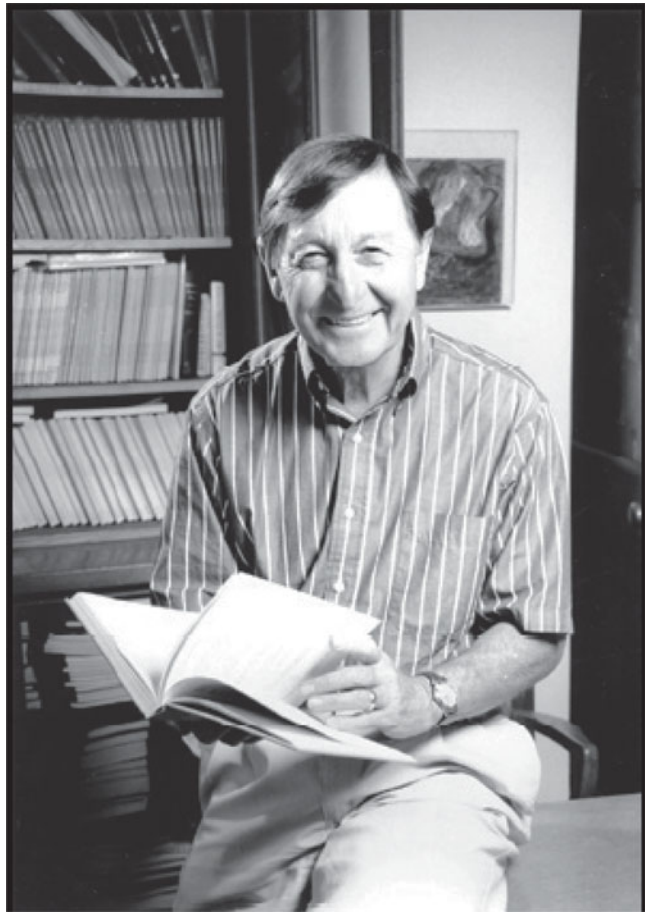
Econometric Theory, **29**, 2013, 153–186.
doi:10.1017/S0266466612000242

THE ET INTERVIEW: PROFESSOR GEORGE JUDGE

Interviewed by Anil K. Bera
University of Illinois at Urbana-Champaign



Professor George Judge.

George Judge was born on a Carlisle, Nicolas County, Kentucky, farm on May 2, 1925. After enduring a depression-era childhood in that small town (2010 population = 2,010 (what a coincidence), U.S. Bureau of Census), at age 18 George

© Cambridge University Press 2012

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

joined the U.S. Air Force and did his share of World War II military service by conducting 30 bombing missions from the island of Saipan to the mainland of Japan. After being discharged from the military, he entered the University of Kentucky in January 1946 and received a B.S. in Agricultural Economics in 1948. Then he went to Iowa State University, where he completed a M.S. and Ph.D. degree in Economics and Statistics, in 1949 and 1952, respectively. However, George did not wait until 1952; without wasting any time he accepted an Assistant Professor position at the University of Connecticut in 1951. In 1955–1958, he served as Full Professor at Oklahoma State University. During 1958–1959, he was a Research Fellow at the Cowles Foundation, where he met Arnold Zellner. They became lifelong friends (and also "partners in many crimes"). Then he moved west to the University of Illinois at Urbana-Champaign (UIUC) as a Professor of Economics and Agricultural Economics, where he had a long and very distinguished career (1959–1986). After that he moved further west to the University of California, Berkeley, as a Professor of Agricultural and Resource Economics, and has been their star faculty ever since. George attained the age of 87 on May 2, 2012, but I have not heard any word of his retirement from active research.

During his more than three-score years of distinguished career, George has made fundamental contributions in each of his chosen fields of research. In his early career, George acted as a bridge between theory and applications. He was the first to apply the Anderson–Rubin limited information maximum method to an overidentified demand-supply model of the feeder cattle sector in Iowa. Starting from this applied mode of research George explored a vast range of research areas: from spatial economics, Markov probability models, planning over space and time, to pre-testing problems and improved inference in econometrics, to maximum entropy and information theory, and finally to the all-encompassing quantum approach to information recovery in econometrics. If one wanted a capsule form of George's research it would be "how to make proper inference from limited data." But it is not just research at which George excels; in terms of econometrics training, George has also co-written some of the most widely used undergraduate and graduate econometrics textbooks, fondly known among the student community as Baby Judge and Big Judge.

If we describe George by his work only, that would be a very incomplete story. I have firsthand knowledge of how George emits positive energy from the time when he was a colleague of mine at Illinois. His door is always open for students and colleagues; he is ever ready to listen to others' problems and ideas and offer suggestions. His optimism is legendary; if one described a bad situation, George's reply would be "That is good; it could have been worse."

This interview gathers some of the recollections of George Judge relative to the econometric trek he has taken over the last six decades; the focus is on the problems he worked on and the fantastic people he has worked with. As he says, he was fortunate to come to economics and econometrics during the golden age of the 1940s and to know and work with some of the best of this and any other period. Through this interview, my initial aim was to give *ET* readers an *illusion* of stepping into a time machine and exploring some of the obscure corners of our discipline and learning some of the human story about the past stars who loom large in our research life. George, however, is a very practical person; he detests

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

illusion. Through this interview, I think, he has provided a *clear picture* not only of his own work but also some glimpses of the lives of the pioneers he came in contact with.

While conducting and compiling this interview, I was very fortunate to have the tireless help of Yu Wang, an Econ-Math exchange student from the Chinese University of Hong Kong, and Xiaying Mao, a senior Econ-major student at UIUC. I am most grateful to them. Lanny Arvan, Phil Garcia, Jayanta Ghosh, Amos Golan, Bill Griffiths, Nazmul Hasan, Geoff Hewings, Matthew Higgins, Roger Koenker, Helmut Lütkepohl, José-María Montero, Dale Poirier, Steve Portnoy, Case Sprenkle, and Aman Ullah very kindly commented upon a draft of this interview and provided many helpful suggestions. I offer my sincere thanks to them. Finally, my very special thanks go to Peter Phillips for his most helpful comments, guidance, and encouragement.

Welcome, George. Thank you very much. First, with your permission, I want to let the readers know that initially you were not so enthusiastic about doing this interview. Why was that so?

I must admit to being a bit reluctant to enter into this discussion-recollection of my activities over the last six decades. My wife Marge is a writer, and in the writing community there seems to be a consensus that there is more truth content in novels and short stories than in autobiographies. So I will just try to stick to some of the things that happened and leave the goods and the bads for others to sort out. Even this framework cannot mask the joy and the fun of the trek, the fact that I enjoy working on problems, the fantastic colleagues with whom I have worked, the satisfaction of the first graduate student, the first published article, the first book [1] and the last [17]. With these disclaimers, I am ready to check in.

Family and Early Education: 1925–1947

So, let us begin at the beginning (as far as this interview is concerned). Tell me a bit about your family background and early education.

I was born May 2, 1925, in Carlisle, Kentucky. I had the experience of living on a farm during the Great Depression and surviving a dated primary and secondary educational system. Having a competitive older brother and sister meant that I did not win many early arguments. My mother died suddenly when I was 11, and I lost an important constant in my life. At age 18, I was invited (ordered) to join the Air Force, where I spent 2 years. This, among other things, involved flying 30 bombing missions over the Japanese mainland, 1,600 miles from my air base on the island of Saipan. In May 1945 I was lucky to be selected as a member of the first crew to return from Saipan to Hamilton Field, California, on a mission weary B 29 aptly named "American Maid." I now had a feeling that maybe now I was going to live the rest of my life! I was released from the Air Force in October 1945 and entered the University of Kentucky (UK) in January 1946. After $2\frac{1}{2}$ enjoyable

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

years at UK, I entered graduate school in economics and statistics at Iowa State University—a very lucky event. Here, I discovered what a university could be, experienced great professors, and was bitten by the problem-research bug. From this, so many wonderful things and experiences to savor have emerged.



Young George on his family farm.

From Kentucky to Iowa—a Long Journey: 1948–1951

How was your transition to Iowa State? How and by whom did you become interested in econometrics?

Entering graduate school at Iowa State was a shock, and I found out how deficient my previous training had been. I had to start playing catch-up, and in a sense I still am. I entered graduate work at a very exciting time that involved Keynes (aggregate economics), Kuznets (input/output), Samuelson (foundations book, pricing and allocation over space and time), Haavelmo (the probability approach to economics), Wald (statistical decision theory), Koopmans (simultaneous equation econometric models and activity analysis), Dantzig (linear programming), von Neumann and Morgenstern (game theory), . . . the list could go on but, any

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

way you view it, this was a great time to switch from B-29s and my undergraduate playground, to getting my nose under the economics and statistics tent.

Boulding (who reminded me that prices don't behave, people behave) and Leo Hurwicz were spending their last year at Iowa State. Kenneth Boulding and Leo Hurwicz shared an office but, due to their different lifestyles, they were never in the office at the same time—they communicated by leaving notes on the blackboard. I was lucky that Hurwicz was willing to tolerate and work with me. Because of Hurwicz, my vocabulary grew to include such terms as "under," "just," and "over" identification, exogenous variables, endogenous variables, instrumental variables, structural econometric models, and of course, least squares bias.



George during his military service, 1943–1945.

Where did this interest and training in econometrics lead to?

This entrance into the econometric world resulted in a 1949 master's thesis [18] that would turn out to be the first application of the Anderson and Rubin limited

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

information maximum likelihood (LIML) method. The focus of LIML was on a single structural equation in a simultaneous equations model under normality of the equation errors. This research gave me an understanding of simultaneous equations econometric models and, in one sense, set the stage for the remainder of my life. The outline I used for the thesis is the one I have used in every applied econometric study since—state the problem, develop the economic model, specify the econometric model, choose the data, select the estimation and inference method, present the empirical results, and discuss the economic and statistical implications.

The study involved a two-equation demand and supply model of the feeder cattle sector in Iowa, with two endogenous and five exogenous-predetermined variables. The demand equation of interest was overidentified. With the crude computing equipment available, carrying through the matrix operations was a task of no small proportions. Finally, on one very hot Iowa afternoon in June 1949, we managed to get a solution, and the signs were right! There was much excitement, and Hurwicz even telephoned a couple of his friends to let them know of our success. As I walked back to my room later that evening, I felt what we had done had put us on a par with the physicists. I still have a carbon copy of the thesis, with India ink Greek symbols written into the equations. When I reread some of the 85-page document, I am amazed that many of the issues of econometric model specification, identification, and causal effects raised there and in the 1949 literature still remain unresolved.

Although I made use of the Anderson-Rubin's *Annals of Mathematical Statistics* article in 1949, my first personal contact with Ted Anderson was in 1951, when he was still at Columbia. I wrote him about the proper formulation of the overidentification test in his 1949 paper. This started an interaction with this wonderful individual that exists today. Since Ted is just down the road at Stanford, we manage to get together at least once a year and talk about kings and cabbages. Ted has a great story about a boat that he and Haavelmo owned when they were at the University of Chicago.

It seems you came to econometrics at the time when it was a very young discipline. It will be very useful for the *ET* readers if you can briefly address the state of econometrics at that time, especially the Cowles Commission work.

The Cowles Commission at the University of Chicago was a virtual Manhattan Project for econometrics, and its monographs provided the foundation stones for statistical inference in economics. For example, Cowles Commission Monograph 10 (1950), *Statistical Inference in Dynamic Economic Models*, edited by Tjalling Koopmans, contained an introduction by Jacob Marschak where he pointed out that simultaneous equations are familiar to theoretical economists but often forgotten by theoretical econometricians. He also pointed to the strong connection

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

between structural models and economic policy analysis. Cowles Commission Monograph 11 (1950), *Economic Fluctuations in the United States, 1921–1941*, by Larry Klein, laid out the framework for econometric ventures and emphasized the interdependent nature of the economic-econometric model, the estimation and inference method, and the data components. Monograph 13 (1951), *Activity Analysis of Production and Allocation*, edited by Tjalling Koopmans, focused on the efficient allocation of resources and the programming of activities. Monograph 14 (1951), *Studies in Econometric Method*, edited by William Hood and Tjalling Koopmans, extended the methods introduced in Monograph 10 and focused on the application of statistical methodology in economics. With the aid of these wonderful monographs, it was easy to be excited about econometrics and the road ahead.

With this digression, let us now move to your Ph.D. work.

Before Hurwicz left Iowa State in 1950 for the University of Illinois at Urbana-Champaign, he gave me some advice. He said that if you want to be a player, here is what you have to do—be the best you can in economic theory, inferential statistics, and theoretical and applied econometrics and do not lose your desire to work on hard/new problems and to learn.

With Hurwicz and Boulding gone from Iowa State, I was fortunate to have the chance to work with Gerhard Tintner, who moved to Iowa State in 1937 after working as a Research Fellow at Cowles Commission, that time located at Colorado Springs. Working with Tintner expanded my quantitative economics world as I completed the course work and developed my Ph.D. thesis. During this period Tintner was working on an econometrics book and a mathematical economics book, and this gave me the feeling that I was where the action was. One of the economics secretaries refused to type anything for Tintner—she was concerned that everything he did ended up equal to zero! Tintner left Iowa State in 1962 for the University of Pittsburg and then moved to the University of Southern California (USC) in 1963. Many years later, I was invited to give a seminar at USC, and when I entered the seminar room, there was a large framed photo of Gerhard on the wall, and I could almost smell the smoke from his cigar and hear him say, "Mr. Judge, please erase the blackboard."

After 3 years at Iowa State and with an unfinished Ph.D. thesis, I accepted a position at the University of Connecticut (UCONN). The department head at UCONN, seeking some information on my undergraduate days, wrote to a UK department where I was supposed to have taken courses. The department head had a hard time thinking of anything good to say about me and in his reply focused on what he called my fine Kentucky family. On receiving this letter, the UCONN department head, a stern New Englander, wrote the UK department head saying thanks for the letter, but we are not interested in Judge for breeding stock!

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

First Job and Meeting Arnold at the Cowles Foundation: 1951–1959

At this stage of your career, you had many firsts: first job, first graduate student, first publication, and so on. How did all these play out at UCONN?

The Connecticut position was a lucky one for me—great colleagues, easy access to Yale (Jim Tobin) and Harvard (Guy Orcutt), a chance to teach an array of courses, have my first graduate student (Ted Booth) and publish an article with him [26], and to get acquainted with the effete East. Shortly after I arrived at UCONN my first article [20], based on research at Iowa State, was published. This article dealt with time and cost functions in egg marketing and brought some nice responses from my colleagues. For some reason John Gould (1908–2003), a columnist for the *Christian Science Monitor*, got his hands on my article and wrote a humorous piece on the editorial page, saying he was not going to show my article, filled with equations, to Clint High, the egg collector of his chicken farm. His message was a good one and reminded me of the importance of the X factor in economics, human behavior. Appearing on the editorial page of a popular newspaper was not the way I had envisioned my appearance in print! I was tempted to respond, but I was given the good advice of never getting into an argument with anyone who has access to an editorial page.

The framework and some writing for my Ph.D. thesis which involved, for then, a large-scale econometric model [22] was well along when I went to Connecticut. I was fortunate that at Connecticut I found a staff member (Sophia Bernat) who was interested in my work and also had a new electronic Monroe calculator. This made the burdensome computations for the econometric model possible as well as the computations for the firm and transportation linear programming models that were a part of my research. At Connecticut I was able to finish my Ph.D. thesis [19] in 9 months and to start a new research program. Some of the things I worked on included estimation and inference in the simultaneous equations area [22], [23], [25], developing production functions from experimental data and linear programming models of the firm [21], and optimal geographical flows and price differentials [24]. The thesis resulted in a technical monograph [22], which won a research publication award that I was happy to share with Sophia.

After a few years at Connecticut you moved west to Oklahoma. How did that happen? Did this move have any effect on your research and teaching agendas?

Some of the work I did at Connecticut brought job enquiries and resulted in my moving to Oklahoma State University (OSU) in January 1955. The move to OSU turned out to be a lucky event for I had great colleagues in mathematics and statistics (Frank Graybill was writing his Linear Statistical Models book), a great graduate student Dudley Wallace, and a free hand in research and teaching.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

For teaching econometrics, I used mostly course notes from my classes at Iowa State. In 1952, Tintner's book, simply called *Econometrics,* was published, and the following year a textbook of econometrics by Larry Klein came out. In 1963, *Econometric Methods* by Jack Johnston was published. Jack's book had substantive chapters on the current state of econometrics in early 1960.

Much of the research that I started in Connecticut [21], [23], [24], [25], [26], I continued and brought to the next level at OSU [27], [28], [29], [30]. Shortly after I joined OSU, an IBM 650 computer arrived. This meant we could make mistakes more efficiently but also meant we could invert moderate-sized matrices to solve some interesting firm and spatial programming models. Albert Tucker from Princeton visited for several weeks one summer and gave great lectures in programming and game theory, inspiring several new ideas. While at OSU, I heard about two-stage least squares (2SLS) but had no idea about its underlying conceptual basis. Larry Klein was visiting Yale at the time, and, although I did not know Larry, I decided to write him and query him about the 2SLS. In very short order, I got back from him a three-page letter that laid out the basis of the 2SLS concept. This kind act made a great impression on me, and, to this day, when I am on campus my office door is always open.

And around this time you also went to Yale as a Research Fellow at the Cowles Foundation.

Yes, by this time the Cowles Commission had moved from Chicago to Yale, and what was going on there was very attractive to me. Under a Social Science grant I was able to spend the 1958–1959 academic year at Yale; there I was in the middle of a veritable galaxy of stars like Tjalling Koopmans, Jim Tobin, and Gerard Debreu, along with Martin Beckmann, Alan Mann, Bart McGuire, Anita and Bob Summers, Art Okun, and Mike Lovell. During this time, Arnold Zellner arrived as a visitor to Yale, and this started a lifetime friendship with one of the great econometric scholars.

I heard that your first meeting with Arnold was somewhat dramatic. Can you go back to that?

I met Arnold for the first time in January 1959. I was sitting at my desk at the Cowles Foundation at Yale and heard a somewhat loud conversation going on outside. Soon, Arnold walked in, took the desk that was backed up to mine, and started a conversation that would last for the next half a century. Over the next 9 months at Yale, we found a common love for econometrics and discussing the kings and cabbages related thereto. We proceeded over the next 9 months to eat our way through some of New Haven's finest and worst restaurants, to enjoy the effete group then at Cowles, and to play golf whenever we could work it in. At this point, bits and pieces of combining equations and Bayes were already on Arnold's mind.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press



Arnold Zellner and (Curious) George.

Any other special memories with Arnold from this period?

One thing that stands out over this period was a trip to the Massachusetts Institute of Technology (MIT) to hear Herman Wold, whose causal chain ideas were not very popular at Cowles. We drove to Harvard in Arnold's car that consumed more oil than gasoline and met Robert Dorfman, who took us to the Harvard Faculty Club, where we dined on a horse meat steak that was the special of the day! We then went to MIT and Wold's seminar. After the seminar, Samuelson generously took us to the MIT faculty club to continue the discussion. To top off this wonderful day, we had dinner at a restaurant on Harvard Square, and at that moment, life seemed infinite and for the taking. As we discussed many times later, we could not at that time envision all the great things that would come with the passing of time. Sadly our time at Yale ended after 9 months; Arnold and his wife Agnes headed back to the University of Washington in the oil guzzler. This Yale meeting resulted in a lifetime of interaction and a front row seat to all of Arnold's many accomplishments. Arnold was a wonderful friend on so many levels. He was always there to read a paper or a book, work with some of my bright students to give them a view of his world, and in general to lend a hand.

After a year at Yale I became a Professor at the University of Illinois at Urbana-Champaign (UIUC) in August 1959.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

Move to Illinois and a Long Stay: 1959–1986

Here I have the home advantage and have too many queries. But I promise to keep these to a minimum. First, could you summarize your time at UIUC and the sojourns you took from there?

The University of Illinois (UI) provided a range of great colleagues and graduate students, a first-rate computer group, and the Illiac computer. Access to the Illiac computer meant I could analyze large-scale econometric and spatial equilibrium models. At the UI I had time to build on my earlier work in econometrics, expand my work on spatial price equilibrium models [32], [33], [34], [35], [37], [45], [46], investigate the use of Markov processes with aggregate economic data [1], [38], [42], [44], [54], and investigate the use of nonsample information in the estimation and inference process [4], [39], [40], [43], [47].

During the 1965–1966 academic year I was fortunate to get a 9-month NSF grant to visit the London School of Economics (LSE). How great it was to meet and talk with Bill Phillips, Denis Sargan, Jim Durbin, and David Hendry, to get to know Jack Johnston and some in Europe such as Henri Theil and Jacques Drèze, and to get acquainted with London.

What follows are a couple of random things, which have for some reason stuck in my mind:

While chatting with Theil one day in his office in Amsterdam, I noted a couple of times that he pulled out his handkerchief and tied a knot in one of the corners. Finally, my curiosity got the best of me, and I asked what was going on. Theil responded that when he wanted to remember something he tied a knot in his handkerchief!! Now you have one of the unknown data points underlying Theil's success.

Occasionally I was fortunate to have a one-on-one conversation with Bill Phillips. One day while having tea with him I learned he was studying Chinese. With all the balls he had in the air, I wondered why this excursion. His response was, there are 3,000 characters in Chinese and this way he would never run out of symbols. Although his Phillips curve article had obtained international attention, I was struck that he seemed uninterested in discussing it with me.

The rich time at LSE provided a chance to think about where I had been and where I hoped to go. One place I hoped to go was to develop a basis for getting information about underlying economic processes from aggregate economic data. Returning from LSE I continued to work on price and allocation models over space and time and to think about how to squeeze micro information out of macro data.

All these were quite new at that time. Did you have problems in getting your papers published?

During this decade I quickly learned the Kabuki dance that ensued when you submitted something new to a journal or looked at an old problem in a new way.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

As Ed Jaynes noted, the review process usually evolved something like this—the result is wrong—OK, the result is right but it is not relevant—OK, it is right and relevant, but we knew it all before! Fortunately for me, two knowledgeable and helpful major statistics journal editors, John Pratt and Brad Efron, helped me through this learning period.

At this stage along with papers, you started publishing books on a regular basis. How did that come about?

In 1970, work with T. C. Lee and Arnold Zellner culminated with the book *Estimating the Parameters of the Markov Model from Aggregate Time Series Data* [1]. The following year, I did a book with Takashi Takayama, *Spatial and Temporal Price and Allocation Models* [2], that summarized work in this area that Tak and I had been involved in over the last two decades. These books were a joy to write, and sometimes I wonder why I didn't just stick with one of these research areas. In 1973 Tak and I edited a North Holland book [3] concerned with "Allocation over Space and Time." Paul Samuelson and Jan Tinbergen contributed chapters and were wonderful to work with. Since the volume covered both space and time, many checked in to see what we had come up with, and some who purchased the book were not too happy with our view of space.

During this period I became concerned with the quality of our economic data and corresponding quantitative analyses [36]. In this regard, I spent some time working with a committee and government data collection agencies. As a result the usual committee report [52] was issued and sadly little was accomplished. About this time a literature committee asked several quantitative types to review the evolution and quality of applied econometric ventures. This joint venture resulted in the book *Agricultural Economics Literature Review (Quantitative Economics)* [4] and the fun of taking our message on the road in several joint seminars.

Around this time you were also involved with the inception of the first econometrics field journal; any recollection from that?

In the early 1970s North Holland publishing company was looking to get in the journal business and started talking with Dennis Aigner about an econometrics journal. This discussion evolved into what is today the *Journal of Econometrics* (*JE*). Dennis Aigner was its first editor and was kind enough to involve me in the formation stages. One big question was the color of the cover! It was such a pleasure to see *JE* evolve into a major econometrics journal with top editors such as Arnold and Takeshi Amemiya and its own list of fellows.

During your long stay at UIUC, did you have any administrative duties?

In 1970, when there was much student unrest and universities were trying to find their mission, I was asked to chair a long-range planning committee for the UI

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

campus. This experience took 1 year of my life and, in some ways, was like herding a bunch of cats. However, it was valuable in that it gave me the knowledge to say no when any other administrative offers came my way.

Let us get back to something more pleasant; any more academic sojourns?

In 1974, I spent another semester at LSE. David Hendry was still there, but the closest I got to Denis Sargan was to have the use of his office, since he was spending the semester at Yale. This semester provided a chance to get reacquainted with the current set of European econometricians and to think about a pre-testing and Stein-rule book, and in general the road ahead.

While I was at LSE, I was invited by the Russian Academy of Science to visit two institutes in Moscow. One institute looked at normative problems and dealt with such questions as an optimum traffic system for Moscow. The other institute looked at the positive world and did input-output analysis and the like. The institutes were in different parts of Moscow and did not interact with each other. Locating and actually traveling to each of the institutes was an accomplishment that should perhaps go on my vitae! It was not until 1982 on another trip to Russia that I found someone to talk statistics and econometrics with and who was interested in the recent books that I was involved in.

In the late 1970s, the Russian Academy of Sciences became interested in the Markov book that I did with Ray (Tsoung-Chao) Lee and Arnold [1]. They decided to translate the Markov book and publish a Russian edition. They did a first-rate job and published 6,000 copies, which was in excess of the number of copies in the two North Holland printings. When I visited the economics department at the University of Warsaw in 2006, I was surprised to find that three members of the faculty had Russian copies of the Markov book for me to autograph.

Now allow me to say something personal. I joined the Australian National University (ANU) as a graduate student in 1979, and the very first econometrics course of my life was from Pravin Trivedi. He used your just published book with Mary Ellen Bock [5]. That made a great impression on me. I also have a clear memory of your visit to ANU around that time and the dinner party in your honor at the Dean of Economics Faculty, Deane Terrell's, house. Tell us about the background of that book with Bock.

Since starting to work in statistics and econometrics, I have always thought that hypothesis testing was an underreported scandal in inferential statistics and that the inadmissibility and Stein-rule work of Charles Stein was very important. Fortunately, I found a person with a similar idea in Mary Ellen Bock. After several years of slugging our way through a bit of math and theoretical statistics

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

[47], [48], [49], [50], [51], [53], we were able to write the book *The Statistical Implications of Pre-test and Stein-Rule Estimators in Econometrics* [5]. This book turned out to be great fun, but I was left with the feeling that I would never again have a chance to do a piece of research that would match this. I felt we had laid down a marker and that perhaps some of the hypothesis testing silliness would stop—how wrong I was!! In 1984, I was asked by the *Journal of Econometrics* to edit an Annals issue [8] on new results concerning Stein-rule and pre-test estimators. I continued to work with Mary Ellen Bock and Tom Yancey in the Stein-like estimation area, and over the next decade the following theoretical and applied journal articles, [56], [57], [58], [59], [66], [69], filled in some of the missing pieces.

Since you mention my visit to ANU in 1980, let me add a few words. While at ANU, we were looking for a micro economist, and earlier in the day I interviewed a couple of ANU people. Late in the day, there was a knock on my office door, and in walked Stephen Turnovsky. Steve said, "If you are looking for a micro economist, how about me?" I said, "Well if we are willing to lower our standards, perhaps we can work something out!" Work something out we did, and Steve and his wife Michelle came to Illinois for a visit and to stay. Steve's presence at Illinois was also later useful as a data point when we learned a young econometrician named Anil Bera was on the job market.



At Illinois: Anil Bera, Mrs. Maitreyee Bera, George, Tsoung-Chao Lee, and Marge Judge.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

Now let us hear about your widely used co-authored theory and practice of econometrics textbooks: Baby and Big Judges.

During the last part of the 1970s, I spent a year at the University of Georgia and a summer with INSEE in Paris. Both ventures were very important for that stage in my life.

The Georgia venture provided the basis for working with young colleagues on a range of econometric topics. The work started in the late 1970s at the University of Georgia and culminated in a 1980 book [6], with R.C. Hill, William Griffiths, Helmut Lütkepohl and T.C. Lee, titled *The Theory and Practice of Econometrics* (*TPE*). The *TPE* book summarized what we thought to be the state of econometrics. That then led to a companion book, [7], *Introduction to the Theory and Practice of Econometrics (ITPE).* Revisions of these two books [9], [11] that took care of some errors of omission and commission appeared in 1985 and 1988. A companion book [12] with Griffiths and Hill, *Learning and Practicing Econometrics* (*LPE*), which filled another niche, appeared in 1993. Finally, an undergraduate text book [14] was published in 1997 and its revised version [15] appeared in 2000.

Tell us a bit more about the process of developing *TPE* and *ITPE*.

The outline-table of contents for *TPE* grew out of decades of teaching graduate econometrics. The book starts in the context of a linear statistical model with the question of how to go about learning from a sample of data. Assuming some understanding of sampling theory and Bayesian approaches to estimation and inference, the learning process continued by asking what-if-problem type questions—what if the sampling errors are not i.i.d.? This question-learning process made the chapters very easy to write. Each chapter took up the question and produced a state of the art conclusion. It was definitely not a definition-theorem-proof or bag of tricks textbook. Relevant tests were introduced, but because of my earlier pre-test work, the three golden rules of econometrics, "test, test and test," were not followed. Simultaneous equation econometric models were not included in the first edition, because we ran out of time before we could write up this material.

In locating a publisher for the book, we had the good fortune of both Wiley and North Holland being very interested. I had worked with Ellen van Koten on my other North Holland books, so early publishing discussions started with her. It turned out the discussions with her were also useful in arriving at a title for the book. Our initial title for the book was "An Econometric Handbook." Michael Intriligator got wind of this and asked us not to use the title as he and Ken Arrow were planning a Handbook in Economics series with North Holland. He suggested we use the title of the last chapter of the book, "The Theory and Practice of Econometrics." This we were happy to do, and that is how *TPE* and *ITPE* came into existence.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

Having done the first edition of *TPE*, we were emboldened to have a go at an introductory *TPE* that would be satisfactory for honors undergraduates and first-year graduate students. Thus, we decided to do the *ITPE*. Actually we found *ITPE* more of a challenge to write than *TPE*. However we did get it quickly put together, and it seemed to find its place and make a nice addition to *TPE*.

Given the writing, rewriting, and proofreading that involved a quintet of people, I wonder in retrospect how we pulled off the first and second editions of *TPE* and *ITPE*. When we did the books, we did not have access to the electronic marvels that exist today. Because of the geographical dispersion of the group, the turnaround of versions of the chapters was painfully slow. This put an emphasis on getting it right the first time. Last week, I cleaned out a cabinet and threw into the recycling bin all the correspondence surrounding the emergence of *TPE* and *ITPE*, from the first preliminary outline to the final proofs. Reading for a final time these words and other symbols made me feel the richness of human existence and to wish I could turn around the arrow of time.

At Illinois many students worked under you and received their Ph.D. degrees. Any one of them stand out in your mind?

Of the many wonderful graduate students that I worked with at the University of Illinois, one particular person stands out. His name is Gang Yi, and we worked on econometric model selection problems [77] [78]. He is now a Professor at Peking



George with Gang Yi and his students at Peking University.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

University and Deputy Governor of the People's Bank of China and the Head of the State Administration of the Foreign Reserve. I would like to think that our work on model specification is useful to him now as he plots the course of foreign exchange and monetary policy. The last time I visited with him in China, he had set up a commercial and residential mortgage practice for Chinese financial institutions and was working with students at Peking University to design a Social Security–like system for China.

There were many other wonderful graduate students that I worked with during this period that led to important econometric model specification articles that are summarized in the publications [71], [72], [73], [74], [75], [83], [85].

At UI you worked jointly with our beloved longtime colleague Tom Yancey on a range of econometric problems. You also wrote a book with him. Tell us about your experiences with him.

When I arrived at Illinois I quickly made friends with Thomas Yancey, a fellow econometrician. Over the years we worked on a range of problems, some of which are summarized in the publications [55], [58], [61], [62], [64], [66], [67], [68], [70], [71], [72], [73]. In 1986, I completed a book [10] with Tom, *Improved Methods of Inference in Econometrics*. This book dealt with the statistical implications of using inequality-type nonsample information and continued some of the work on Stein-rule estimation that I started with Mary Ellen Bock. Tom was a pleasure to work with and was a good restraining force. I cannot remember the number of times when I was racing ahead on a problem, and he would say, "George, you are ahead of the arithmetic!" Tom and I also worked with a colleague in the statistics department, Bob Bohrer, who had a severe vision and other medical problems. It was inspirational to watch Bob overcome these challenges as we did some interesting work on a range of pre-test and inequality restrictions problems [79], [81]. During this period I continued to work on pre-testing and Stein-ruling with Carter Hill, Mary Ellen Bock and several others [76], [80], [82], [84].

You had a long stay at UIUC and were instrumental in hiring and keeping econometricians like Dennis Aigner (1963–1968), Dale Poirier (1973–1977), Takamitsu Sawa (1977–1980), Paul Newbold (1979–1997), and Roger Koenker (1974–1976, 1983–present). More personally, in 1983 after having a few job offers, when I sought the advice of Jacques Drèze (CORE, Belgium), he had a straight answer: "Go to Oorbana," in his French accent, "George is there." Do you want to add a bit more on econometrics at Illinois during your time there? At UIUC you were also associated with the Department of Agricultural Economics, Statistics, and the Control Systems group in Engineering. Any reflection on that?

Econometrics at Illinois, while I was there, was a work in progress. There were great econometric colleagues and graduate students. I was very fortunate to have

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

consistent long-term NSF funding. The supporting faculties across campus were first rate, research minded, and always looking for ways to learn from their experimental and nonexperimental data. Joint appointments between departments were encouraged. The Computer Science, Mathematics, and Control System faculties were first rate and not only supportive but helpful. While I was at Illinois a Department of Statistics was born, providing joint appointments for some in econometrics and a willingness to discuss the statistical needs of our econometrics graduate students.



Group photograph in front of the David Kinley Hall during a Conference at UIUC in honor of George, May 1–2, 1999. Front left: Yannis Bilias, Zhijie Xiao, Tereko Hippo, Luiz Lima, Ana Campelo, unidentified, Matthew Higgins, Bill Griffiths, Tsoung-Chao Lee, Carole Amidon, Mohammad Nazmul Hasan, Anil Bera, Ted Juhl, George, Tom Yancey, Dennis Aigner, Roger Koenker, Dale Poirier, Amos Golan, unidentified, Bob Resek, Mary Ellen Bock, unidentified, Arnold Zellner, unidentified, unidentified, unidentified, Naoko Miki, unidentified, and Gamini Premaratne. Incidentally, David Kinley founded the Department of Economics at UIUC in 1895. Later he was the 15th President of the American Economic Association and the President of UIUC from 1920 until 1930.

The Final Stop—University of California, Berkeley: 1986–Present

To our disappointment you decided in 1986 to abandon us and move west permanently. How did that change your research agenda?

After several visiting appointments at the University of California at Berkeley, I accepted a position at Cal in August of 1986 with the Giannini Foundation. This

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

wonderful university has been my home ever since. In the last part of the 1980s, in the context of "Van Gogh's Sky and Einstein's Space," I started discussing with Amos Golan the incidence of ill-posed inverse problems in econometrics and reviewing some solution possibilities. This led to work on the maximum entropy (MaxEnt) principle and its possible use as a new way to think about estimation and inference [86], [87], [89], [90], [91], [92], [93], [94]. I also used the pure inverse MaxEnt formulation to return to the first-order discrete time Markov problem that I had worked on earlier with Lee and Zellner [88].

Building on the pure inverse MaxEnt basis for information recovery, Amos Golan, Doug Miller, and I started to think about inverse problems with noise and the implications this might have for analyzing a range of econometric models. The work started with Golan and Miller in the MaxEnt area and resulted in the book *Maximum Entropy Econometrics* [13] that was published by John Wiley in 1996. This book was great fun, since it represented a new way to think about a range of econometric problems.

About this time, in correspondence with Art Owen, I became interested in the empirical likelihood approach to estimation and inference. With this on my mind, in 1996 I met Ron Mittelhammer between planes at the O'Hare Hilton to discuss the possible joint interest in this area. This was a very lucky event for me because I met and added a very wonderful colleague who shared my research goals. Our early work culminated in 2000 with the book *Econometric Foundations* [16]. This book covered traditional material and a couple of chapters on information theoretic methods. These two chapters led to a range of information theoretic econometric based papers [95], [96], [97], [98], [99], [102], [104].

Work in the entropy area brought me into contact with some in physics. David Wolpert, a NASA scientist, is one contact over the last decade that stands out. David is kind of a Don Quixote researcher with broad training and seemingly willing to take on any problem that looks interesting. Our first interaction came when using an entropic base; he suggested a game theoretic formulation where the equilibrium of a game is described by a distribution and a loss function. An econometrician might think of it as a statistical decision problem under uncertainty. Physicists seem to find this a natural development, since they view behavior systems like physical systems as statistical in nature. However, it has been difficult to find someone in the game theory community who will leave their single equilibrium world and even discuss it.

It seems you are getting more productive as we are passing chronologically. Here is a short question: What has kept you busy over the last decade? I am sure you have a lot to say on that.

Around the year 2000, I made contact and started work with Marian Grendar, an exceptional Slovakian graduate student. This was another very lucky event, as I will indicate. Also about this time, Wendy Tam Cho and I found a common interest in ecological problems in political science, and we have spent the last

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

decade applying information-theoretic methods to this problem area [100], [107], [110].

Indeed, the last decade has been rich in research problems and colleagues. It has permitted some new ways to think about information recovery, in general, and econometric estimation and inference, in particular. My main focus has been on information-theoretic methods, and the objective has been to present a plausible basis for reasoning in (i) situations involving indirect noisy observations and (ii) econometric models in the form of ill-posed inverse problems (more unknowns than data points). This scenario describes the current quantitative economic landscape and suggests traditional econometric statistical methods may not be designed in many cases to cope with indirect noisy data and the ill-posed inverse problem restriction. As a case in point, many have attempted to identify causal effects from indirect noisy observed data-statistical evidence. From an econometric point of view, the causal effects problem (determining unknown causes from noisy indirect observations of their effects) involves among other things the solution to a nonparametric stochastic inverse problem. Perhaps each cause does not have just a single history, but many possible histories, each with its own probability (Stephen Hawking, *The Grand Design*). Problems such as this place a limit on the precision of conventional statistical information recovery methods and suggest that, just as in the 1940s, we should be using methods consistent with the nature of the data and the corresponding econometric models [122]. The use of conventional methods of econometric estimation and inference, along with the teaching of 1970s econometrics in graduate courses, will inevitably have a slow decay rate. However, the nature of quantitative economic problems and the limits of the imperfect science of current theoretical econometrics should hasten the information-theoretic day.

Now tell us about your recent research agenda. Again, I am sure, you have plenty to talk about.

My recent research in information-theoretic methods has involved a flexible new collection of distribution functions, whose members constitute the complete class of potential probability distributions satisfying standard regression error orthogonality conditions. The resulting likelihood functions are both consistent with parametric specifications of a range of econometric models and are minimally power divergent from any possible reference distribution for the unknown probabilities. The corresponding class of statistical models and associated estimators represent a large set of alternatives to traditional parametric and conventional semiparametric methods of analysis. The new class of probability distributions is interesting in its own right, and has potential for use in a wide array of econometric-statistical models. This work also sets the stage for research concerning the choice of the optimal Cressie–Read functional, under squared error or Kullback–Leibler loss. This framework has yielded a basis for dealing with real world nonparametric stochastic inverse problems. Perhaps each data set does not have just a single

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

history, but many possible histories (pdfs), each with its own probability. Some of the econometric possibilities, in this context, are reflected by the following examples.

Recent research with Alexander and Pavel Gorban considers the large family of entropy functionals, seeks their unification, and notes their information-theoretic interpretation [118].

Research with Marian Grendar using the large deviations concept [111], [119] demonstrated that the empirical likelihood framework has a well-defined probabilistic interpretation that justifies its use in a Bayesian context [114].

In a recent work with Ron Mittelhammer [121], a minimum discriminant information principle was used to identify an appropriate flexible parametric family and corresponding statistical models and estimators for binary response models.

In research with Joanne Lee and Wendy Cho, we examine the interrelationship between Benford and other monotonically decreasing distributions and use, via information-theoretic methods, first moment information to extend the conceptual basis underlying Stigler's distribution [117], [120]. In work with Laura Schechter, Benford's law was used to assess the quality of survey data [112]: "It is Friday afternoon in Nairobi, do you know where your enumerators are?" An information-theoretic approach to analyzing the Benford first significant digit problem was developed in a physics journal [108].

In another work with Marian Grendar, involving general estimating equations and maximum empirical likelihood estimation and inference, we indicate that the solution set may be empty for some data-based *empirical estimating equations* models and a range of other conventional models with finite data samples [116].

Ron Mittelhammer and I considered the implications of combining models-estimators under squared error loss [101], [103], [105], [106] and demonstrated the relationship between the combining idea and Stein's shrinkage estimator. In the context of moment-based estimation and inference, the Cressie–Read family of divergences was used to provide an information-theoretic approach to information recovery in the case of continuous and binary problems [112], [113], [115], [121].

Much of this and other research are contained in the book *An Information Theoretic Approach to Econometrics* [17], with Mittelhammer, from Cambridge University Press. This book is intended to provide the reader with a firm conceptual and empirical understanding of basic information-theoretic econometric models and methods. After basic chapters dealing with parametric and semiparametric linear probability models are presented, the focus turns to the solution of nonparametric stochastic inverse problems. In succeeding chapters, a family of power divergence measures–likelihood functions is introduced for a range of traditional and nontraditional econometric models-problems. Finally, within either an empirical maximum likelihood or loss context, a basis is suggested for choosing a member of the divergence-likelihood family. In developing this choice rule a convex combination of members of the Cressie–Read family of divergences is used. This convex combination leads to a Lyapunov function that

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

has interesting characteristics of its own, and in a special case, leads to Jeffrey-J divergence.

In another context, although I am somewhat accustomed to end of distribution outcomes, I was not prepared when Joanne Lee, a 17-year-old entering graduate student, walked into my office in August 2007 and wanted to talk about her graduate program. As it turned out Joanne and I decided to work together as she completed her course work and started thesis research for her Ph.D., which she received in May 2011. In her first year of graduate work she did a M.S. degree in statistics while pursuing the usual graduate courses in economics. The consensus is that she is the youngest person to receive an M.S. in Statistics at Berkeley. I can hardly wait to see what the future holds for her.

You are now 87 and as young as ever. What are your plans for the next decade? What does the future hold for Curious George? Or, to put it in your words, "How much more damage do you want to do?"

Building on the base of the last decade, I would like to continue to work with the graduate students at Cal and colleagues around the world. Someone needs to write a book on the "Foundations of Information-Theoretic Methods" that would tie together the concepts of entropy, measures of divergence, and likelihood functions, as a basis for information recovery in economics and econometrics. Marian Grendar and I have started to think about a book along this line. Because I am also interested in applied econometrics, I would like to continue the work with Mittelhammer and Cho and develop an applied information-theoretic research book.

The problem I am most excited about right now is the prospect of developing a quantum-like basis for information recovery. Conventional information-theoretic econometrics use the Cressie–Read family of divergences and an empirical maximum likelihood concept to identify a risk minimizing likelihood function; e.g., see [121]. This method is consistent with traditional semiparametric and parametric econometric and statistical approaches to estimation and inference from a finite sample of data. The focus is on what are the parameter(s) and the corresponding sampling distribution underlying the sample of data. There is something that is troubling about this approach as a basis for learning from a sample of data. To ask what the likelihood-density function is rather than what it could be is to ask an unnecessarily difficult question.

Parameters, structural or otherwise, are unobserved and indeed are unobservable. Indirect noisy sample observations may not come from a single sampling distribution, but many sampling distributions, each with its own probability. Perhaps a sample does not have a single history, but many possible histories, each with its own probability. This view is consistent with quantum information recovery, which recognizes that economic-behavioral systems are statistical in nature and that these systems are seldom, if ever, in equilibrium. In this context, the equilibrium ensemble is unknown and unknowable, and the probability of any sample observation is constructed from all the possible likelihood functions–sampling

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

distributions, each with its own probability. Under this scenario–data generation scheme, there would not be a search for the appropriate likelihood function, but the search for the mix of likelihood functions, consistent with the indirect noisy sample observations. This way of thinking gives new meaning to what is a likelihood function and what is the appropriate underlying sampling distribution of an econometric-statistical model. I am anxious to see where this quantum type of thinking is going to lead.

As I look back over the years, my partners in crime and the books, articles, seminars, and meetings, there are so many wonderful memories—I am one very fortunate fellow. As I look ahead, I hope to continue to have econometric fun and not do too much damage. Problems, such as the quantum-one above, keep me anxious each day to get in the office and press the computer on button.

We lost Arnold on August 11, 2010. After retiring from the University of Chicago in 1996, he was a regular visitor to your department here at Berkeley, his alma mater. When did you see him last?

The journey I started with Arnold Zellner in 1959 ended in 2010. The last time I saw Arnold was in mid-March at the Berkeley City Club, where he and Agnes stayed during their visits to Cal. Over tea and many cookies, Arnold, Agnes, Marge, and I had a long conversation whose tone was in some sense like 1959 all over again. However we all knew we were on a different time clock—we just did not know how short the minutes were and how sharp the pain of our loss and of the words unsaid would be.



George and Marge.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

Now George, the last question! It is said there is always a woman behind a successful man. Of course, here I am referring to Marge. I fondly remember my early days at UIUC when she used to invite fresh assistant professors to your home at Farhill Drive, Champaign, and provide much needed respite. Here is a story. Once while you and Marge were returning from an overseas trip there was a surprise drug raid at the Chicago O'Hare airport. All incoming passengers were stopped and their luggage was thoroughly checked. The queue was long, and when your turn came, the immigration officer, before looking at the passports, shouted, "Who are you?" You were very nervous, but Marge calmly replied, "We are Judges." The officer was taken aback and politely said, "Madam and Sir, please proceed towards to Exit." I realize this has nothing to do with econometrics, but I find it a wonderful story. Please tell us about her influence on your life and work.

I have been fortunate to have the help of two strong women, Sue and Marge, and two wonderful daughters, Lisa and Laura, during my academic journey. Marge came into my life in 1976 when I had just turned 50 and was searching for a North Star. As the record above reflects this has been a productive and happy time in my life. Marge became a published novel and short story writer over the last 20 years and laid down her marker and challenge to me.

I am happy to have a chance to acknowledge the women, including my sister, that have been so important to whatever I have accomplished.

Thank you so very much, George, for all the time you have given me for this interview. This conversation has been truly wonderful. You have had an extraordinary research career, to say the least. At a personal level, you were instrumental in bringing me to Illinois, my second home. You then took me under your wing and guided me through. I am most grateful to you, George. I wish you many more years of a happy and productive life.

REFERENCES

Anderson, T.W. & H. Rubin (1949) Estimation of the parameters of a single equation in a complete system of equations. *Annals of Mathematical Statistics* 20, 40–63.

Graybill, F.A. (1958) *Introduction to Linear Statistical Models.* McGraw-Hill.

Hawking, S. & L. Mlodinow (2011) *The Grand Design.* Random House.

Hood, W. & T. Koopmans (eds.) (1951) *Studies in Econometric Methods*. Cowles Commission Monograph 14. Wiley.

Johnston, J. (1963) *Econometric Methods.* McGraw-Hill.

Klein, L. (1950) *Economic Fluctuations in the United States, 1921–1941.* Cowles Commission Monograph 11. Wiley.

Klein, L. (1953) *Text Book of Econometrics.* Rowe-Peterson.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

Koopmans, T.C. (ed.) (1950) *Statistical Inference in Dynamic Economic Models.* Cowles Commission Monograph 10. Wiley.
Koopmans, T.C. (ed.) (1951) *Activity Analysis of Production and Allocation.* Cowles Commission Monograph 13. Wiley.
Phillips, A.W. (1958) The relation between unemployment and the rate of change of money wage rates in the United Kingdom 1861–1957. *Economica 25*, 283–299.
Tintner, G. (1952) *Econometrics.* Wiley.

SELECTED PUBLICATIONS OF GEORGE JUDGE

BOOKS

1970

1. With T.C. Lee & A. Zellner. *Estimating the Parameters of the Markov Probability Model from Aggregate Time Series Data,* 1st ed. North-Holland. 2nd ed. 1977. Russian ed. 1977.

1971

2. With T. Takayama. *Spatial and Temporal Price and Allocation Models.* North-Holland.

1973

3. With T. Takayama (eds.). *Studies in Economic Planning Over Space and Time.* North-Holland. Reissued as a two-volume paperback set 1976.

1977

4. With R.H. Day, S.R. Johnson, & G.C. Rausser. *Agricultural Economics Literature Review (Quantitative Economics).* University of Minnesota Press.

1978

5. With M.E. Bock. *The Statistical Implications of Pre-test and Stein-Rule Estimators in Econometrics.* North-Holland. 2nd ed. 1982.

1980

6. With W.E. Griffiths, R.C. Hill, & T.C. Lee. *The Theory and Practice of Econometrics.* Wiley.

1982

7. With R.C. Hill, W.E. Griffiths, H. Lütkepohl, & T.C. Lee. *Introduction to the Theory and Practice of Econometrics.* Wiley. Chinese ed. 1987.

1984

8. (Ed.). *Pre-Test and Stein-Rule Estimators: Some New Results*. North-Holland.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

1985

9. With W.E. Griffiths, R.C. Hill, H. Lütkepohl, & T.C. Lee. *The Theory and Practice of Econometrics,* 2nd ed. Wiley.

1986

10. With T.A. Yancey. *Improved Methods of Inference in Econometrics.* North-Holland.

1988

11. With R.C. Hill, W.E. Griffiths, H. Lütkepohl, & T.C. Lee. *Introduction to the Theory and Practice of Econometrics,* 2nd ed. Wiley. Chinese ed. 1993.

1993

12. With W.E. Griffiths & R.C. Hill. *Learning and Practicing Econometrics.* Wiley.

1996

13. With A. Golan & D. Miller. *Maximum Entropy Econometrics: Robust Estimation with Limited Data*. Wiley.

1997

14. With C. Hill & W. Griffiths. *Undergraduate Econometrics.* Wiley. 2nd ed. 2000.

2000

15. With C. Hill & W. Griffiths. *Undergraduate Econometrics,* 2nd ed. Wiley.
16. With R.C. Mittelhammer & D.J. Miller. *Econometric Foundations*. Cambridge University Press.

2011

17. With R.C. Mittelhammer. *An Information Theoretic Approach to Econometrics*. Cambridge University Press.

THESES

1949

18. The extent and type of cattle feeding in Iowa. Master's Thesis, Iowa State University.

1952

19. An econometric analysis of the demand for eggs. Ph.D. Thesis, Iowa State University.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

PAPERS

1952

20. With R.L. Baker. Time and cost functions for egg collection. *Poultry Science* 30, 1–15.

1953

21. With I. Fellows. Economic Interpretations of Production Problems. Technical printed monograph, University of Connecticut.

1954

22. Econometric Analysis of the Demand and Supply Relationships. Technical printed monograph, University of Connecticut.
23. With J.A. Nordin & O. Wahby. Application of Econometric Procedures to the Demand for Agricultural Products. Technical printed monograph, Iowa State University.
24. A Spatial Equilibrium Model. Technical printed monograph, University of Connecticut.

1955

25. Estimating the coefficients of behavior equations for agricultural products. *Econometrica* 23, 326–327.

1956

26. With E.J.R. Booth. The impact of the choice of model on measurements of economic behavior relationships. *Journal of Farm Economics* 38, 570–583.

1958

27. With T.D. Wallace. Estimation of spatial price equilibrium models. *Journal of Farm Economics* 40, 801–820.
28. With T.D. Wallace. Econometric Analysis of the Pork and Beef Sectors. Technical printed monograph, Oklahoma State University.

1959

29. With T.D. Wallace. Spatial Price Equilibrium Analyses of the Livestock Economy. Technical printed monograph, Oklahoma State University.
30. With T.D. Wallace. Spatial Analysis of the Beef Marketing System. Technical printed monograph, Oklahoma State University.

1963

31. Estimates of the aggregate agricultural production function from cross sectional data. *Journal of Farm Economics* 45, 429–432.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

1964

32. With T. Takayama. An interregional activity analysis model for the agricultural sector. *Journal of Farm Economics* 46, 349–365.
33. With T. Takayama. Equilibrium among spatially separated markets: A reformulation. *Econometrica* 32, 510–524.
34. With T. Takayama. Spatial equilibrium and quadratic programming. *Journal of Farm Economics* 46, 67–93.
35. With T. Takayama. An intertemporal price equilibrium model. *Journal of Farm Economics* 46, 477–484.

1965

36. Measuring supply and demand in underdeveloped agriculture. *Journal of Farm Economics* 47, 418–421.
37. With J. Havlicek & R.L. Rizek. An interregional model: Its formulation and application to the livestock industry. *Agricultural Economics Research* 17, 1–9.
38. With R.T.C. Lee & T. Takayama. On estimating the transition probabilities of a Markov process. *Journal of Farm Economics* 47, 742–762.

1966

39. With E. Buchholz. Ein Standortmodell der tierischen Production der Vereinigten Staaten von Amerika. *Berichte Uber Landwirtschaft* 44, 392–431.
40. With T. Takayama. Inequality restrictions in regression analysis. *Journal of the American Statistical Association* 61, 166–181.

1968

41. The search for quantitative economic knowledge. *American Journal of Agricultural Economics* 50, 1703–1717.
42. With R.T.C. Lee & A. Zellner. Maximum likelihood and Bayesian estimation of transition probabilities. *Journal of the American Statistical Association* 63, 1162–1179.

1969

43. With T.A. Yancey. The use of prior information in estimating the parameters of economic relationships. *Metroeconomica* 21, 97–140.
44. With R.T.C. Lee & R. Cain. A sampling study of the properties of estimators of transition probabilities. *Management Science (Theory)* 15, 374–398.

1970

45. With T. Takayama. Alternative spatial equilibrium models. *Journal of Regional Science* 10, 1–12.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

46. With T. Takayama. Equilibrium among spatially separated markets. In R. Dean (ed.), *Spatial Economic Theory*, pp. 307–322. Free Press.

1972

47. With T.A. Yancey & M.E. Bock. Some finite sample results for Theil's mixed regression estimator. *Journal of the American Statistical Association* 67, 176–179.

1973

48. With M.E. Bock & T.A. Yancey. Some comments on estimation in regression after preliminary tests of significance. *Journal of Econometrics* 1, 191–200.
49. With M.E. Bock & T.A. Yancey. The statistical consequences of preliminary test estimators in regression. *Journal of the American Statistical Association* 68, 109–116.
50. With T.A. Yancey & M.E. Bock. Properties of estimators after preliminary tests of significance when stochastic restrictions are used in regression. *Journal of Econometrics* 1, 29–47.
51. With T.A. Yancey & M.E. Bock. Wallace's weak mean square error criterion for testing linear restrictions in regression: A tighter bound. *Econometrica* 41, 1203–1206.

1974

52. With J.T. Bonnen, J.J. Hildreth, G. Tolley, & H. Trelogan. Our obsolete agricultural data systems: New directions and opportunities. *American Journal of Agricultural Economics* 54, 867–875.
53. With M.E. Bock & T.A. Yancey. Post data model evaluation. *Review of Economics and Statistics* 16, 245–253.
54. With R.T.C. Lee. Estimation of transition probabilities in a nonstationary finite Markov chain. *Metroeconomica* 24, 180–201.
55. With T.A. Yancey & M.E. Bock. A mean square error test when stochastic restrictions are used in regression. *Communications in Statistics* 3, 755–768.

1976

56. Some alternatives to linear unbiased estimation and traditional pre-test procedures. *American Journal of Agricultural Economics* 28, 543–545.
57. With M.E. Bock. A comparison of traditional and Stein-rule estimators under weighted squared error loss. *International Economic Review* 17, 234–240.
58. With T.A. Yancey. A Monte Carlo comparison of traditional and Stein-rule estimators under squared error loss. *Journal of Econometrics* 4, 285–294.

1977

59. With D. Aigner. Application of pre-test and Stein estimators to economic data. *Econometrica* 45, 1279–1288.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

1978

60. With C. Hill & T. Fomby. On testing the adequacy of a regression model. *Technometrics* 20, 491–494.

1981

61. With T.A. Yancey. Sampling properties of an inequality restricted estimator. *Economics Letters* 4, 327–333.
62. With T.A. Yancey & M.E. Bock. Testing multiple equality and inequality hypotheses in economics. *Economic Letters* 7, 249–255.

1982

63. On the theory and practice of econometrics. In R. Day (ed.), *Festschrift for G.S. Shepherd*, pp. 91–103. Iowa State University Press.
64. With T.A. Yancey & R.R. Bohrer. Power function comparisons in inequality hypothesis testing. *Economics Letters* 9, 161–167.

1983

65. With M.E. Bock. Biased estimation. In Z. Griliches & M. Intriligator, *Handbook of Econometrics*. North-Holland.
66. With T.A. Yancey & M.E. Bock. Pre-test estimation under squared error loss. *Economics Letters* 6, 347–352.
67. Wiht T.A. Yancey & D. Mandy. The sampling performance of pre-test estimators for the scale parameter. *Economics Letters* 6, 181–186.

1984

68. Stochastic regression models. In S. Kotz & N.L. Johnson, *Encyclopedia of Statistical Sciences*. Wiley.
69. With M.E. Bock & T.A. Yancey. A simple form for the inverse moments of non-central $\chi 2$ and F random variables and certain confluent hypergeometric functions. *Journal of Econometrics* 25, 217–234.
70. With T.A. Yancey & M.E. Bock. The non-optimality of the inequality restricted estimator under squared error loss. *Journal of Econometrics* 25, 165–177.
71. With T.A. Yancey & S. Miyazaki. Some improved estimators in the case of possible heteroskedasticity. *Journal of Econometrics* 25, 133–150.

1985

72. With S. Miyazaki & T.A. Yancey. Minimax estimators for the location vectors of spherically symmetric densities. *Econometric Theory* 1, 409–417.
73. With S. Miyazaki & T.A. Yancey. Some information on the sampling performance of Stein's new estimator. *Economics Letters* 18, 253–256.
74. With X.W. Zhi. On assessing the precision of Stein's estimator. *Economics Letters* 18, 143–148.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

1986

75. With S. Miyazaki & T.A. Yancey. Estimation of location parameters under nonnormal errors and quadratic loss. *Journal of Business & Economic Statistics* 4, 263–269.

1987

76. With R.C. Hill. Improved prediction in the presence of multicollinearity. *Journal of Econometrics* 35, 83–100.
77. With G. Yi, T.A. Yancey, & T. Teräsvirta. The extended Stein procedure for simultaneous model selection and parameter estimation. *Journal of Econometrics* 35, 375–391.

1988

78. With C. Yi. Statistical model selection criteria. *Economics Letters* 28, 47–51.

1989

79. With T.A. Yancey & R. Bohrer. Sampling performance of some joint one-sided preliminary test estimators under squared error loss. *Econometrica* 57, 1221–1228.

1990

80. With R.C. Hill. Improved estimation under collinearity and squared error loss. *Journal of Multivariate Analysis* 32, 296–312.
81. With R. Bohrer & T. Yancey. Some statistical implications of multivariate inequality constrained testing. *Communications in Statistics—Theory And Methods* 19, 413–430.
82. With R.C. Hill & M.E. Bock. An adaptive empirical bayes estimator of the multivariate normal mean under quadratic loss. *Journal of Econometrics* 44, 189–213.

1991

83. With A. Özcam. Some risk results for a two-stage pre-test estimator in the case of possible heteroskedasticity. *Journal of Econometrics* 48, 355–371.

1992

84. With W. Griffiths. Testing and estimating location vectors when the error covariance matrix is unknown. *Journal of Econometrics* 54, 121–138.

1993

85. With A. Özcam, A. Bera, & T.A. Yancey. The risk properties of a pre-test estimator for zellner's seemingly unrelated regression model. *Journal of Quantitative Economics* 9, 41–52.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

1994

86. With A. Golan & S. Robinson. Recovering information from incomplete or partial multisectoral economic data. *Review of Economics and Statistics* 76, 541–549.

1996

87. With A. Golan. Recovering information in the case of underdetermined problems and incomplete economic data. *Journal of Statistical Planning and Inference* 49, 127–136.
88. With T.C. Lee. Entropy and cross-entropy procedures for estimating transition probabilities from aggregate data. In D.E. Berry, K.M. Chaloner, & J.K. Geweke (eds.), *Bayesian Analysis in Statistics and Econometrics*. Wiley.
89. With A. Golan & L. Karp. A maximum entropy approach to estimation and inference in dynamic models or counting fish in the sea with maximum entropy. *Journal of Economic Dynamics and Control* 20, 559–582.
90. With A. Golan & J. Perloff. Estimating the size distribution of firms using government summary statistics. *Journal of Industrial Economics* 44, 69–80.
91. With A. Golan & J. Perloff. A maximum entropy approach to recovering information from multinomial response data. *Journal of the American Statistical Association* 91, 841–853.

1997

92. With A. Golan & J. Perloff. Estimation and inference with censored and ordered multinomial response data. *Journal of Econometrics* 79, 23–51.
93. With A. Golan & D. Miller. The maximum entropy approach to estimation and inference: An overview. In C. Hill & T. Fomby (eds.), *Advances in Econometrics*, pp. 3–24. JAI Press.

1998

94. With A. Golan. Information recovery in simultaneous equations' models. In D. Giles & A. Ullah (eds.), *Handbook of Applied Economic Statistics,* pp. 365–381. Marcel Dekker.

2002

95. With M. Van Akkeren & R. Mittelhammer. Generalized moment based estimation and inference. *Journal of Econometrics* 107, 127–148.
96. With R. Mittelhammer. Finite sample performance of the empirical likelihood estimator under endogeneity. In D. Giles (eds.), *Computer Aided Econometrics*, pp. 347–369. Marcel Dekker.
97. With R. Mittelhammer. Endogeneity and moment based estimation under squared error loss. In A. Wan & A. Ullah (eds.), *Handbook of Applied Econometrics and Statistical Inference*, pp. 149–173. Marcel Dekker.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

98. With R. Mittelhammer, M. van Akkeren, & S. Cardell. Coordinate based empirical likelihood-like estimation in ill-conditioned inverse problems. *Journal of the American Statistical Association* 97, 1108–1121.

2003

99. With R. Mittelhammer. Some empirical evidence on EL-weighted combinations of structural equation estimators. *Journal of Agricultural and Applied Economics* 35, 91–102.

2004

100. With D. Miller & W. Cho. An information theoretic approach to ecological estimation and inference. In G. King (eds.), *Ecological Inference*, pp. 162–187. Cambridge University Press.
101. With R.C. Mittelhammer. A semiparametric Stein-like basis for combining estimators under quadratic loss. *Journal of the American Statistical Association* 79, 479–487.

2005

102. In R. Mittelhammer & R. Schoenberg. Empirical evidence concerning the finite sample performance of EL-Type structural equation estimation and inference methods. In D.W.K. Andrews & J.H. Stock (eds.), *Festschrift for Thomas Rothenberg*, pp. 282–305. Cambridge University Press.
103. With R.C. Mittelhammer. Combining estimators to improve structural model estimation under quadratic loss. *Journal of Econometrics* 128, 1–30.

2006

104. With R.C. Mittelhammer & D. Miller. Estimating the link function in multinomial response models under endogeneity. *Festschrift for Stanley Johnson*. California University Press.
105. Shrinkage-based estimation in economics. *Palgrave Economics Dictionary*. Palgrave McMillan.

2007

106. With R.C. Mittelhammer. Estimation and inference in the case of competing sets of estimating equations. *Journal of Econometrics* 138, 513–531.
107. With W. Cho. Information theoretic solutions for correlated bivariate processes. *Economic Letters* 97, 201–207.
108. With M. Grendar & L. Schechter. An information theoretic family of data based Benford-like distributions. *Physica A* 380, 429–438.
109. With L. Schechter. Detecting problems in survey data using BenFords law. *Journal of Human Resources* 44, 1–22.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press

2008

110. With W. Cho. Recovering voter choice from partial incomplete data. *Journal of Data Sciences* 6, 155–171.
111. With M. Grendar. Large deviation theory and empirical estimator choice. *Econometric Reviews* 27, 513–525.
112. With R. Mittelhammer. Robust moment based estimation and inference. In B. Schipp (eds.), *Statistical Inference and Econometric Analysis*, pp. 163–178. Springer-Verlag.

2009

113. With R.C. Mittelhammer. Moment based estimation and inference: The generalized cressie-read estimator. In B. Schipp & W. Kramer (eds.), *Statistical Inference, Econometric Analysis and Matrix Algebra*, pp. 163–179. Springer-Verlag.
114. With M. Grendar. Asymptotic equivalence of empirical likelihood and bayesian MAP. *Annals of Statistics* 37, 2445–2457.
115. With R.C. Mittelhammer. A minimum power divergence class of CDFs and estimators for the binary choice model. *International Econometric Review* 1, 1–17.
116. With M. Grendar. Empty set problem of maximum empirical likelihood methods. *Electronic Journal of Statistics* 3, 1542–1555.

2010

117. With J. Lee. Stigler's approach to recovering the distribution of first significant digits in a natural data set. *Statistics and Probability Letters* 80, 82–88.
118. With A. Gorban & P. Gorban. Entropy: The Markov order approach. *Entropy* 12, 1145–1193.
119. With M. Grendar. Large deviations theory and econometric information recovery. In A. Ullah & D. Giles (eds.), *Handbook of Empirical Economics and Finance.* Chapman & Hall.

2011

120. With J. Lee & W. Cho. Generalizing Benford's law: A re-examination of falsified clinical data. In S. Miller (ed.), *Benford's Law*. Princeton University Press.
121. With R. Mittelhammer. A family of empirical likelihood functions and estimators for the binary response model. *Journal of Econometrics* 164, 207–217.

2012

122. The Information Theoretic Foundations of a Probabilistic and Predictive Micro and Macro Economics. CUDARE Working paper 1123, University of California at Berkeley.

https://doi.org/10.1017/S0266466612000242 Published online by Cambridge University Press