Michel_Balinski_Interview by Louis Billera, July 19, 2017, Stonybrook, NY

Early Life

LOUIS BILLERA: Hi. I'm Louis Billera. I'm here with Michel Balinski to discuss his career in OR and related things and various aspects of the field as it's developed. So, Michel, talk about your early life. Where were you born?

MICHEL BALINSKI: Well, all that is somewhat complicated. That is, I was born Polish in Geneva, Switzerland, where I lived with my grandparents. And we moved to France in late '30s. And then, when the war started, we left via Spain and Portugal and took a boat to the United States. That was in June 1940.

LOUIS BILLERA: June 1940? I see. And your grandfather was a diplomat?

MICHEL BALINSKI: My grandfather was an international diplomat, I guess you would describe, but a doctor. He was the head of the health section of the League of Nations and then became the founder of UNICEF.

LOUIS BILLERA: And so how old were you when you came to the US?

MICHEL BALINSKI: I was six. Almost seven, but not yet.

LOUIS BILLERA: And where did you live?

MICHEL BALINSKI: Well, my mother found work in New York, and she put me into a progressive school that was in Greenwich, Connecticut, where I was a boarding student.

LOUIS BILLERA: And you went through high school there?

MICHEL BALINSKI: I went all the way through high school there, right.

LOUIS BILLERA: And you ended up at Williams College as an undergraduate?

MICHEL BALINSKI: And then I went from the school, it's called Edgewood School, a progressive school, with a fantastic mathematics teacher whose name was Louis Scala who also had the distinction of being a Communist, card-carrying Communist, which was rather rare in the US in those days. And then went to Williams College as an undergraduate.

LOUIS BILLERA: And you majored in mathematics?

MICHEL BALINSKI: Where I majored in mathematics.

LOUIS BILLERA: So did you meet Ralph Gomory there? I know he had been there, too.

MICHEL BALINSKI: No.

LOUIS BILLERA: You weren't there at the same time?

MICHEL BALINSKI: That was much later, but Ralph graduated the year I began. So he graduated in 1950, and I got there in September of 1950.

LOUIS BILLERA: And then, from there, you went to MIT?

MICHEL BALINSKI: From there, I went to MIT. And I guess of interest to INFORMS, having done mathematics at Williams College, I wanted to do mathematics that would be, let's say, socially useful. I wanted to do applied kinds of work. And I, quite by accident, heard about this new discipline called operations research. So I thought that this sounded like just the thing for me, and I talked with, actually, an economics professor, who was a friend of the family. His name was Emile Despres, who was at Williams. And then, subsequently, when Stanford raided the East Coast, he went to Stanford, but he was not at all mathematically inclined.

But he sent me down to a young assistant professor at MIT by the name of Bob Solow. Now, at that time, there were two universities that did operations research. One was Johns Hopkins, and the other was MIT. So I headed towards MIT, but there, you had to sign up for a PhD in one of various disciplines-- economics, mathematics, mechanical engineering, electrical engineering, civil engineering. I guess I can't remember them all. And I don't quite remember why, but I chose economics.

And then you would write a thesis that would be sort of an operations research thesis but linked to that discipline.

LOUIS BILLERA: So this was before the OR Center?

MICHEL BALINSKI: This was well before the OR Center existed. Philip Morse, who had pushed operations research nationally and during the war, was somehow the leading figure, at that time, at MIT in operations research. So I had to do the PhD program, of course, in economics. Well, I soon discovered that, first of all, the theory was very much, what do I say, it sounded like first year calculus that I'd had. So it sort of chased me away, and I decided, no, I had to get much more training in mathematics. So after two years at MIT, I got a Masters in economics and went off to continue my studies at Princeton.

PhD at Princeton

LOUIS BILLERA: And why did you choose Princeton?

MICHEL BALINSKI: Well, because Princeton seemed be the best place going at the time. Not too far from New York. Maybe that played. I'm not sure. But it seemed like a very good place to go, and I'm very glad that I did so.

LOUIS BILLERA: So you got there in 1956?

MICHEL BALINSKI: Got there in the fall of 1956.

LOUIS BILLERA: So was Von Neumann still alive at that time?

MICHEL BALINSKI: Von Neumann was no longer alive.

LOUIS BILLERA: I see.

MICHEL BALINSKI: Or I think he maybe died in '56 or something like that, but he wasn't present then, anymore.

LOUIS BILLERA: So the person then was Al Tucker?

MICHEL BALINSKI: Al Tucker, of course, was there. It was also a bit the beginnings of game theory at that time. There were various conferences in game theory that were starting that centered around, well, I guess, Tucker, who supported all this, Kuhn. Harold Kuhn was there.

LOUIS BILLERA: So he was back to Princeton from Bryn Mawr by then?

MICHEL BALINSKI: Well, no, I don't think he was yet back to Princeton. That was a few years later, maybe. But anyhow, he was still closely aligned to what was going on. And then there were various students. I mean Shapley, after all, had just gone through, and there was Isbell. I'm trying to think of who the others are, but I'm very bad at remembering names.

LOUIS BILLERA: Well, I looked at Al Tucker's students, and in the years between 1949 and 1959, he had seven students. David Gale was the first. You were the last in that list. I mean, he had more since then. In that list, there were two Nobel winners, Nash and Shapley, and Marvin Minsky from artificial intelligence. So this was a banner period for Al. What was going on there at that point?

MICHEL BALINSKI: Well, I think this is-- Curtis Eaves has often talked to me about this and saying, look what was it-- That was exactly your question. What was going on at Princeton that there was all this effervescence of - I guess one has to call it - creativity. New things coming up, new barriers, new mathematics, not in the traditional vein, necessarily. And there were others besides the list that you've just given. And I think that, in a way, maybe it was still this after war sense of a re-beginning of many things.

There seemed to be a sense of great openness. Now, one has to remember that Princeton mathematics was really quite a traditional place, and, you know, the traditional areas of mathematics, those were the main ones. These other types of this new, if I can put it, applied mathematics, optimization, linear programming and its extensions, first game theory, this was not at all the interest of the main part of the department. And yet, this is what took hold very quickly. I mean, Nash. I remember John Nash was there, also.

I remember, I've said before to people that what I am thankful for of those years at Princeton is that, somehow, I felt that I had been armed to go out and be able to look at any problem. I mean, that doesn't mean you could, for example, go work in biology. You'd need a biologist, obviously, somebody who has much more insight into the actual thing. But somehow, that you had the tools. You can think about any problem. Why constrain oneself to some set of well-defined problems? No. The world is an open place. Lots of problems to be solved.

LOUIS BILLERA: It was an exciting time.

MICHEL BALINSKI: It was a very exciting time, very exciting time.

LOUIS BILLERA: It's interesting how that happens in some places. There's just a period of ferment, and there's lots of stuff going on. And then it stops.

MICHEL BALINSKI: Right. But the other thing is I remember-- presumably other universities are like this, but I have never seen as many weekly seminars as were held at Princeton. You know, you had a weekly seminar in essentially each of the disciplines. So you kept having a lot of non-faculty members of Princeton, I mean visitors coming from here, there, and everywhere, who were giving talks. And that, I think, made an enormous difference.

LOUIS BILLERA: After all, it was Princeton. It was easy to attract people.

MICHEL BALINSKI: Exactly.

LOUIS BILLERA: You didn't have to work very hard to convince someone to go to Princeton.

MICHEL BALINSKI: And also not far from New York, which helps.

LOUIS BILLERA: On the train line.

MICHEL BALINSKI: Yes.

LOUIS BILLERA: So, after you graduated, did you then go to Penn?

MICHEL BALINSKI: No. While I was a graduate student, maybe the last year or so, this new consulting company got formed called Mathematica. This was largely the impetus of a man by the name of Harlan Mills, who is a mathematician who came from the Midwest. Spent a year, maybe, as a visitor in mathematics at Princeton. Quite a good salesman and who worked in industry a good deal, consulting in one thing or another. And he conceived the idea of a consulting company that would really have outstanding research scholars associated, and he got the support of Oskar Morgenstern for this and they finally persuaded--

Now, I don't remember the name of the person, but somebody who ran opinion polls, but I guess they were opinion polls done by, how do you call this, not random selection, but they had a fixed audience to whom they kept asking questions every once in a while. I can't remember the names. At any rate, associated with this were Oskar Morgenstern, Al Tucker, George Dantzig. Ralph

Gomory was involved at a certain time, and I'm convinced that he was the one who thought of the name of Mathematica, because we started first without one-- You know, weren't quite fixed for a name.

So I worked part-time there, and I was part-time a lecturer at Princeton in mathematics for a year or a couple of years, about, before I went on to Penn, where I was appointed an associate professor of economics.

Academic Appointments

LOUIS BILLERA: Was it in Wharton?

MICHEL BALINSKI: Well, it was in Wharton and not in Wharton, because Wharton didn't have the fame and the opulence that is now associated with it.

LOUIS BILLERA: So you were there until, when was it, '65?

MICHEL BALINSKI: So I was there for two years and decided, no, I'd rather be in a mathematics department. And at that point, it was the Graduate Center, but of course, you know all about this. The Graduate Center of the City University of New York got formed. Mathematics was the big subject there. And Leo Zippin, I guess through the influence of Al Tucker, hired me there. So I spent maybe, I don't know, something like 17 years. Something like that, with several years off for one thing or another.

LOUIS BILLERA: So I guess we arrived at the same time there.

MICHEL BALINSKI: Yes, I think we did.

LOUIS BILLERA: I had been at Al Tucker's course in the spring of '65 and became disenchanted with the subject I was in, which was experimental psychology. And I asked him, what could I do? And he told me about the Graduate Center, this new operation forming. Because I remember we met for the first time in your Mathematica office.

MICHEL BALINSKI: Oh, I see.

LOUIS BILLERA: I remember, almost precisely to the date, it was, like, one or two days after my oldest son was born. And I remember you chased me out, told me to go to the hospital and be with my wife. Which was good advice. The first piece of good advice.

MICHEL BALINSKI: That shows I'm an applied mathematician.

LOUIS BILLERA: So at CUNY, this is another time when there was sort of a confluence of people and ideas. I sort of credit a lot of it to you. I don't know if that's the case. You were able to get support for combinatorics. In a general sense, I remember the seminar in applied combinatorial mathematics. There probably has not been one with that name since. I don't know. Perhaps he-- So, I don't know, did you--

MICHEL BALINSKI: Well, I mean, Leo Zippin was Chairman. He was a very open-minded fellow. I mean, I was the only, to begin with, person sort of interested in the applied aspects of things and in combinatorics and combinatorial optimization, in particular. And you might say, more generally, operations research, if you wish, because of the types of speakers who came into the seminar.

But the thing that I think was really quite marvelous is that the department basically was a pure mathematics department. And yet, they supported this wholeheartedly. And not only did they support it wholeheartedly, but I'm sure, as you remember, most of the faculty members came to this applied mathematics seminar and combinatorial seminar. So it was a lively place. There was that aspect, and there was a second aspect.

And that is that, for example, Alan Hoffman, who of course was at IBM, he taught there, gave courses there regularly. And this was after-- I remember being able to engineer things with Ralph Gomory, who was, by that time, I think Director, or at least he was Director of Mathematics, at IBM. Afterwards, he moved on up. But through arrangements with him, I don't remember any of the details, Alan Hoffman came and taught. Benoit Mandelbrot was involved at various points. And also, what was his name? Rifkin-- A numerical analyst who gave courses. I think Rifkin. Something like that. Anyhow, there were various people from IBM Research who--

LOUIS BILLERA: This was after my time, but it continued?

MICHEL BALINSKI: Yes. It continued, that's right. That's right.

LOUIS BILLERA: So you were there 17 years. This is where Peyton Young comes in.

MICHEL BALINSKI: And at that point, it was somewhere in those years-- I can't remember exactly which year-- that Jack Edmonds contacted me saying he was looking for a job, and he recommended Peyton. And Peyton came to the City University.

LOUIS BILLERA: It turns out, checking the citation indices, that Peyton is your most frequent co-author. I don't know if you're aware of that.

MICHEL BALINSKI: No.

LOUIS BILLERA: So you wrote a lot of things during the years he was there.

MICHEL BALINSKI: Yes.

LOUIS BILLERA: Did you leave at the same time?

MICHEL BALINSKI: Well, what happened was I was still-- I mean, I was officially there and was offered a position at IIASA, the International Institute for Applied Systems Analysis, which was an East/West type of endeavor and was located just outside of Vienna at Laxenburg. And Peyton and I had been working a lot together, so I made it a condition that if I went, there would

be a position for him, too. So he came with me, and we continued working there together. He stayed longer than I did. I left after 2 1/2 years. I can't remember exactly how long he stayed.

LOUIS BILLERA: So I'm a little unclear about Yale and Stony Brook. Yale came first?

MICHEL BALINSKI: Yale came first. I left IIASA and went to Yale in what was then called Administrative Sciences and was also part of the Yale Business School, which was called the School for Organization and Management. I stayed there 2 1/2 years, essentially, before moving to France.

LOUIS BILLERA: To France?

MICHEL BALINSKI: Mm-hmm.

LOUIS BILLERA: I see. And then, when did Stony Brook come into it?

MICHEL BALINSKI: Well, Stony Brook-- Let's see now. You ask me questions. Stony Brook, I guess, came in about something like '82 or '83, somewhere in there. I got to Yale in '78, and I left in '80, so it was maybe '81, '82, something like that, where I came on a half-time arrangement.

LOUIS BILLERA: At that point, you started something here.

MICHEL BALINSKI: Well, at that point, I felt that in order to-- I came to the applied mathematics department in Stony Brook, and my sense was that in order to attract some really very first-class people in the areas I was interested in and felt I could do something in-- in optimization, combinatorial, but also non-linear and so on, but primarily combinatorial optimization on the one hand and game theory on the other-- was to get an Institute going where people could associate themselves in a psychological sense with this as being really a first-rate group of people. And that this would be the thing that would facilitate attracting such people.

And so that was given support. The President of the university supported the idea. And it's at that point that Pradeep Dubey and Abraham Neyman started here. Bob Aumann started visiting. Now, then, I sort of don't remember exactly who the other people came and in what order. And also, from the OR optimization side, there was Ellis Johnson, who was teaching here, and also Manfred Padberg. And we were in negotiations with others and so on. So we really had a small, but very fine, operation starting up.

LOUIS BILLERA: So that's what eventually developed into the Center for Game Theory?

MICHEL BALINSKI: Exactly. After I left, various kinds of things changed. The leadership in applied mathematics changed, and this operation got moved towards economics. And then, they changed the name and put all the emphasis on game theory. And really built something of continuing interest.

LOUIS BILLERA: We're here under their auspices at the moment.

MICHEL BALINSKI: Exactly.

From Convex Polytopes to Apportionment

LOUIS BILLERA: We can turn to your research interests. I mean, your thesis was on convex polytopes, actually, and polyhedra, and then things developed. You want to describe how that went?

MICHEL BALINSKI: Well, you know, I don't know. At the beginning, I guess, since I started working in that area-- I liked linear programming. In fact, I'd started working in linear programming at MIT, because there had been a joint seminar that was run between mathematics-- Well, no, it was run by the economists. It was run by Solow and Samuelson, and it was based on their book with Dorfman. So we had the RAND reports as texts, and there were students from both mathematics and from economics in this course.

And so I got interested in that. I had to do a-- You did not a thesis, but a kind of a mini thesis or kind of a one-semester project or something like that. And I remember that what I did was to simply write up linear programming in a more abstract matrix way, without lots of detailed formulas, if I can put it that way. So my interest in that area started before I got to Princeton, but then, once with Tucker, of course, it got more pushed in that direction.

Well, there was that stimulation. So it was the problems that were coming out of the discipline. Then, consulting work with Mathematica, that gave you another set of problems. Fixed-cost transportation problems, I started looking at those. And this was basically in response to either the ONR or the Army Research Office. I can't remember which. They were interested in being able to solve this kind of problem.

And then, also, I think a very important thing happened to me, which is rather amusing that I got involved in these real problems on the basis of that. And that is that at the Graduate Center-- well, you remember well this-- there was a-- New York, being a very political place, it was decided that the Graduate Center, where only PhDs were being given out, that 200 incoming freshmen would come every year, for several years, who were supposedly only interested in social sciences, literature, everything somehow nonscientific.

But the mathematics department was asked, would anybody be interested in giving a one-semester course in mathematics to such students? And that seemed interesting to me, so I said, yes, I would be. And that sent me chasing around to find really interesting applied problems which could make students aware that there is mathematics everywhere, all around them, that they could understand.

And also, I would add that this was because the textbooks I remember always having was that all the applications seemed sort of empty. They seemed terribly artificial, I guess, is what--

LOUIS BILLERA: Toy problems.

MICHEL BALINSKI: Exactly. You look at this and you think this has got nothing to do with-- I wanted to have something that seemed real. And so I started looking at problems, and one was the Gale-Shapley marriage problem, the stable marriage problem, because that gets extended into the college admissions problem. And here were these students who had just gone through the college admissions process. So I thought, well, this is going to interest them.

So that was one of the problems, and in later years, I worked on this problem and published a number of papers on it and generalized it in various ways. And the other problem was the problem of apportionment. How many seats should each state have in the House of Representatives?

And that also seemed to me a problem that would interest students and that you could elicit from students methods for how you solve this quite easily. And therefore, somehow, fool them into thinking something was good and then, through seeing what the consequences were, make them see that, in fact, there might be some serious difficulties with this. And these are two problems that really became two of the problems that I studied the most in my lifetime.

LOUIS BILLERA: So did this start in the spring of '68? Because that's what I was involved in this as your-- I was your TA in one of these courses.

MICHEL BALINSKI: I know. I think this was the beginning, yes, but I don't remember.

LOUIS BILLERA: And then it continued after that?

MICHEL BALINSKI: Looking at the apportionment problem, I realized that there were various things that bothered me about what had been done mathematically before, so I started looking into it. I got a contract with the NSF, I think it was, for summer support to look on this. And when Peyton came, he had nothing for the summer, so he came and he worked with me on the problem. And finally, we sort of developed a theory on what to do about this and wrote a book and so on, on the problem.

LOUIS BILLERA: And the rest is history. At least on that, in any case. So what's your attraction to this? Because it's a very hard integer problem, not your standard integer programming kind of problem?

MICHEL BALINSKI: Exactly. Well, I think I've always been interested in nonstandard problems, at a certain point. And what also excited me about it, I've always been interested in politics. So here was a nice combination for me of something that was really quite political in the end, but at the same time, there's some real mathematics and real history. And I love history, also. So it was a great combination and certainly from the point of view of history, I remember the five traditional methods in apportionment.

We were able to attach names to four of the five, I remember. There was still this one other method, and I was somehow hunting for all this. At that time, the Princeton library, the stacks were open. You could go down and-- You know. So I was looking here and there and digging

around. And finally, I found-- I think it was in the correspondence of John Quincy Adams, I found his suggestion of this method, which we call, now known as the Adams method.

I remember the thrill of finding this, finally we could get this name attached. It was almost as much of a thrill as finding, somehow, a new theorem that really has some clout.

LOUIS BILLERA: An historian, at that point.

MICHEL BALINSKI: Yes. So it was fun.

LOUIS BILLERA: Did that eventually segue to your voting interests?

MICHEL BALINSKI: I mean. There were two extensions to this work with Peyton. The first one had to do with what is now known is bi-proportionality. And this came about because-- I think it's in Holland. They look for solutions, apportionment solutions, in which each party has a number of seats proportional to its vote, but in which each community has a number of seats according to their populations. So this means that you are--

Excuse me, I add another thing. The input to this is that if you, Lou, are living in Holland and are Dutch and allowed to vote in a particular constituency, you vote for a party list. And so there is, you could imagine, a table or a matrix in which the columns represent political parties, the rows represent constituencies. And so you vote somewhere. Your vote contributes to a number in one of those entries.

And so the problem becomes that you are looking for a matrix in integers, which is quote-unquote proportional to this voting pattern that you've gotten, but in which you are restricted to make sure that the sum of each row gives the number of seats that is due to the constituency, for each of the constituencies. And at the same time, that the sum in each column gives each party the number of seats it deserves on the basis of its total vote. So that interest--

I mean, at the beginning, I knew this problem came from Holland, and yet, they had a solution which I didn't like very much. So I started working on that. And the nice thing about this is this system is actually being used today in a number of different cantons in Switzerland for their local parliaments. And apparently, in Switzerland, they're thinking about doing this nationally. And other cantons-- I think they have 22 cantons in all or something like that. And other cantons are considering it. At this point, I think there are about seven that are using this method in their election.

LOUIS BILLERA: This method is something you developed?

MICHEL BALINSKI: Yes, absolutely. Absolutely.

LOUIS BILLERA: Well, that must be exciting.

MICHEL BALINSKI: That's the kind of thing that I think I was looking for when I left Williams.

LOUIS BILLERA: I see. I mean, I've often wondered whether or not or your interest in these areas and, I would think, your confidence that you could actually change the world in some ways-- Which is, I think, what you're trying to do when you're trying to change the way a country votes, for example. Does this sort of come from your grandfather's experience?

MICHEL BALINSKI: Well, yes, I think so, perhaps. I mean, he was really quite a fantastic figure in the sense that he, as Director of the Health Section in the League of Nations-- I mean, you don't remember this. Well, maybe you do. In traveling, there was an international kind of card which had all of your vaccinations and all that kind of thing. He did a lot in that regard. He did a lot with regard to helping countries set up health systems and this kind of thing. And then, of course, he went and he started up UNICEF, was its first President. And all this as a Polish citizen. So all this during the Cold War.

I mean, he felt you can change the world. One of his very close friends whom I got to know, of course, as a younger person was Jean Monnet, who was generally considered the father of Europe from the point of view of Europe getting together. So I saw these such people that as a young person. so you think, OK, look, they've made a difference. Why not you? In whatever your own--

LOUIS BILLERA: His influence remains. I have a cousin who works for UNICEF, and she told me there's a conference room with his name on it in the UN building here. Here, New York. So at what point-- I mean, at some point you got into procedures for voting.

MICHEL BALINSKI: I can tell you how this happened. What happened was after these other things-- In France, there is a popular science magazine being called Pour la Science, for science. It is half owned by Scientific American and half owned by a French publisher, Belin. The editor asked me if I would organize what they call a dossier, a file, of a number of different papers on the mathematics of voting.

This is the kind of thing I love, so I agreed and had found a number of collaborative collaborators. Among them, Rida Laraki. There were about, maybe, five articles. One was on electing one person. One was on apportionment. One was on this bi-proportional apportionment. One was on districting. You know, a computer approach to how do you design districts for, say, congressional districts here, but this was done in the French context.

Ranking Wines and Voting in France

And as a result of this, maybe two, three months afterwards, I got a call from a man whom I later discovered was-- is-- quite a well-known oenologist, an expert in wines. From the point of view of production, he wrote numbers of different books, from a point of view of how to taste wines, how to produce wines, all kinds of things. Everything having to do with wine, of course, is very important in France.

And he wanted to see me, because he said, look, we have difficulties in how to rank wines in competitions. And he said, I feel that the things we're doing are not reasonable. And I read these articles in Pour la Science, and it struck me that you were thinking about this in somehow the

right way. I have lots of data. Could I come and see you? Of course, come. And we had lunch. He had a colleague with him. And I looked at data, and we discussed it and so on.

I said to him, I think it's extremely interesting. I don't have the time right then. I can't remember what had me occupied, but I said, give me a few months and maybe we could do it. In the meantime, Rida Laraki, who had been a student in the PhD program that I'd organized in Paris had, by then, finished his thesis. He finished it with Sylvain Sorin in game theory. And then he got an appointment in our laboratory, where he'd done his thesis. So I knew him well.

But he said, look at, I would like-- Why don't we do a project together? And he kept asking me to do a project together. And so finally, when I had the time, I went to Rida and said, look, let's look at this wine problem. How do we do this? So we started looking at-- This gentleman had written various books, so we had his books. We could read what had been done there and what was done in wine. And we started looking at how do you rank wines? Now, I think, I knew about Arrow's theorem and all those things, but I never really thought about them. I had it in the back of my mind that I wanted to do it some time.

But somehow, it was wines, not elections. So I think that freed us. Rida knew about Arrow's theorem, as well. But I think that that somehow freed us-- We weren't stuck in that framework and could think about this problem more freely. And very quickly, we honed in on what we thought would be the right approach. And then, we realized that, oh, I know, we overcome Arrow's theorem, Arrow's impossibility theorem. Here's a method that seems very practical. Easy for voters. In fact, our intuition was they should like this method. And so we started working.

Now, there's something very interesting about all this, and maybe it's a good occasion to say this. My sense was we were going to look at this problem in a way so very different than anybody else looked that we would be unable to publish anything on what we had done unless we'd done the whole thing. We somehow had to have all our arguments together. So I said to Rida, look, I'm afraid we're going to have to work in secret and just work and talk to no one about our work, write a book. That way, we'll have all our arguments.

Now, this was quite a risk for him to take, being a young man, but he agreed. And we worked for about five years and produced the book. Well, almost produced the book. And then I was invited to open a conference of the Social Choice and Welfare Society, which was held in Istanbul, in I think this was 2007. And so I decided that, about a year and a half before, here was a date to plan for. Rida would then give a paper afterwards. Then, I was allowed to give another paper. So he gave the two talks, the two other talks, more technically. I gave the sort of overall talk in the opening plenary session of this conference.

And it was interesting because it was quite a bombshell. I mean, many of the traditionalists were absolutely furious and thought this is ridiculous, very much against. The young people, much more interested and thinking, I think quite rightly, here's something new. There's going to be a lot of new things to work on.

Then, in the same year, it was 2007, we conducted an experiment which you could not do in this country. Because we were able to get permission from the Ministry of the Interior to do the

following thing. Set up voting booths, ballots, et cetera, urns, the whole paraphernalia of what you need when you carry out a vote, to carry out our method. And this would take place in the voting bureaus of several-- Actually, it was one town in France, Orsay, which is not far just outside of Paris.

We did this in five voting bureaus. Voting bureaus that said something-- You get around 400 to 500 people voting, more or less, per bureau. And so people would vote officially, and then they would come to our thing. We had posters. And we had this, that, and the other, and a bunch of students to explain what the method was and try to help persuade people to participate. We got very large participation, 75%. And the results were extremely interesting. So we had one-- Let's see, what was it? We had 1,700-some-odd participants, so that many, and sort of a database of this many ballots, which we then used to study.

What was interesting was that what many people were saying ahead of time, that you're going to ask voters much too much. It's going to be much too complicated. Nobody's going to be able to do this. You're nuts. It was exactly the opposite. The voters liked it. And what they were asked to do, basically, is simply to grade every student-- Every student. Excuse me, every candidate. If you wish, in grades that are words that carry their own meaning. So they were asked to judge on the quality of each candidate as being either excellent or very good, good, mediocre, poor, or to be rejected.

This worked out extremely well, so that I think we found out a lot of things that most people studying these problems still don't know because of the type of question we asked. And just to give you one example of this, I think it is something like 14% of all of these ballots-- There was sort of the main right candidate, who was Sarkozy. There was the main moderate left, they call it the moderate right, the moderate left or socialist candidate was Segolene Royal. And the third was sort of the middle of the road candidate, whose name was Bayrou.

You had some voters, around 14%, who gave their highest grade to all three, which obviously you can't do anything about with any of the other ongoing systems or suggestions. So this is what they wanted to do. And it has nothing to do with, obviously, with the right-left spectrum or anything else. God only knows what it is, but it's their democratic right to vote the way they wish.

LOUIS BILLERA: I mean, in the end, you can presumably come out with a ranking of these candidates.

MICHEL BALINSKI: Yes.

LOUIS BILLERA: So is there a reason this doesn't violate Arrow's theorem? Is it that the voters are not giving you a ranking? They're giving you a weak order.

MICHEL BALINSKI: That's correct.

LOUIS BILLERA: They can say three people are the top, and they don't have to sort them?

MICHEL BALINSKI: No. I mean, the whole problem with voting in the traditional way, that is in-- Sorry, the analysis of voting has been, throughout the last hundred years at least, you list all the candidates in order of your preference. But I find that totally ridiculous, and I point out this last election in the United States, where even in the runoff-- I mean, you got two candidates. I know there were a few others, but forget them, because they're very minor. There were these two candidates.

I don't think there are many people who are going to say one is really excellent and the other is really bad. There will be a few, but I think there are going to be a lot who say they're both very bad. But you can't do it with majority voting. Doesn't work. You can't, because you're naming one and not the other. Finished. You can't do anything. You can't express yourself. And that, I think, is extremely bad. Nor can you do it, incidentally, if you have 10 candidates. I mean, you list the first and you list the last. Maybe you think they're all bad.

LOUIS BILLERA: I can't imagine anybody has an actual sorting of 10 candidates, right?

MICHEL BALINSKI: Of course, no, no. Neither can I. You can sort maybe one or two or three, but then the rest, you don't give a damn about.

LOUIS BILLERA: I mean, in some ways, starting with wines, to use the current phrasing, enabled you to think outside the box on this problem?

MICHEL BALINSKI: Exactly. I think so, yes. I really believe so.

Early Influential People

LOUIS BILLERA: Let me think. We mentioned several people. You talked about Al Tucker, who was your advisor at Princeton. You mentioned Ralph Gomory in various ways. But in some places, I see that you somehow credit him for being your advisor, because Al was on leave the year you wrote your thesis.

MICHEL BALINSKI: Al Tucker was away for the year. And he suggested a problem to me, and then he left. So I was there. He was in Geneva, I think, for his sabbatical. So I would go to see Ralph Gomory occasionally to talk with him. He was then a lecturer at Princeton, just having come back from several years in the Navy. So, really, he was the one I could talk with. Then, Al came back for two weeks in the spring, asked me to show him what I'd done. So I showed him. He said, fine, that's good enough for a thesis. Write it up. That was that.

So, often, I say Ralph was, in a way, my co-director, at least. And he's told me, well, you're the only student I've ever had.

LOUIS BILLERA: So another person, it's another G person, David Gale, you sort of knew him well--

MICHEL BALINSKI: Very well.

LOUIS BILLERA: --late in his life. Well, maybe it isn't the entire career.

MICHEL BALINSKI: I don't remember when I first met David, because he was a student, as you mentioned, of Al Tucker, also. But the first or second year I was in Paris, it was very early, he got in touch with me, because he was going to spend a year in Paris. And could I help him with, I don't know, various things? You know, mundane things. Where to live and things like that. And it turned out that he was able to get something exactly in the same building where I was living, sort of just at the end of the hallway, and so we saw a good deal of each other then. In ensuing years, he became more and more interested in Paris. Finally bought an apartment and would come.

Whenever I had space to give him in our research group, we called them laboratories in France, whenever I had a space to be able to give him a desk, he would have a desk in the laboratory. And if there wasn't any room, well, he'd come around anyhow. He had eating privileges in our canteen, so we would see really a good deal of him in Paris, and we became very good friends.

LOUIS BILLERA: I see. So is there anyone else that I haven't mentioned that you consider influential in your career?

MICHEL BALINSKI: Well, you know, I mean, I would say that, as I look into the past, Ralph was a strong influence. Al Tucker was a strong influence. Harlan Mills, also, because he really had a way of getting into real problems. And I remember this became quite a passion for me when I was doing things with Mathematica, going and seeing potential clients and trying to ferret out what their real problems were.

Often, there was a description, and I suspect this is very common in the OR, people doing OR in the real sense, that you go and you have people who realize they have the problem, but they don't see the problem itself very well. It can even get mixed up with something else which has nothing to do, really, with the problem. And so trying to ferret out what was the right thing and then persuading them that this was the right thing to look at, this was great fun. I mean, I found this extremely stimulating.

LOUIS BILLERA: It's hard to teach that.

MICHEL BALINSKI: Yes, I think it is.

LOUIS BILLERA: You learn by doing it.

MICHEL BALINSKI: Yeah. I think it's by doing it. I think so. But I think I would like to add that, in France, I've been very lucky that late in my life, I've worked with two younger people-- who are now in their 40s, but then, they were much younger. One is Rida Laraki, who is an extremely bright, young guy. Now, not all that young, one would say, but nevertheless, he's still extremely bright and an excellent person. And we have a very, very close relationship. And the other is somebody by the name of Mourad Baiou, with whom I did a lot of work on stable matchings. Both of them have been-- I guess we've mutually influenced each other.

Work in Districting

LOUIS BILLERA: So I have a question about you did some early work on districting. I think I remember in Bergen County, New Jersey or something like that.

MICHEL BALINSKI: You're right, yes.

LOUIS BILLERA: Because I used to live there, so it jumped out when I saw it. Have you ever questioned having done this? I mean, in the sense of what's been done with districting since then. It's become a dark science.

MICHEL BALINSKI: Yes.

LOUIS BILLERA: Do you ever regret having--

MICHEL BALINSKI: Well, look, there were two points. The first point is that combinatorially, the work on the New Jersey districting must have been, I don't know, in the early '70s or something of that variety. There were fascinating combinatorial aspects, sort of applied combinatorial aspects, in the sense that-- Well, let me say what the conditions were. We were doing this for the New Jersey Supreme Court, and what they wanted was districts that are contiguous, but otherwise, only the numbers counted in each--

They wanted as close as possible, you know. The quote-unquote proportionality as close as you could get. We didn't, at that point, have all these great tools that you have today. And so we did, basically, a kind of enumerative approach, formulated this as a set covering problem, as I recall it. And this meant just brute force work. I mean, we had computers, of course. And we found tremendous numbers of different districtings that satisfied the Supreme Court's wish, but where the two numbers were the same.

And I remember that the most difficult case was-- I've forgotten what county it was, but there were 67 municipalities, and they had five representatives. So sort of you have to assign these 67 into five. And the best solution we found, which I found absolutely astounding, was the difference between the biggest and the smallest was something like 37 persons. Where the average size of a district was about, I don't know, 150,000 or 200,000 or something like that. So it was just absolutely minuscule. I found that absolutely fascinating. First point.

Second point is of course I agree with you with this districting now. It's just nonsense to think that equal numbers are the only thing that counts. There are other things that count, but I'm convinced, I'm totally convinced, that the notion that there is a best districting in a state is utter baloney. There isn't. We don't even know how to define it. Worse, I can give you two, and we don't have criteria by which to say, this is better than that. The reason that is, there are conflicting constraints.

I mean, you want something that looks more or less reasonable. You don't want a thing looks like a salamander, which is what's going on today. But you also want equal numbers. You also want, somehow, natural frontiers. And incidentally, if you start doing this for state representatives, for

federal representatives, you get one districting piled up upon another. So presumably, you're living on 38 Main Street and I'm living on 37 Main Street or maybe 36, to be on the same side, and maybe that's where one of the lines comes, so that we can discuss some of our candidates, but not all. I mean, it just doesn't make any sense.

My sense is there is no such thing. There is no such thing as a fair districting. And there is a kind of Arrow impossibility, if you wish, but the problem is how do you formulate this? Well, I think somebody should be working on that and get away from this notion of thinking no.

LOUIS BILLERA: The Supreme Court is going to start looking at this, at least from the political, using politics as the criterion.

MICHEL BALINSKI: Well, I mean, the history of the Supreme Court on this, I've read a good deal of it. First of all, of course, the big revolution came in the '60s, when you had certain districts of representatives in the US House of Representatives in one state, where you'd have one representing 900,000 people and another representing 100,000 people. I mean, it was enormous differences. And always, the Court, for many years, said, no we don't want to get involved in these. These are essentially political issues. This is outside of our domain. We don't want to get involved.

Finally, it got to be so much that they conceded. And at that point, you see, the problem was, well, what are the criteria? And it's very interesting to read all this, because they go in a circle and they want this criteria and they want that, but this goes against that. And in the end, you don't have any.

I mean, there's one Supreme Court Justice who really realized this and that was-- I've quoted him in a paper. I can remember. Stevens. I think it was Stevens, who basically called for a new method of election. So I have a proposal for that, and that is this bi-proportionality. But the notion for the US would be that you draw districts. Take the state of New York.

Well, let's take an easier state. Let's say Virginia. Maybe they have 12 representatives or something. What you do is you define your 12 districts, but you define them in a loose sort of a way so it's not exactly the number of same people everywhere, but you have something that is reasonable from the point of view of geography and sociology and city, country, things of that sort. And you vote as usual.

However, instead of the person who gets the most votes in the district winning, you now say, how many votes in total did the Democrats get? How many in total did the Republicans get? Apportion the number that each should get, and now, figure out who should be elected in each. And that turns out to be a complicated-- I mean, it's an easy calculation with a computer, but you can't do it by hand. You can check it by hand, but you can't do it by hand. You can check once you have the solution.

And of course, this is what's used in Switzerland, in a slightly more complicated format. The idea simply being that you take a state like Massachusetts. They have nine representatives, I think, now. And basically, they elect all Democrats, two years after two years, all the time. And yet,

Republicans should be electing, out of nine, maybe three, but their votes go to waste. So result, often you don't have a Republican candidate at all. Well, I mean, in some sense, it's ridiculous.

LOUIS BILLERA: I think there's some range. Within the Democrats, there's a wide range, I think.

MICHEL BALINSKI: Of course.

LOUIS BILLERA: Basically, they all call themselves Democrats, but some are conservatives and some are liberals. It separates that way, I think. Let me think for a second.

Impact on the Field of Operations Research

LOUIS BILLERA: One of the questions, actually, that the INFORMS guidelines asked me to ask, which is how would you like to be remembered?

MICHEL BALINSKI: Wow. Well, I take it they mean this from a INFORMS point of view.

LOUIS BILLERA: From an INFORMS point of view, of course.

MICHEL BALINSKI: Well, I guess I would like to be remembered as somebody who contributed some real solutions to some real problems.

LOUIS BILLERA: So I recently checked some databases on citation records, just out of curiosity, and you might be surprised to see-- They vary a lot, because it's not clear to me that-- One of them is the Web of Science, which is the science citation index on the web, I think. And then there's the MathSciNet, which does math papers, and then Google Scholar. It's not clear to me exactly what data Google Scholar is accessing, which is probably all data, right? That seems to me.

And there are some similarities, and there are some differences among these. What I noticed, in Web of Science, I could do a time search. And I don't know if you realize that your total annual citations actually hit a lifetime maximum in the last complete year, 2016. So maybe it makes sense. Your body of work has gotten larger, so things are being cited, but that the older stuff is still current, actually. So on the Web of Science, the top three papers in the citations are the "Integer Programming-- Methods, Uses, and Computation" from '65, so that was the paper that won the Lanchester Prize, right?

MICHEL BALINSKI: Mm-hmm.

LOUIS BILLERA: And the third one was an algorithm for finding all vertices of a convex polyhedral set.

MICHEL BALINSKI: Wow, that was the thesis.

LOUIS BILLERA: Yes, right. That one, I don't know if-- But the one that showed up here, and one that I didn't even know about myself, the number two listed was on integer programming for delivery problems, that paper with Quandt.

MICHEL BALINSKI: Right.

LOUIS BILLERA: So that was written in 1964, and it had 13 citations in 2015. So this paper's still alive. And it shows up on the Google Scholar list, as well. It was number three. There, they have a total of 435 citations, so that means that it was mentioned 435 times in all the data they were looking at. And the "Integer Programming" paper was number two on the Google list. And your book with Peyton Young was number one, which no surprise, I guess, but it somehow doesn't show up on the other ones.

The math one seems to have the most of your papers, but maybe it's short in citations. So what that means to me is that your papers are sort of going in as mathematics, but then they're being received by all sorts of subjects that the math doesn't cover things. Things that cite your papers are appearing in journals that the MathSciNet doesn't look at.

MICHEL BALINSKI: Right.

College Admissions Problem

LOUIS BILLERA: And so the Google Scholar one then turns out to be it has an enormous number of citations. So here's another one that showed up, which I'm not familiar with. I'm wondering if you can tell me a little bit about it. It's a paper. It was number one total on the MathSciNet. It's "A Tale of Two Mechanisms-- Student Placement" with Tayfun Sonmez.

MICHEL BALINSKI: Yeah, I could tell you what that-- This is on the college admissions problem, and it looks at the case of Turkey. Now, the case of Turkey is a special one, because the universities do not establish their own lists. In the traditional college admissions problems, the idea is sort of like what happens here in the US. Each student lists his or her preferences for universities. Each university lists its preferences for students. OK? Strict order.

That's the basic data, and now you look for a stable assignment. And so there's an optimal stable assignment from the point of view of the students, and there's an optimal from the point of view of the universities. OK, now, in the Turkish example, the universities have no role, so they're going to use no strategy. There's nothing going on from there. It's only the students, because the students sit exams, national exams, and their score determines the order in which the university must take the students.

Now, there's another choice, as I recall, that the students make, and that is they say they want to study in architecture, or they want to do history, or they want to do literature, or I don't know what. So their score on these different subjects will be different from the point of view of these national exams. But still, the university has no choice. Therefore, this becomes sort of a one-sided thing, and there isn't a single best solution, which is the best from the point of view of the students.

LOUIS BILLERA: That's sort of a marriage problem?

MICHEL BALINSKI: Well, it's a marriage problem, except that it's college admissions in the sense that a student goes to one university, but a university has many students. Now, incidentally, this is quite amusing, because in France, the way the procedure goes for appointing professors or assistant professors, whatever, in a university also uses stable matching. But the way, there, it's used is that a university announces a position. People apply for it. This is, of course, the state system. There are very few private universities in France.

Then, the university rank orders all those it is willing to accept. This is sent to the Ministry of Education. At that point, the applicants express their preferences for where they want to go. Then they do a stable matching computation. However, they do optimal from the point of view of the universities.

Now, I attacked them on this. That is, I approached them, and I explained to them that, look, you're doing something wrong here. They were unwilling to listen, so I finally published an article in Pour la Science, again, in which I pointed all this out. So I had ensued a rather warm, let us say, exchange about my positions on this problem.

Retrospective on the field of Operations Research

LOUIS BILLERA: We may be running out of memories here, but there are a couple of retrospective questions that INFORMS would like to see addressed. I mean, one of them has to do with how do you think your field of OR has developed over the years? I mean, you've been involved in OR pretty much since its inception. It's a post-war phenomenon.

Do you have some opinion of how the field of OR, in general, or integer programming, integer optimization, has developed over the years?

MICHEL BALINSKI: Well, I don't know how good-- I have the impression that big data seems to be the big buzzword now in operations research. You see it over and over again, to the point where I think that some people want to change the name. I fail to understand why one cannot continue to call this operations research in the sense that, at least as far as I see it, it's simply the notion of using, let's say, more widely said, technical tools-- they can be mathematical tools, they can be computer tools, et cetera-- to address all kinds of people, of problems, of society which have to do with operations of one type or another.

So this is a very wide field that goes into all kinds of things which, for example, economists might call economics or political scientists might wish to call political science. I think that the basic notion that mathematics and now calculations, so let's say computer sciences, are extremely useful in resolving all kinds of human problems. I mean, of course, it goes into medicine. It goes into all kinds of things. And I think this is one of the very nice things.

Incidentally, in this regard, I'd started to talk about this earlier, but this work with Rida Laraki on voting, to be really quite honest, economics journals have just refused us. Exactly what I felt was going to happen has happened. I mean, we published our book, but trying to publish new results

in this, that they don't want them. However, *Operations Research* has published our work. So from that point of view, I can say, if I call this my profession, I'm proud of my profession. They have a much more open mind

LOUIS BILLERA: Less doctrinaire.

MICHEL BALINSKI: Yes. They're ready to look at other things, and they're ready to look at different models. The big problem for the economists with our approach is, no, the right way, in their opinion, or at least this is what I surmise, the right way for a voter to express himself is to say, here's my first candidate, here's my second, here's my third. Well, OK, then you buy into all the problems. It seems totally ridiculous to continue when you know you have Arrow's impossibility theorem to begin with, but secondly, it's damned hard to do.

As you mentioned a little earlier, you have 10 candidates. Nobody has a notion of 1, 2, 3, 4, 5, 10. We face this every presidential election in France, and also others, where you have-- So first round of the election, you have 10, 12, 14 candidates. Well, nobody's going to do that. I mean, they know maybe two, three, or four that they will express themselves on. The others, I mean, perhaps they don't even know who the hell they are.

LOUIS BILLERA: And they have to vote for one.

MICHEL BALINSKI: And they have to vote for one. If they were asked to list them, I mean, they wouldn't-- You know, it's just much too hard.

LOUIS BILLERA: Even to name them, frankly.

MICHEL BALINSKI: And incidentally, Australia, where you're forced to vote, they do force you to give a complete listing. However, the parties give you the listing. So they give you little pieces of paper so you know how to vote. And of course, what's that the result of? Well, there must be all kinds of behind-the-scenes negotiation between the parties. Who puts who where. I'll put you here if you put me there, and this, that, and the other. It's a ridiculous thing, in my opinion.

LOUIS BILLERA: So OR has its good sides, apparently.

MICHEL BALINSKI: Absolutely. Absolutely.

LOUIS BILLERA: What's the most valid criticism of OR, in your view, and how would you respond to it?

MICHEL BALINSKI: I guess I don't know how to answer that. One should be well trained in mathematics and computer sciences in order to go into OR, and then, look at the problems that interest you or that come your way.

LOUIS BILLERA: So are there areas, questions-- I mean, you mentioned the districting issue is something that needs attention. Are there other questions that haven't received enough attention? You know, operational questions, any sort?

MICHEL BALINSKI: Well, I mean, I guess you were asking about-- Again, I don't see how to answer that question directly. I think that when I look at integer programming or mixed integer programming, optimization of various sorts, all of this keeps going forward. At this point, though, the power of computing machinery today is such that you just can do enormous amount that you couldn't touch.

You mentioned this paper with Dick Quandt on a delivery problem, and that was a delivery problem where you had both concave and convex costs, and you could formulate this as an integer programming problem, zero and ones, whether you do the route or you don't, this kind of thing. And it was really very interesting, because first of all, I think it was one of the first real applications of using the Gomory cuts and actually getting solutions.

LOUIS BILLERA: I see.

MICHEL BALINSKI: And secondly, what was very interesting, as I recall, is that these decisions had been made by hand. And in many of the problems, they weren't so far from the optimum, every I don't know how many, fifth or six problem-- For several problems, they made big errors in difference that you really got a much better solution. But I think, mainly, it was that there had been almost nothing done computationally at that time.

LOUIS BILLERA: Will computer speed eventually make OR unnecessary, or just it allows you to do bigger and bigger things?

MICHEL BALINSKI: It seems to me that there are always new problems coming up. We're going to find out new ways of formulating. We're going to find that the old ways of formulating a problem took too many shortcuts. I mean, that was what you could do at the time. Now, we can do something different, and so presumably, we'll ask for a different mathematical development, which, in turn, will ask for a different way of solution, and so on. I don't think they'll be killed by just the sheer speed.

LOUIS BILLERA: Do you have anything else you wanted to add?

MICHEL BALINSKI: No. I think it's been an interesting life in this profession. I'm glad I made this choice.

LOUIS BILLERA: It's been an interesting discussion. Thank you very much.

MICHEL BALINSKI: Thank you.