genes. Unfortunately, my dad passed away this past year. But he was 102 years old, and had been pretty much healthy the whole time.

My mama's 96. And she's kind of weak, but she's still hanging in there. So I mean I seem to have good genes. And I enjoy it. I try to exercise. I try to eat well. And it's fun.

I mean, I think to me, being a university professor is always for the most part been research and teaching. I mean, we all have to do some administrative things, some things that are not always so much fun, that you just have to do to do your share. But the main thing has been research and teaching. And for me, you know, we put in a lot of hours some times, because it's a lot it's a lot of fun.

STEVEN LIPPMAN: So it's been a lot of fun talking to you and interviewing here today. And it's interesting to hear how somebody whom so many students have read your books, and how did this all come

about. So if it's been fun-- but if you were to give a piece of advice or two pieces of advice to young assistant professors or graduate students, what would you tell them?

SHELDON ROSS: Advice to-- OK, so it's a little different I think. To a graduate student who-- I think the job opportunity is good these days in our fields. So I think-- I mean, in some fields, I think you would want to tell your grad student that you don't have to be a professor to have an interesting and fun life.

But I think if that's the direction that they want to go, I would say, well, you know, there is more pressure these days than when I started. One of the great things about the University of California and particularly Berkeley, maybe all UC, I don't know, was at least when I was there, what counted was scholarship, even in engineering. Nowadays in engineering, there is certainly a lot of pressure on young people to get research grants, bring in money to the university.

When I was at Berkeley that never was an issue. I mean, I was there during the days of the Vietnam War, when the primary supporter of academic research in say statistics, operations research was Department of Defense. And there were many people who decided on principle they would not accept money from the Department of Defense. But they continued doing research.

I mean in science, it's tough if you don't have got a grant. You have to run a lab. But in mathematics, mathematics-related fields, pencil and paper was all we needed. And so people did-- and I don't think there were any-- none of them were hurt academically. It never came up when people came up for promotion that they don't have research grants, as long as they have research papers.

Nowadays in a lot of places, you have to have research grants. So I would tell them, even though, you know, this is the case, do what you're interested in. Do the research.

I mean, to me I went into academia because the big advantage academia had over industry-- and there were good industrial places to work in those days also, Bell Labs, IBM-- was in academia you could choose your problems. You could work on what interests you. And I never felt, thought of myself, as being in general a great problem solver. I was good at working at a certain type of problem. And those are the ones that interested me. And those are the ones that were fun to think about.

And if you have a problem, if you're doing research, and it's not fun to think about, and you're forcing yourself to do it, you're not going to get that far. So my advice would be to research-wise, pick an area which you really enjoy, and then stay with it.

STEVEN LIPPMAN: If you do that, you might write 150 papers and 13 books. That would be great. Sheldon, it was great.

SHELDON ROSS: Thank you so much, Steve, this has been a pleasure.

STEVEN LIPPMAN: Great talking to you today, and inspiration for researchers and students. So thanks very much.

SHELDON ROSS: Thank you.