A CONVERSATION WITH PROFESSOR ZHIDONG BAI

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Zhidong Bai is a Professor in Department of Statistics and Applied Probability, National University of Singapore. He also holds an appointment in the School of Mathematics and Statistics, Northeast Normal University, China. He has a very illustrious career which in many aspects resembles a story book. Currently he is in the editorial boards of Sankhya, Journal of Multivariate Analysis, Statistica Sinica and the Journal of Statistical Planning and Inference. Atanu Biswas is an Associate Professor in the Applied Statistics Unit, Indian Statistical Institute, Kolkata. Dr. Biswas visited Professor Bai during January-February 2006 for some collaborative research when Professor Bai was in National University of Singapore. During that visit, Dr. Biswas had the opportunity to talk with Professor Bai in a casual mood, which reveals a really interesting career of a strong mathematical statistician. Dr. Jian Tao of the Northeast Normal University, China, was present during the full conversation.

Biswas: A very different question to start with. Professor Bai, most of the Chinese names have meaning. What does the name Zhidong mean?

Bai: This is an interesting question. Zhidong means Towards east.

Biswas: That is interesting. Could you tell me something about your childhood? How did you grow up?

Bai: I was born in 1943, in the cold Hebei province of Northern China. Hebei means North of the Yellow river. My hometown was in Laoting county.

Biswas: That was the war time, not a very cool and normal surrounding, I suppose.

Bai: Right. The Chinese resistance war against Japan war and the second world war were going on.

Biswas: So how was your time? Any memory of those war days? You were really young at that time.

Bai: Sure, I was too young. But, I still remember, it was a run-away time. Peo-

ple hid quite often in not-easy-to-find places in the countryside out of the fear of the Japanese.

Biswas: Could you tell me something about your family, your parents?

Bai: I was adopted by a poor peasant family. I have no information about my biological parents. My father was working secretly for the Eighth Army Group led by the Chinese Communist Party at that time. I still remember he ran away from home frequently to escape from the Japanese. At those days, we knew nothing about the Communist Party, we simply called Ba Lu (meaning Eighth Army Group) for any people associated with the Eighth Army Group.

Biswas: Could you now talk about your school days?

Bai: I went to elementary school in 1950. The school I attended was originally established by the Ba Lu people during the war time under very poor condition. It was originally a temple with a big hall. The classes for all grades were conducted in the same hall at the same time. You could hear all the other classes. The teachers were not formally educated. They were demobilized soldiers from the Cimmunist let army. They acquired their knowledge in the army. There were no teaching facilities except the big hall. No tables, no chairs, no papers, no text books, nothing at all. The pupils had to carry their own stools from home every day to sit on. They had also to carry a small stone slate with their homework done on it because of lack of papers. The stone slate had to be cared so that what was written on it did not get erased. I came out of this school in 1957.

Biswas: That is very interesting. Any memory about your childhood plays?

Bai: I liked to play table tennis (Ping Pong), which was very popular in China even at that time. Since there was no Ping Pong table, we used a prostrate stone-made monument on the ground, which was about 2 meters long, as our Ping Pong table. But we really had fun.

Biswas: What was your next school?

Bai: I was admitted to a Junior High School in 1957. It was 5 kilometers from my home. The school was established in 1956, I was in the second batch of the students. I graduated from the school in 1960.

Biswas: What did you learn there?

Bai: Eucleadian Geometry and logical thinking, among others.

Biswas: Any special teacher you remember?

Bai: Yes, there was one excellent teacher. That is Teacher Zhang Jinglin.

Biswas: What about your Senior High School?

Bai: My senior high school was in the capital of Laoting county, 8 kilometers from my home. I got admitted into the school in 1960. I stayed in the school dormitory. This was the first time I left my family and lived alone. I still remember vividly the joy of "go-home-week", which was only once a month. I studied there for 3 years. I got very good trainings in mathematical and logical thinking, writing and so on. I learned the first time the notion of mathematical limit in that school, which amazed me and had an effect on my later research interests. I also learnt some elementary courses in Physics, Chemistry, Nature and Culture, and so on. One of the teachers whose name I still remember, Teacher Sun Jing Hua, left me with a deep impression. Sun Jing Hua did not have much formal education. He was a student in a High School run by the Ba Lu people during the resistance war against Japan. After two years study there, he together with all teachers and students of that school joined the Eighth Army Group collectively due to the war situation. He remained in the army until 1949. Then he quitted from the Army and became a teacher of my senior high school. He educated himself by self studying while teaching, and soon became a well-established teacher. My impression of Teacher Sun Jing Hua had a certain influence on my later life.

Biswas: Then, the University. How was that?

Bai: I joined the University of Science and Technology of China (USTC) in 1963. At that time the USTC was located in Beijing.

Biswas: You studied mathematics, right?

Bai: Yes, the first two years were interlinked with the mathematics department. From the third year onwards I studied statistics and operation research. I was in the statistics group. I had a broad training in mathematics and statistics in those five years. I studied Mathematical Analysis, Advanced Algebra, ODE, PDE, Probability, Real and Complex Analysis, Measure theory, Functional analysis, Matrix Theory, Ordinary Physics, Applied Statistics, Theoretical Statistics, Advanced Statistics, which covered Lehmanns book.

Biswas: You were the best student in the class, I suppose.

Bai: I am one of the three best students in a class of 37.

Biswas: Then you graduated in 1968.

Bai: Yes, graduated, but without a degree. There was no degree system in existence

at that time in China.

Biswas: What next?

Bai: After graduation I went to Xinjiang Autonomous Region, west of China, and started my job as a truck driver's team leader. My job was to supervise the truck drivers.

Biswas: Could you continue study or research during that time?

Bai: No way. It was during the Cultural Revolution. I remained in this job for 10 years, from 1968 to 1978.

Biswas: You were married in this period. Right?

Bai: I married in 1972, and my two sons were born in 1973 and 1975.

Biswas: How did you shift to academics?

Bai: In 1978, China restarted tertiary education after ten years interuption. I seized the opportunity to take an examination and get admitted into the graduate program of the USTC as a graduate student. I completed my graduate thesis in 1980. But there was still no degree system in existance until then. No degree was conferred to me at that time. However, the China government began seriously to consider the establishment of the degree system. It was approved by the State Coucil (the China cabnet) in 1982 that the degree system be adopted by the China Academy of Sciences as a trial. I was then conferred the Ph.D degree. I was among the very first batch of Ph.Ds in China, which consists of only 18 people. There were 3 among the 18 are in Statistics. I was one of them.

Biswas: I am a bit puzzled. How was that possible? You were out of touch of academics for 10 years. Then you had to recapture everything when you came back. How could you finish your thesis within 2 years then?

Bai: To recapture I had to read something, but that was easy. I found everything I learned 10 years ago was getting fresh after a quick glance at it. And writing the thesis was not at all difficult as I just compiled 15 papers of mine to form the thesis.

Biswas: When did you write these 15 papers?

Bai: Within these 2 years. Of course these were in Chinese, and not all of them were published at that time, half published and half pending publication.

Biswas: This is beyond my comment. Could you tell me something about your thesis, and about your supervisor?

Bai: The title of my thesis is: "Independence of random variables and applications". I had two advisors: Yin Yong Quan and Chen Xiru. None of them had Ph.D degree, because of the reason mentioned earlier.

Biswas: What next? Did you start your academic career then?

Bai: I started teaching in USTC in 1981 as a Lecturer for three years, then I moved to the United States in August 1984.

Biswas: That must be a new beginning.

Bai: True.

Biswas: Tell me the story.

Bai: My advisor Yin Yong Quan had been in good terms with P.R. Krishnaiah. Krishnaiah came to know about me from Yong Quan, and invited me to visit him at the University of Pittsburgh. I went there as a research associate.

Biswas: Did you face any serious problem with English at that stage? I understand that you did not have much training in English in China.

Bai: I did have some problem with my English, and the problem continued for many years. At the beginning, I could not understand Krishnaiah when we talked face to face, but quite stangely I could understand him over phone. I attributed this to the fact that my English training is obtained mainly through listening to the radio.

Biswas: What about your research there?

Bai: I collaborated with the group of Krishnaiah on signal processing, image processing and model selection. In collaboration with a guy named Reddy from the medical school, I worked on some cardiological problem to construct the shape of the heart, to be pricise, the left ventricle, using two orthogonal pictures. It was altogether a completely new experience to me. I had quite some number of papers with Krishnaiah, a large number of unpublished technical reports also. Unfortunately Krishnaiah passed away in 1987 and C.R. Rao took over his Center of Multivariate Analysis. Then I started collaborating with C.R. Rao. I worked in collaboration with C. R. Rao until 1990. It was a different and fruitful experience. Rao's working style was different. Quite often we tackled the same problem from different angles and arrived at the same results.

Biswas: How many papers have you coauthored with C.R. Rao?

Bai: Roughly around 10.

Biswas: How do you compare your research experience in China with that in the US?

Bai: In China we did statistical research just by doing mathematics, paper to paper. But, in the US I observed that most of statistical research is motivated by real problems. It was interesting.

Biswas: What next?

Bai: I joined Temple University in 1990 as an Associate Professor and stayed there until 1994. My family moved to the US in that period. There was a teachers strike in Temple during my first year there, and the University lost about one-third of the students. As a consequence, some new recruits had to go. I was one of them. I moved to Taiwan in 1994.

Biswas: Thats interesting. How was your experience in Taiwan being a mainland Chinese?

Bai: People there were friendly. I was in Kao Hsiung, southern Taiwan, during 1994-1997, as a professor.

Biswas: When did you move to Singapore?

Bai: In 1997. I could not work there for too long since I was holding a Chinese passport. So I had to leave Taiwan. Singapore was a good choice. I joined the National University of Singapore as a Professor in 1997 and remained there since.

Biswas: Now let's talk something about your reseach area.

Bai: Spectral analysis of large dimensional random matrices is my biggest area of research. I have about 30 papers published in this area, some in IPES journal. For one of these papers I worked for 13 years from 1984 to 1997, which was eventually published in Annals of Probability. It was the hardest problem I have ever worked on. The problem is: Consider an n by n random matrix of i.i.d entries $X = (X_{ij})$, where $EX_{ij} = 0, EX_{ij}^2 \leq 1$. If $\lambda_1, \ldots, \lambda_n$ are the eigenvalues of $X/\sqrt{n}$, the famous conjecture is that the empirical spectral distribution constructed from $\lambda_1, \ldots, \lambda_n$ tends to the uniform distribution over the unit disk in the complex plane, i.e., $\frac{1}{\pi}I\{x^2 + y^2 \leq 1\}$. We derived the limiting spectral density, which is a circular law.

I've written about 10 papers on Edgeworth expansion. Some of them were jointly with Jogesh Babu.

I did some works on model selection, as well, mostly jointly with Krishnaiah. Mostly AIC based, the penalty is C_n multiplying the number of parameters, where C_n satisfies $C_n/\log\log n \to \infty$ and $C_n/n \to 0$. Then, with probability 1, the true model is eventually selected. The paper was published in JMA which is the most

cited among my papers.

Recently I have been doing some works on adaptive allocation, some works with Hu, Rosenberger, now with you.

There are about 10 papers on Applied Probability in Algorithms. I did some interesting works on record problem, on maximum points, with H.K. Hwang of Academia Sinica in Taiwan.

There are a few works on small area estimation and time series as well.

Biswas: Who is your favourite coauthor, except me?

Bai: Silverstein. Besides, I enjoyed working with C.R. Rao in Statistics, and with Jogesh Babu in Mathematics.

Biswas: What is your view on theoretical research?

Bai: I believe that research should be practical problem oriented. To me theoretical research is an art, an entertainment. But, practical research is for the benefit of the people. This is some sort of push and energy to do something. But, there should be some freedom to do something from your mind.

Biswas: I know that you are a strong follower of Chinese culture.

Bai: Certainly, the Chinese cultute, the festivals, the Chinese medicines.

Biswas: What is your general view on research?

Bai: Research in Universities are of two types: "interesting research" and "survival research". Interesting research are those which you do from your own interest. Survival research are those you do for your mere survival, to get promotion, to get your contract renewed and so on. This is the major portion of now-a-days research.

Biswas: How many "survival papers" you have writen?

Bai: Roughly around two thirds of my about 160 published papers.

Biswas: What is your view on the future direction of research in statistics?

Bai: I think new theories are to be developed for high dimensional data analysis. Random matrix theory is one of them. Classical large sample theory assumes the dimension is fixed while the sample size goes to infinity. This assumption is not realistic nowadays. You may see that for human DNA sequence, the dimension may be as high as several millions. If you want a sample with size as large as its dimension, you need to collect data from half of the world population. It is impossible. Then how can you assume p is fixed and n tends to infinity? Now-a-days, big impact in statistics comes from modern computer technique. It helps us

to store data, to analyze data. But the classical statistical theory still works for large data set, especially with large dimension? Now, consider a simple problem: Suppose $X_{ij} \sim N(0,1)$. Denote the $p \times p$ sample covariance matrix by S_n. If we consider p fixed and n large, then $\sqrt{\frac{n}{2p}} \log |S_n| \to N(0,1)$ in distribution. But, if $p = [cn]$, we have $\sqrt{\frac{n}{2p}} \log |S_n| \to -\infty$. More preciously, one may show that $(1/p) \log |S_n| \to d(c) < 0$ and $\sqrt{\frac{n}{2p}} (\log |S_n| - pd(c))$ tends to normal. Now, suppose $n = 10^3, p = 10$. Now, it is the problem of interpretation. One can as well put the relationship in many other forms, $p = n^{1/3}$, or $p = cn^{1/2}$. Then which assumption and which limiting result you need to use? Assume p is fixed (as suggested by all current statistics textbooks)? Or assume $p/n \to 0.01$? Simulation results show that the empirical density of $\sqrt{\frac{n}{2p}} \log |S_n|$ is very skewed to the left. Therefore, I would strongly suggest to use the CLT for linear spectral statistics of large sample covariance matrix. Again, in one of my recent work, I noticed that the rounding in computation by a computer results in inconsistent estimation. For example, suppose the data comes from $N(\mu, 1)$. We just use the t-test to test the true hypothesis. When the data were rounded, surprisingly, when n is large, the t-test eventually reject the true hypothesis! In the statistical problems in old days, the sample size was not large and hence the rounding errors were not a problem. But today, it is no longer the case! It has been a very serious problem now!

Biswas: What is your idea about Bayesian philosophy?

Bai: To be honest, I could not understand that philosophy. I am not a Bayesian. I like Lehmanns idea of average risk.

Biswas: Is Lehmann your favorite statistician?

Bai: You are right.

Biswas: Tell me something about your family, your wife.

Bai: My wife worked in China for some years, before she went to the US to join me. She managed my kids quite efficiently, she is a good manager of my family. My two sons are now well-settled in the US, one is a Professor in Electrical Engineering, and the other works in FDA.

Biswas: Where is Professor Bai after 10 years from now?

Bai: No idea.

Biswas: Thank you, Professor Bai.

Bai: My pleasure.