Interview with Peter Whittle by Frank Kelly, January 10, 2017

1: Early life in New Zealand

FRANK KELLY: Thank you, Peter, for agreeing to join me for this interview. It's a great pleasure for me to be able to interview my former PhD supervisor, Professor Peter Whittle, formerly the Churchill Professor of Mathematics for Operational Research here at the University of Cambridge.

Peter, let me start off by asking you some questions about your family background.

PETER WHITTLE: Definitely.

FRANK KELLY: Where you were born, and when you were born, and early family life.

PETER WHITTLE: Well, yes, I was born in Wellington, New Zealand, 1927. We lived on-- you know New Zealand has got the two islands, and I was living at the southern tip of top northern island looking out onto the straits. It was a really, very dramatic and very beautiful, which most of New Zealand is.

FRANK KELLY: How many siblings did you have?

PETER WHITTLE: I had two sisters, Claire and Gillian. It was just the three of us.

FRANK KELLY: You went to school in Wellington?

PETER WHITTLE: Yes, I went to school in Wellington. At first we went to the local school, which was right down in Island Bay, which is a suburb of Wellington, looking on the straits. Yes, so I went to Island Bay School first. I was a very mild character, but somehow I had to look after myself. I bloodied three or four noses, I'm afraid. It wasn't a nice thing to do. But I remember the teacher saying to me, "Peter Whittler, you're too keen. You're too good with your fists." And then she sort of smiled.

FRANK KELLY: So which subjects interested you while you were at school?

PETER WHITTLE: Oh, ones I certainly disliked were geography and history. By god, they just seemed to be messes of data, nothing else. Languages I hadn't caught on to, or even English straight away, but later found languages. I always like to get into a foreign language. Science, of course. If you want to go into science, you get into mathematics. You sort of do that in one move. Arithmetic I didn't care for, but mathematics, yes.

FRANK KELLY: So then you went to college.

PETER WHITTLE: Yes, Wellington Boys College. That was a good college, I enjoyed it. I was winning, I may say, prizes by that same book-- classroom prizes, book prizes, et cetera. But also there was a competition, there was a scholarship examination. In other words, one was competing for scholarships, and so one was ranked on this. I was lucky to be ranked, sometimes at the top, but always near the top. So it worked out very well. The same thing happened when I went to university. One competed in a scholarship examination, the scholarship being for post-graduate work. You were trying finance yourself ahead of time.

2. Undergraduate years at University of Wellington

FRANK KELLY: At university as an undergraduate, your main subjects were mathematics, physics, and chemistry.

PETER WHITTLE: Mathematics, physics, and well actually I didn't do language. As I say, I liked like languages very much at college, but by the time I got to university it was just science. But I was in town going to the French Society, et cetera et cetera, and wanted to keep that up. Later, of course, I went to Sweden, so I liked that. And even English I liked as a subject, but geography and history, no. Languages, mathematics, and physics, yes.

FRANK KELLY: This was shortly after the end of the Second World War.

PETER WHITTLE: Yes, that's correct.

FRANK KELLY: Presumably, operational research, operations research had begun as a discipline, but it was not perhaps widely known.

3: Working at New Zealand Department of Scientific and Industrial Research

PETER WHITTLE: No, it wasn't widely known. Actually, as I said, I was at the University. But I started working in the holidays while still at university, and that was NZ's DSIR, New Zealand Department of Scientific and Industrial Research. Really that was very helpful to get onto that. It was enjoyable.

FRANK KELLY: The problems were natural operational research problems, perhaps classified.

PETER WHITTLE: Well there was no real optimization in the sense that they were concerned on many things akin with business, concerned with farming, in several directions.

FRANK KELLY: The early influences on your work were then partly that work you did with the New Zealand government department, then?

PETER WHITTLE: Yes, certainly. The interesting thing was the gadgets they had there. The group was, first of all, called biometric division. And that goes and became the applied mathematics laboratory, which is concerned more generally. Then the place where we worked, during the war had been occupied by the military, and all kinds of gear left lying around, which is very interesting.

For example, we had a direct current supply, a DC supply. I was interested in wanting to do some electroplating. The solution I used was potassium cyanide, which is a remarkable thing. I had to go down to the chemist and ask for a half pound of potassium cyanide. I'd had a great discussion and shock about this, but somehow managed to get it in the end. We got this potassium cyanide, and it worked very well. It did this plating. But somebody went and tipped all my cyanide away.

FRANK KELLY: Oh my goodness, that sounds dangerous.

4. Interest in time series; Hartree's differential analyzer

PETER WHITTLE: There were other things there. One of them was-- a remarkable place for equipment-- it was Hartree's original differential analyzer we had. It was this thing for essentially solving nonlinear problems. I'd say, as it was, it was made of Meccano, with six purpose built rolling ball integrators. It was actually solving nonlinear differential equations. So that was very interesting. The semi dismantled analyzer looked like what it was, a hybrid of a giant Meccano set, and some special purpose components, requiring a lot of insight to bring it into life.

FRANK KELLY: I mean Hartree's equipment there, it was an analog computer at around the time that digital computers were just beginning to be constructed elsewhere.

PETER WHITTLE: Yes, an analog computer. One of the machines they had that was essentially to calculate the Fourier transform of a realization. In other words, there is a theory of stochastic processes. Much more special case of this is time series, because it's much more elementary. You're not looking at distributions, you're on the whole looking at first and second order moments. And I did write down the different moments, an auto-regression and a moving average. You're interested in one thing, in the covariance. The covariance over a separation, xt and xt minus s. You're interested in that. You're also interested in the breakup into-- what's the word?

FRANK KELLY: Frequencies?

PETER WHITTLE: Yes. You take it to break it up into frequencies. To see it as a sum of--

FRANK KELLY: Trigonometric functions?

PETER WHITTLE: Trigonometric functions, [INAUDIBLE] wave functions are some of the key functions, I would say, several different functions.

Well first of all, we had this machine, which in fact developed into periodogram. The way it worked was-- it was in fact built by the Navy. It was a huge thing. I guess they had their own reasons for it. They wanted it for analysis of signals and that kind of thing.

It was a big flywheel about three feet in diameter. If you had a series, you wrote that out on a tape as a stripe of varying width. Well this was stuck on the fly going around, and the wheel was driven by an electric motor. You could set the speed of it. It was illuminated at one point. The limit for probability elimination, you get a reflected signal into a photoelectric cell. What this gave you, at a given speed, if you're getting this at a given speed, you're getting an indication of the strength in a particular part of the spectrum. It would actually tell you to what degree that was so.

FRANK KELLY: Fascinating analog machine, then.

PETER WHITTLE: It's an analog machine that did it. If you put it to speed and let it run down by itself, then you're going to get the whole periodogram. First of all, as it went to great speeds, you get first the high frequency elements, and that would come down and you get the whole thing. And that's exactly what it did. That was quite important.

It led actually to another development. You were talking about some-- getting to the frequency spectrum of a series or something like that. And it's not really quite clear how this is done. A series really goes from minus infinity to plus infinity as far as time is concerned. We're not going to do much about between minus infinity and plus infinity.

The other thing is that they'll just give you a chop, a series over a given period of time. But what do you mean by the Fourier analysis of that? Because it's not the original series, and it's distorted by being truncated. But the way around that is if you've got the thing on an interval, on the time interval, instead of routing it around and joining it up. So then instead of having-- instead of talking about translation and variance stochastically on the whole line, you're talking about invariance under rotation around a circle. Which is a much neater notion, much neater notion altogether.

What it indicates, in fact, has an interesting effect. If you have a signal running around the circle, which is invariant under rotation around the circle, it really has to be made up of-- a single sinusoid would have to be-- you don't want that coming to an end and not matching. If it's going to match, that has got to be-- the number of oscillations must be integral--

FRANK KELLY: Integral, right, the phase has to match as it--

PETER WHITTLE: Yes. It must be. It means essentially that the frequencies which can occur must be some constant times a natural number, the natural number being the number of individual swings that one gets out of, as we can go around the loop. You get a kind of quantization in frequency, because the frequency's restricted to natural numbers times some constant. That's kind of an interesting fact in itself.

FRANK KELLY: Peter, the flywheel was where? It was back in New Zealand that the--

PETER WHITTLE: Yes. It existed in more than one country.

FRANK KELLY: But you saw it at the New Zealand Department--

PETER WHITTLE: Certainly had one in New Zealand. It was very impressive. This thing came up to speed, it was rumbling and rumbling, and got a high speed. It was like a train going by. They let it come down and it would come down gradually. That was quite impressive, yes.

FRANK KELLY: That must have inspired some of your later work on time series, then.

PETER WHITTLE: Yes, I think it must have done. I mean there are many electronic ways of getting a frequency spectrum. They didn't use electronic ways, they used to make this thing on the flywheel.

FRANK KELLY: The flywheel gradually slowing down to give you the range.

PETER WHITTLE: Yes, yes.

FRANK KELLY: But you were interested in time series earlier than that, and this was just another example of method of analysis.

PETER WHITTLE: I was always interested in time series. It was applied. I think I will be able to give you in a moment is an interesting version of time series in oceanography. It was an Englishman who came out to New Zealand, and he introduced something quite novel on this. He actually could locate storms just from an analysis of these lines of detectors. Could isolate, locate storms.

FRANK KELLY: It's quite striking, isn't it, to solve the inverse problem of where the storm was.

PETER WHITTLE: You're solving an inverse problem in some way or another. It's all very ingenious, it's all very ingenious.

5. Influence of Maurice Bartlett

FRANK KELLY: Peter, I understand Maurice Bartlett was a significant influence on your early intellectual development. Did you meet him, or did you just read his papers?

PETER WHITTLE: I had met him at that time. I had read his works and books and his papers. He was so very convincing. I got to know, principally I think one of the articles he wrote, he wrote a big page article. He must have been in the mid 40s or something like that. That was something one read again and again, and it had lots of seminal notions in it.

No, I didn't get to know him until I came to Britain. Actually, when I was in Sweden, he came to Sweden too. He came to the station, and here was this man, he was dampened. He was a very pleasant person, and he was always a very decent kind of a chap, and I respected him greatly.

The thing was, I didn't expect-- when I moved to Britain and I came to know him, an Indian came to replace him. I followed him in the chair at Manchester. On the account of his support that I think that that happened. Likewise when I moved to Cambridge, I think I had his support, and again counted for a great deal. But he was a very kind man. He certainly was on top of the heap.

FRANK KELLY: In his work, he brought probability and statistics and mathematical structure to bear on various problems.

PETER WHITTLE: Yes, he did. He considered real life things. He had a feeling for physical problems. He certainly had an intuition, and that showed up.

6. Doctoral studies at University of Uppsala; Influence of Herman Wold

FRANK KELLY: The decision to go to Sweden for your doctoral work, what influenced you in that choice?

PETER WHITTLE: A great mixture of things. First of all, the Swedes were very clever and had done a lot of work on time series and things like that, made connections with all kind of things, First connection was telephone works, I mean you've got these big telephone companies, they have technical problems there. Forestry, in forestry you get all kinds of things we're concerned of. And the Swedes, they were technically very strong on these things. So it was good to go there, and there was a [INAUDIBLE] calling us.

The other thing, of course, was that they were very athletic as well. They're big, the very good runners in those days were Swedish and Finns. I mean in the 1936 Olympic games, 10,000 meters was Ilmari Kal-min-en. There was the-- Ilmari Salminen, he was-- the 10,000 meter runner. He won that 5,000 over Volmari Iso-Hollo, a Finn. He won the 5,000 meters. 1,500 meters was a New Zealander.

FRANK KELLY: You yourself were a cross-country runner.

PETER WHITTLE: Yes, very much. There were not a lot of national standard clubs then. But I did enjoy that. It was good, we got around a lot. That was very helpful, I enjoyed that. Same thing when I went to Sweden. In the morning, they had sessions in the gyms I suspect. You sort of did a bit of free running roundabouts, and a few exercises, and then up in the bath and that was great fun.

FRANK KELLY: At Uppsala, your supervisor was Herman Wold.

PETER WHITTLE: Oh, Herman Wold, yes.

FRANK KELLY: So tell us about your time as a doctoral student.

PETER WHITTLE: Wold was very helpful. He was nice. He was not of-- he aimed to be one of the real quality scientists, or a scholar, a real scholar, which he wasn't really. I mean compared with Cramer, for example. Cramer, I was struck immediately by his qualities, quality both as a man and his quality as a scientist. Wold was very good. He wasn't brilliant, but he was very kind. The thing I liked, well I get along very well with Swedes. The Swedes are very nice.

7. Social life at a Swedish university

FRANK KELLY: For a New Zealand boy on the other end of the world, everything must have seemed strange. The food, the climate.

PETER WHITTLE: Yes. We're living in Uppsala. As I said, Wold was very kind and helpful to me. Living in Uppsala was pleasant. One could take these runs in the forest. Everybody was running, in a sense. But it was student life, if I go back to student life, I could read a bit actually, as I've got it.

A very heavy social element in student life was provided by the *nationer*, the nations. These were student bodies, each one taking members, all who came from a particular region of Sweden. Roughly speaking, the counties. Their purpose was a very relevant one, in the days when communications were poor and Sweden had a simple rural economy. It was to ensure that students far from home would have the practical and psychological support of the familiar, and so provide a social safety net in time of trouble. Each *nation*, nation, had seven *nationer hus*, nations' house. Usually a substantial and elegant building would offer all the amenities, from an evocation of history to a lively social life.

But people like myself who came from outside, allocation was usually on the random ground of social contact, personal contact. I've forgotten how it came about, but I was accepted by Vastmanlands-Dala as one of the groups, and a very happy opportunity it turned up to be.

I came in a stranger from overseas. And this was really post war. The Swedes were generally very receptive, very hospitable. But one group that I found difficult to deal with, that what they call the *flyktingar*, that means refugees. These are people usually that had a tough time, and they were carrying various medical conditions. That's why, if you came to the university, you had to go for a physical check. I had a feeling, an ominous result in that I had no disease at all. But that was the thing they were looking out for. I was perfectly healthy.

Speaking of the social life in Sweden, I was still desperately homesick. In V-Dala, the nation's house, after alleviation from the lonely bedroom, the feasts of one kind or another were not singing. Their old time dance sessions with wonderful Strauss waltzes and very good Swedish country dances, one they called hambo. Then there's polka, *skotsk dans*, that's Scottish dancing. And the weekend excursions to the country. There'd be long discussions in various friends' rooms in the evenings. The girls were bright and healthy, would have been very kindly, but I was already committed in New Zealand.

In fact by the end of my first term, I realized that social life was preceding my work. It was a deadline for me that I should complete my thesis within two years. I therefore cut back radically on attendance at V-Dala, which really was a shame. It had provided the kind of free lyric companionate experience that only the brief student years in such an environment can offer. The Swedes were, in general, very warm and hospitable. That was certainly the case.

There's one interesting-- it wasn't a counter-example, but it was sort of halfway to a counter-example. It was a staff member, whose name was Gunnar Eklund. He had a rather grating, abrupt, dismissive style of speaking. There was a time when I had been away from Uppsala for quite a period, quite long. And when I came back and met him, he gripped me by the hand, addressing me as *gamle vän*, meaning old friend. And in fact, I could see it in his eyes almost, which is surprising. I think this reflected simply friendship, warmth, idealism, which was certainly present in this particular case.

8. Auto-regression and moving average

This is an auto-regression. Auto-regression, meaning regressing on itself. It is a difference equation of a certain order. You don't have to labor to produce a forecast. You just apply it repeatedly and we will develop a forecast, although somewhat random of course, because of this.

The other one is what's called a moving average. It's an average, recall it was not really an average, but it's a linear function of the disturbances, which are coming in the random disturbances, which are coming in, which drive xt. As I said, we call it a moving average. The Swedes call it a *löpande medelvärde*, which really means a running average.

In Sweden when you go for your doctorate, you have to defend yourself. In other words it's more or less what we're doing now. You have to stand and explain what you've been doing and answer questions on it, et cetera et cetera. The funny thing about it is that they regard this as a kind of a joke. The person who's doing the questioning is called opponent You have a first opponent someone who wrote, and an under opponent Well my opponent was making great business of this. He knew that I did a certain amount of running. And he says, here we have a running *löpande medelvärde*, a running average. Well, it wasn't a very good joke, but they nevertheless tended to make jokes, while I look for--

FRANK KELLY: Lighten the atmosphere.

PETER WHITTLE: Lighten the atmosphere up, yes. The opponent, really there were two kinds. There were people who were really testing you, and that was part of the examination. And there were others who were really making a sort of circus performance of it for the general enjoyment. It was really a question of making a good joke rather than making any great point. That was something. They said that I had brought in *löpning*, because I had been running, et cetera et cetera. They want to know where the running was.

FRANK KELLY: These equations were on your board for your thesis defense?

PETER WHITTLE: It would be similar equations, yes. I forget.

FRANK KELLY: And they went forward into what became your first book on prediction regulation.

PETER WHITTLE: Yes, that's true, that's true. A thing I've thought about is that it was the use of this machine in New Zealand, the big wheel turning about, which made me think of the development of the process the way it has. I mean, we were saying that instead of regarding the process as being on a stretch of time, it's really on a loop of time. Putting it on a loop has this quantizing effect. That is interesting that this notion of a loop, it occurs naturally in the machine, and it makes good mathematical sense as well. Yes.

FRANK KELLY: Peter, thank you so much for coming along to be interviewed today. I'm so pleased you were able to do it. Thank you.

PETER WHITTLE: Thank you. I'm glad that you made me think about those memories, which are interesting, varied, and, at their best, marvelous. Thank you.