

ADVANCES IN STATISTICS



Zehua Chen
Jin-Ting Zhang
Feifang Hu
editors

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ADVANCES IN STATISTICS

Proceedings of the Conference in Honor of
Professor Zhidong Bai on His 65th Birthday

National University of Singapore 20 July 2008

editors

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ADVANCES
IN STATISTICS

PREFACE

In August, 2006, while Professor Xuming He, University of Illinois, and Professor Feifang Hu, University of Verginia, were visiting the Institute of Mathematical Sciences, NUS, we had a dinner together. Besides Xuming, Feifang and myself, in presence at the dinner were Professor Louis Chen, Director of the Institute of Mathematical Sciences, Professors Anthony Kuk and Kwok Pui Choi, the head and deputy head of the Department of Statistics & Applied Probability, NUS. The idea of a mini-conference in honour of Professor Zhidong Bai on his 65th birthday was conceived during the dinner. Louis suggested for me to take the lead to organise this conference. I felt obliged. Zhidong and I have been long time friends and colleagues. I first met Zhidong in 1986 when Zhidong together with Professors Xiru Chen and Lincheng Zhao visited the University of Wisconsin-Madison while I was still a PhD student there. After Zhidong joined the NUS, we became colleagues, co-authors and close friends. It is indeed my honour to play a leading role in the organizing of this event. A organizing committee was formed afterwards. It consisted of Feifang Hu, Jin-Ting Zhang, Ningzhong Shi and myself. Jin-Ting is a professor of the National University of Singapore and Ningzhong is a professor of the Northeast China Normal University. It was decided to have a proceedings of the mini-conference published. Xuming later suggested to publish a volume of Zhidong's selected papers. This led to the current book.

The book consists of two parts. The first part is about Zhidong's life and his contributions to Statistics and Probability. This part contains an interview with Zhidong conducted by Dr. Atanu Biswas, Indian Statistical Institute, and seven short articles on Zhidong's contributions. These articles are written by Zhidong's long term collaborators and coauthors who together give us a whole picture of Zhidong's extraordinary career. The second part is a collection of Zhidong's selected seminal papers.

Zhidong has a legendary life. He was adopted into a poor peasant family at birth. He spent his childhood during the Chinese resistance war against Japan. He had an incomplete elementary education under extremely backward conditions. Yet he managed to enter one of the most prestigious universities in China, the University of Science and Technology of China (USTC). After graduation from USTC, he worked as a truck driver's team leader and was completely detached from the academics for ten years during the Cultural Revolution of China. However, he successfully got admitted into the graduate program of USTC in 1978 when China restarted its tertiary education after ten years interruption, and became

one of the first 18 PhDs in China's history four year later. In 1984, he went to the United States. He soon had his academic power felt. He became elected as a fellow of the Third World Academy of Sciences in 1989, elected as a Fellow of the Institute of Mathematical Statistics in 1990. Zhidong has worked as researcher and professor at University of Pittsburgh, Temple University, Sun-Yat-Sen University at Taiwan, National University of Singapore and Northeast China Normal University. He has published three monographs and over 160 research papers. He has produced numerous graduate students. Zhidong's life and his career would inspire many young researchers and statisticians.

Zhidong's research interests are broad. He has made great contributions in various areas such as random matrix theory, Edgeworth expansion, M-estimation, model selection, adaptive design in clinical trials, applied probability in algorithms, small area estimation, time series, and so on. The selected papers are samples among many of Zhidong's important papers in these areas. These selected papers not only present Zhidong's research achievements but also an image of a great researcher. Zhidong is not a trendy statistician. He enjoys tackling hard problems. As long as those problems are of scientific interest, he does not care too much about whether papers can be produced from them for the purposes of "survival" such as tenure, promotion, etc. Such character is well demonstrated in his dealing with the circular law in the theory of large dimensional random matrix. It was an extremely difficult problem. He delved into it for thirteen years until his relentless effort eventually bore fruit. Zhidong has left his marks in Statistics, indelible ones.

This book provides an easy access to Zhidong's important works. It serves as a useful reference for the researchers who are working in the relevant areas.

Finally, I would like to thank the following persons for their contribution to the book: Biswas, A., Silverstein, J., Babu, G. J., Kundu, D., Zhao, L., Hu, F., Wu, Y. and Yao, J.

The permissions for the reprinting of the selected papers are granted by Institute of Mathematical Statistics, Statistica Sinica and Indian Statistical Institute. Their permissions are acknowledged with great appreciation.

The editing of this book is a joint effort by Feifang Hu, Jin-Ting Zhang and myself.

Zehua Chen
(Chairman, Organizing Committee
for the Conference on Advances in Statistics
in Honor of Professor Zhidong Bai on His 65th Birthday)

Singapore
30 September 2007

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PART A

Professor Bai's Life and His Contributions

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 Communist 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: Euclidean 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 interruption. 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 existence 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 Council (the China cabinet) 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: That's 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 research 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 $\lambda_1, \dots, \lambda_n$ are the eigenvalues of X/\sqrt{n} , the famous conjecture is that the empirical spectral distribution constructed from $\lambda_1, \dots, \lambda_n$ 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 $C_n/\log \log n \rightarrow \infty$ and $C_n/n \rightarrow 0$. Then, with probability 1, the true model is eventually selected. The paper was published in JMA which is the most