

Selected Works in Probability and Statistics

Jianqing Fan
Ya'acov Ritov
C.F. Jeff Wu *Editors*

Selected Works of Peter J. Bickel

 Springer

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Editors

Selected Works of Peter J. Bickel

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Foreword

I am very grateful to Jianqing, Yanki, and Jeff for organizing this collection of high points in my wanderings through probability theory and statistics, and to the friends and colleagues who commented on some of these works, and without whose collaborations many of these papers would not exist.

Statistics has contacts with, contributes to, and draws from so many fields that there is a nearly infinite number of questions that arise, ranging from those close to particular applications to ones that are at a distance and essentially mathematical. As these papers indicate I've enjoyed all types and have believed in the mantra that ideas developed for solving one problem may unexpectedly prove helpful in very different contexts. The field has, under the pressure of massive, complex, high dimensional data, moved beyond the paradigms established by Fisher, Neyman, and Wald long ago. Despite my unexpectedly advanced age I find it to be so much fun that I won't quit till I have to.

Berkeley, California, USA

Peter J. Bickel

Preface

Our civilization depends largely on our ability to record major historical events, such as philosophical thoughts, scientific discoveries, and technological inventions. We manage these records through the collection, organization, presentation, and analysis of past events. This allows us to pass our knowledge down to future generations, to let them learn how our ancestors dealt with similar situations that led to the outcomes we see today. The history of statistics is no exception. Despite its long history of applications that have improved social wellbeing, systematic studies of statistics to understand random phenomena are no more than a century old. Many of our professional giants have devoted their lives to expanding the frontiers of statistics. It is of paramount importance for us to record their discoveries, to understand the environments under which these discoveries were made, and to assess their impacts on shaping the course of development in the statistical world. It is with this background that we enthusiastically edit this volume.

Since obtaining his Ph.D. degree at the age of 22, Peter Bickel's 50 years of distinguished work spans the revolution of scientific computing and data collection, from vacuum tubes for processing and small experimental data to today's supercomputing and automated massive data scanning. The evolution of scientific computing and data collection has a profound impact on statistical thinking, methodological developments, and theoretical studies, thus creating evolving frontiers of statistics.

Peter Bickel has been a leading figure at the forefront of statistical innovations. His career encompasses the majority of statistical developments in the last half-century, which is about half of the entire history of the systematic development of statistics. We therefore select some of his major papers at the frontiers of statistics and reprint them here along with comments on their novelty and importance at that time and their impacts on the subsequent development. We hope that this will enable future generations of statisticians to gain some insights on these exciting statistical developments, help them understand the environment under which this research was conducted, and inspire them to conduct their own research to address future problems.

Peter Bickel's research began with his thesis work on multivariate analysis under the supervision of Erich Lehmann, followed by his work on robust statistics,

semiparametric and nonparametric statistics, and present work on high-dimensional statistics. His work demonstrates the evolution of statistics over the last half-century, from classical finite dimensional data in the 1960s and 1970s, to moderate-dimensional data in the 1980s and 1990s, and to high-dimensional data in the first decade of this century. His work exemplifies the idea that statistics as a discipline grows stronger when it confronts the important problems of great social impact while providing a fundamental understanding of these problems and their associated methods that push forward theory, methodology, computation, and applications. Because of the varied nature of Bickel's work, it is a challenge to select his papers for this volume. To help readers understand his contributions from a historical perspective, we have divided his work into the following eight areas: "Rank-based nonparametric statistics", "Robust statistics", "Asymptotic theory", "Nonparametric function estimation", "Adaptive and efficient estimation", "Bootstrap and resampling methods", "High-dimensional statistical learning", and "Miscellaneous". The division is imperfect and somewhat artificial. The work of a single paper can impact the development of multiple areas. We acknowledge that omissions and negligence are inevitable, but we hope to give readers a broad view on Bickel's contributions.

This volume includes new photos of Peter Bickel, his biography, publication list, and a list of his students. We hope this will give the readers a more complete picture of Peter Bickel, as a teacher, a friend, a colleague, and a family man. We include a short foreword by Peter Bickel in this volume.

We are honored to have the opportunity to edit this Selected Work of Peter Bickel and to present his work to the readers. We are grateful to Peter Bühlmann, Peter Hall, Hans-Georg Müller, Qiman Shao, Jon Wellner, and Willem van Zwet for their dedicated contributions to this volume. Without their in-depth comments and prospects, this volume would not have been possible. We are grateful to Nancy Bickel for her encouragement and support of this project, including the supply of a majority of photos in this book. We would also like to acknowledge Weijie Gu, Nina Guo, Yijie Dylan Wang, Matthias Tan and Rui Tuo for their help in typing some of the comments, collecting of Bickel's bibliography and list of students, and typesetting the whole book. We are indebted to them for their hard work and dedication. We would also like to thank Marc Strauss, Senior Editor, Springer Science and Business Media, for his patience and assistance.

Princeton, NJ, USA
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Jianqing Fan
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Biography of Peter J. Bickel

Peter John Bickel was born Sept. 21, 1940, in Bucharest, Romania, to a Jewish family. His father, Eliezer Bickel, was a medical doctor, researcher and philosopher. His mother, Madeleine, ran the household. After World War II, the family left Romania for Paris in 1948, and moved to Toronto in 1949. His father died in 1951 when he was eleven. He moved to California with his mother in 1957, having finished 5 years of high school in Ontario. He started his undergraduate study at Caltech in 1957 but only stayed for 2 years before transferring to the University of California, Berkeley in 1959. For some inexplicable reason, a substantial number of leading statisticians of his generation came from Caltech, where statistics was not taught. They include Larry Brown, Brad Efron, Carl Morris, and Chuck Stone, among others. At Berkeley he obtained his bachelor's degree in mathematics in 1 year. After quickly obtaining a Master's degree in mathematics, he started his doctoral study in 1961 in the Statistics Department. He obtained his Ph.D. degree in 1963 at the age of 22 under the supervision of Erich Lehmann. He and Lehmann later became close friends. He was immediately hired by the Department, which marked the beginning of his long association with and loyalty to Berkeley. He served as Chair of the Statistics Department (twice) and Dean of the Physical Sciences (twice). He officially retired from Berkeley in 2006 but has continued to maintain his office and an active research program in the Department.

When Bickel joined the Berkeley Statistics Department in the early 1960s, it boasted some of the leading figures in the statistics profession: Jerzy Neyman (its founder), David Blackwell, Joe Hodges, Lucien LeCam, Erich Lehmann, Michel Loeve, and Henry Scheffe, among others. During his student days, he met Kjell Doksum and Yossi Yahav who became close friends and collaborators. He coauthored a widely used textbook ([Bickel and Doksum 2001](#)) in mathematical statistics with Doksum. He made several visits to Israel to collaborate with Yahav, including his sabbatical in 1981 in Jerusalem, when Yahav introduced him to a graduate student named Ya'acov Ritov. Bickel became Ritov's chief thesis advisor. They have subsequently collaborated on many papers for the next 30 years. Among Bickel's coauthors, Ritov has the unique honor of having written the most papers with him. Another of his long term collaborators and close friends is Willem van

Zwet from the University of Leiden. They met briefly in the 1960s but started working together in asymptotic theory when van Zwet visited Berkeley in 1972. On the personal side, he married Nancy Kramer in 1964; they had two children Amanda and Stephen and five grandchildren. His attachment to his children and grandchildren has influenced his latest choices of research in weather prediction and genomics, since his daughter Amanda lives in Boulder and his son Stephen outside Washington, D.C. (Ritov 2011). He and Nancy have enjoyed a “loving and intellectually lively family life”.

Bickel has made wide-ranging contributions to statistical science. As his students, each of us had just a glimpse of the total picture. Only during the compilation of this volume, did we begin to comprehend the breadth of his research and the magnitude of his impact. It did not take long for us to realize that, in order to include the necessary in-depth discussions, we would have to divide the collection of papers in this volume into eight categories. The readers may consult another review (Doksum and Ritov 2006) of his research contributions. His research in the early period was mostly theoretical, including rank-based nonparametrics, classical asymptotic theory, robust statistics, higher order asymptotics, and nonparametric function estimation. His ability, at a young age, to pursue serious work in a broad range of areas is unusual. However, he did not shy away from doing applied work. In a 1975 *Science* paper (Bickel et al. 1975), he and coauthors gave an explanation of an apparent gender bias in graduate admissions at UC Berkeley by relating it to Simpson’s paradox. Over the years he has continued to expand his research horizon into other areas such as bootstrap/resampling, semiparametric and nonparametric estimation, high dimensional statistics and statistical learning. During this period, his work and impact have grown beyond theoretical statistics. He once said that as he got older, he “became bolder in starting to think seriously about the interaction between theory and applications, - -” (Ritov 2011). His interest in real world applications is evident in his major work in molecular biology, traffic analysis, and weather prediction. The breadth and impact of his work is also reflected in the 60 Ph.D. students (list in this volume) he has supervised so far. The dissertation topics of these 60 students are as varied as one can imagine. He is known to be an effective, helpful and supportive thesis advisor.

For the depth, breadth and impact of his work, Bickel is widely viewed as one of the greatest statisticians and a leading light of his time. He has received many distinguished awards and honors. Only a few are mentioned here. He was the Wald Lecturer and Rietz Lecturer of the IMS and the first recipient of the COPSS Presidents’ Award. He received a MacArthur Fellowship, was elected to the National Academy of Sciences, the American Academy of Arts and Sciences, and the Royal Netherlands Academy of Arts and Sciences. He has also received an honorary doctoral degree from the Hebrew University of Jerusalem and was appointed Commander in the Order of Oranje-Nassau by Queen Beatrix of the Netherlands. Among his doctoral students, three have received the COPSS Presidents’ Award, which must be a record for a thesis advisor. In spite of the fame and recognition he has received since early days, he remains a very modest person. As his former

students, we were surprised to read a statement like “I became more self-confident (after getting the MacArthur Fellowship)” (Ritov 2011).

Besides his busy research, he has rendered dedicated service to the profession and the country. He was the President of the Institute of Mathematical Statistics (IMS) and of the Bernoulli Society. He has served on many national committees and commissions, including those in the National Academy of Sciences, National Research Council, the American Association for the Advancement of Science, and EURANDOM.

While most people at his age either decelerate or become idle, he has maintained a vigorous research program and started working in some new directions in biology and computer science. Some may even claim that since his retirement, he has become more active than before. He once confided to one of us that, without the bounds of official duties, he can now choose the course he wants to teach, and go to the meetings he feels comfortable attending. He seems to enjoy the freedom from his retirement and has found more energy for research “despite his unexpectedly advanced age” (Bickel this volume). In a decade or two from now, we will need to undertake a major update of his career and research.

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