

Interview with Arnold Zellner

By Kathy Morrissey
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Quad Club, Chicago

Dr. Arnold Zellner was born on January 2, 1927 in Brooklyn, New York to Ukranian immigrants, Dora Kleiman Zellner and Israel (Sam) Zellner, who, along with a loving Grandmother, reared Arnold, and his older brother Norman, with a great appreciation for the American freedoms and opportunities denied to citizens of their native country. Arnold attended Harvard University on a scholarship, earning a Bachelors degree in Physics in 1949. Upon completing his tour of duty in the Army, he used his GI Bill benefits to attend the University of California, Berkley and earned a Ph.D. in Economics in 1957. He held appointments in the Department of Economics at the University of Washington (1955-1960) and the University of Wisconsin (1961-1966) before accepting an appointment as the H.G.B. Alexander Professor of Economics and Statistics¹ at the University of Chicago, Graduate School of Business (1966-1996). Since retiring in 1996 from the University of Chicago, he has been a frequent lecturer throughout the world and a frequent visiting professor in the Department of Agricultural & Resource Economics at his alma mater, the University of California, Berkley.

Two existing interviews provide an excellent discussion of Arnold's academic work. Peter Rossi's 1988 interview is published in *Econometric Theory*² and Antonio García-Ferrer's 1996 interview is published in the *International Journal of Forecasting*³. A summary of Arnold's research contributions is provided in the introduction of *Bayesian Analysis in Statistics and Econometrics, Essays in Honor of Arnold Zellner*, edited by Donald A. Berry, Katheryn M. Chaloner and John K. Geweke⁴:

"The enthusiastic response of the Bayesian community to this opportunity [to submit papers to this volume] is a fitting honor not only for the Seminar, but also for the leadership that Arnold Zellner has provided in so many dimensions. His intellectual leadership in Bayesian econometrics and statistics was established with the publication of *An Introduction to Bayesian Inference in Econometrics* in 1971, a volume that essentially created the discipline of Bayesian econometrics by bringing together and extending the initial research of the 1960s, much of which was undertaken by Zellner and his collaborators. Since then, he has actively and continuously contributed to Bayesian econometrics and statistics, with contributions to regression analysis, latent-variable models, time-series analysis, simultaneous-equations models, and dichotomous-variable models, and with applications to production and consumption theory, seasonal adjustment, and forecasting of international output. This leadership in research has been complemented by unparalleled contributions to the infrastructure of the profession: not only through the organization of SBIES and the Savage Award, but also as editor or coeditor of 10 volumes of collected papers, as a founding coeditor of the *Journal of Econometrics*, as founding editor of *Journal of Business and Economic Statistics*, as founder of the International Society for Bayesian Analysis, and as president of the American Statistical Association in 1991. It is fitting that this unmatched

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combination of intellectual and organizational leadership in Bayesian econometrics and statistics be recognized by the 98 contributors of 48 papers in this volume."

My aim in the following interview is to cover everything else, perhaps an overly-ambitious aim, but I wanted to learn more about Arnold as a person: his childhood, his early career, his interests, and how these influence the way he approaches his professional activities. I had previously met Arnold at various Chicago Chapter ASA (CCASA) events, and I was impressed by his energy and his enthusiasm for discussing key issues in a presenter's material. At the Statistical Advocate Award dinner held by CCASA in October 2004, Fritz Schueren, who was the 2004 honoree and ASA President-elect, asked Arnold and me to team up for this interview project. It was my first interview, and I was willing to give it a try. Arnold, knowing me only as the current President of CCASA, graciously agreed. As I worked on this interview, I found Arnold to be a genuinely kind and generous person, well-respected by colleagues and well-appreciated by former students for his generosity of time, ideas and respect.

Indeed, as Edward A. Snyder, Dean of the University of Chicago, Graduate School of Business told me, "Arnold Zellner is one of the most important academics in the history of the GSB. His professional career reflects, of course, a deep passion for the power of new ideas, and also his unwavering approach to developing them and communicating them. His spirit is infectious. He is disciplined, dedicated, and respectful of all members of the GSB community."

In talking with Arnold, I saw three themes in his professional career. The first is his efforts to bridge the disciplines of statistics, particularly Bayesian methods, economics and econometrics. In 1970, he founded the Seminar in Bayesian Inference in Econometrics and Statistics (SBIES), which proved very popular and was the first organization to provide a means of collaboration among Bayesians. (After discontinuing operations in the late 1990s, it has recently been revived under the leadership of Sid Chib, of Washington University in St. Louis.) Two new organizations have been formed with Arnold's support and participation: the International Society for Bayesian Analysis (ISBA) founded in 1992, and the American Statistical Association (ASA) Section on Bayesian Statistical Science (SBSS), also founded in 1992. Arnold is active in many professional societies, achieving the status of Fellow in each of the following: the American Statistical Association, the Econometric Society, the American Economic Association, the American Association for the Advancement of Science, the International Institute of Forecasters and the American Academy of Arts and Sciences.

The second theme is furthering knowledge on important problems. Arnold is concerned about social and economic problems such as hunger, unemployment, the business cycle and economic stagnation. In his consulting work he has tackled such projects as evaluating whether the Pacific Halibut Conservation Program was successful, determining the expected effects on regional growth of building dams on the Susquehanna River, and devising better methods for modeling our economy. In each case, he follows his principle of avoiding complexity for complexity's sake, and instead using "sophisticatedly simple" models.

The third theme is a commitment to his "customers," his students, and helping them to achieve their dreams and goals. Arnold feels he was lucky to be born in America and have the opportunities he did. As he said, he wants students to realize that in America, "we are very fortunate to have the freedom to do what we want and that much of what

we do is useful and contributes to making our society better...we hope.” I spoke with several of Arnold’s former students who appreciated his time and ideas, the ability to work under Arnold’s grants and the opportunity to co-author papers. Many of Arnold’s students have gone on to successful and important careers in academia and in business.

I would like to thank the following people for generously giving me their time and thoughts in preparation for this interview: Barbara Bailar, Jose Bernardo, Sandy Grossman, Peter Rossi, Steve Fienberg, S. James Press, Edward A. Snyder, George Tiao, and Walter Vandaele.

The following interview took place at the Quad Club near the University of Chicago on November 15, 2004 and was refined over the following months.

Early Life and Career

Morrissey: Would you tell me a little bit about your childhood, what your parents were like? What did you do at play time?

Zellner: I was very lucky during my childhood years. I had very caring parents, a wonderful grandmother and a loving brother. My parents came to the U.S. in about 1906 from the Ukraine, as immigrants. They found the U.S. to be much to their liking. They both were in business and gave us a great upbringing.



Isreal (Sam) Zellner,
Arnold’s father. 1950s

I’m curious, what captivated your interest as a child?

I was active in almost all the sports, baseball, basketball, football, golf, tennis, etc. I had a great time in sports activities. Then too, I liked to read, particularly Mark Twain, Leo Tolstoy and the works of other famous authors, and of course, I tried my hand at playing musical instruments. I was a violinist in our Junior and Senior high school orchestras and also played piccolo for a year in the high school band.

If I asked your brother what were you like as a child, what would he say?

Well, you know how older brothers are, troublesome at times, but generally we got along very well. He was really supportive, a very good older brother who thought that I was bright and promising, but at times somewhat bothersome.

What was high school like? What activities captured your interest? Did you have a part-time job or summer job?

We were very lucky in high school. The town I grew up in was Long Branch, New Jersey, about 50 miles south of New York, right on the Atlantic coast.

Long Branch had one of the best school systems, I would say, in the country. Long Branch High School was outstanding. We had great courses in English. Ms. Davis taught us English courses that were on par with any college courses I took later. Mr. Seeley taught physics and Mr. Tobey taught math. These fine courses, along with courses in history, biology, chemistry, problems of American democracy, etc. were first rate. I received a wonderful education there for which I am most grateful. I was active in the high school drama club and played on the junior high school basketball team as a substitute. We were undefeated for 3 years. Also, I played on sand-lot football and baseball teams. In high school, I was a substitute on the baseball team. I really enjoyed sports quite a bit, but had to cut my sports career short in order to help my parents in their retail grocery business from about 11th grade on. I did learn a lot about business from this experience.



Arnold's mother Dora Zellner, with Arnold, cousin Helen and Norman, Arnold's brother. Brooklyn, NY 1929.

Why did you choose to study physics? Did you have a particular reason for choosing Harvard?

Physics and math in high school were very challenging topics. I enjoyed solving problems. Some of the courses like "Problems in American Democracy" were somewhat "soft." American, English and World literature courses, taught by Ms. Davis were very good courses. What attracted me to math and physics were the beauty of the subjects, the ability to solve problems and to check answers with data and real life outcomes. As regards Harvard, Long Branch High School had a tradition of funneling their best students to Harvard. I went to Harvard mainly because of that tradition and also because I received a scholarship. Without a scholarship, I couldn't afford Harvard. It was a very great opportunity. As you know, earlier there was a lot of discrimination against minorities, Blacks, Jews and others. This was just the period of time when higher education was softening its discriminatory policies. It was a great opportunity to be able to study at Harvard.

Do you have any fond memories from that time that you'd be willing to share?

One that is very fond was the outcome of the compulsory freshman English examination. After passing the exam, I was asked why I did so well on the exam. Of course, I mentioned the wonderful English courses that I took in high school with Ms. Davis.

Another fond memory I like to recall is that freshmen were required to take an athletic test that determined whether we went into a required "exercise" part of the athletic program, or could choose our sport. In this step test, you had to step up and down, up and down, for many, many times and then they'd check your pulse. The person who checked my pulse, asked, "Are you an athlete?" I said "No, I just worked in my father's store. Carrying all the cases of groceries, bags of potatoes, etc. up and down the stairs got me in shape!" Thus, I got out of the required athletics exercise course and was able to participate in wrestling. Since my brother had wrestled at Rutgers, I decided to get on the wrestling team at Harvard. For one semester, I wrestled on the Harvard team, but it took up so much time, I couldn't afford it and thus dropped wrestling after that.

Another significant experience was my part-time job working as B.F. Skinner's assistant helping to build equipment for his psychological learning experiments with pigeons and fish. It was great to learn about his experiments and to talk with his grad students about them. The equipment for the pigeon and fish experiments was ingenious, though not as much publicized as the famous Skinner baby boxes.

Last, in a course in advanced calculus lectured by David Widder, he posed a difficult, as yet unsolved, problem for the class to solve. I turned in my solution and was pleased to see him put my name (slightly misspelled) and my solution on the blackboard the next day.

Did you and your brother ever compete against each other?

All the time! In everything – ping pong, wrestling, horseshoe throwing, baseball, football, golf, etc. We competed in all the sports and were lucky to have these opportunities. For a number of years we went to camp during the summer and learned many of these sports there with good instruction, including swimming. Long Branch is right on the ocean and every morning we'd be swimming in the pool and ocean. For a number of years we enjoyed competing in many activities.

After Harvard, you were a physicist at Naval Ordnance Test Station in China Lake, California and then a Cyclotron Crewman at the University of California Radiation Laboratory. Would you tell me a little bit about what you did in those jobs?

After I finished my undergraduate studies at Harvard, I wanted to see a different part of the country and noticed that there were summer openings at the Naval Ordnance Test Station at Inyokern, CA, right on the Mojave Desert. I said "That would be different!" I spent the summer there doing two projects. One involved working on how to calculate, or determine, the orientation of a missile in space,

from photographs taken at spatially separated telescopic photographic stations. The idea, provided by the head of the unit to which I was attached, was to take photographs at the same instant in time from a couple of photographic stations and use them in equipment that I built to determine the orientation of the missile in space. Next, photographs, taken later in time, were employed and again, they were used to determine the orientation of the missile, and so on. I was able to determine the orientation of the missile at various points in time in its flight from photographs taken at different sighting stations. I built the equipment to perform these operations and was happy that it worked, as explained in my written report on the project that included a photo of me and the device that I built!



Norman Zellner (Arnold's bother) in the late 1940s as a graduate student at the University of California at Berkeley.

The second project involved determining how much the orientation of a lens in a telescope is changed when the telescope is taken out on the range in the hot sun, e.g. on a summer day when the temperature is 115 degrees Fahrenheit or higher, as occurs on the Mojave desert.

When the telescope is taken outside, the top of the cylinder is heated and for some time, the temperature at the top is different from the temperature at the bottom, and the question was, how much did this unequal heating affect the orientation of the telescope's lens? I was given the problem of determining how the unequal heating of the tube holding the lens would shift the plane of the lens. To solve the problem, I used a thermocouple to determine the heating differentials, after taking a telescope tube outside in the hot sun, and measuring them at various times. Then I brought the tube inside and put a mirror where the lens would be, used heating lamps to heat the tube unequally and used an optical lever to determine the changes in the orientation of the lens as the tube was heated by the heating lamp. That is, a light was shone on a mirror in the lens holder and reflected down a long hallway to an exposed photographic plate. Then I'd cover it up and reheat it and expose the photographic plate again. By making measurements on the photographic plate's images, it was possible to determine how much the mirror changed its orientation as the heat differential changed. I learned a lot working on these two projects. It was a hard summer, but the experience of being out on the Mojave Desert is something I'll never forget. It was the wild, wild west and it was exciting!

As a cyclotron crewman, I merely served as an assistant to those doing experiments using the cyclotron and gained some useful knowledge about how to perform cyclotron experiments.

After starting your graduate studies in physics at Berkley you joined the Army. What did you do in the Army and where were you stationed?

Well, I was drafted into the Army, and took my basic training in Fort Ord, CA, down the coast between San Francisco and Los Angeles. After basic training, given my technical background, I was assigned to the Special Professional Program (SPP) and assigned to Fort Detrick, Maryland, the chemical warfare center of the United States Army. And of

all people, guess who was there too, Don Marquardt, the statistician, who was to become a President of ASA! He was in the SPP, given his fine background in statistics.

I worked in biophysics at Fort Detrick. I was asked to get the micro- electrophoretic equipment working that was in the lab, but not operating, in order to make measurements on red blood cells to determine their surface charge densities, with and without viruses attached. Measuring the surface charge density and how it changes when you add viruses and change ph levels provided biologists and others with information about the structure of the viruses, a fundamental problem. I got the equipment working and made the measurements I described, with results published in two co-authored papers in The Archives of Biochemistry and Biophysics, one with the director of the lab, Dr. J. B. Bateman⁵ and one with two biologists and the director.⁶ That was one project on which I worked.

The other project was to get the light scattering equipment operative in order to measure the shape and molecular weight of a large polypeptide molecule. I got the light scattering equipment operative and used it to determine the molecular weight and shape of a large polypeptide molecule. From the scattering patterns, it's possible to determine whether the molecule is a long curly-chain molecule, or an ellipsoid, or some other shape, and the molecule's molecular weight. A civilian researcher down the hall was using ultracentrifuge techniques to determine the shape and the weight of the same molecule, independently. For a time, we agreed on the molecular weight and the long curly chain shape of the molecule. However, one day he came into my lab and said "Arnold, I think it's an ellipsoid." I believed it was a long curly-chain molecule. Thus, I said, "We have to have a conference." We spent two hours in the afternoon at the "conference." Out of the conference came the conclusion that it's probably a long curly chain molecule. To this day, I'm not sure. It was a really difficult problem. I did get the measurements performed and presented them, and my qualified interpretations, in a report. One thing about this, when I did the calculations, I sent the data upstairs to the statisticians, Don Marquardt and his group, and they provided me with beautiful charts and results of detailed calculations. I appreciated their statistical charts and calculations. However, they never came down to check whether we were giving them good information or not!

Well, that's the way I spent my two years in the army. Then, even though I had an offer to go to Harvard as an assistant to Professor Oncley, one of our consultants, or to stay on at the lab as a civilian, I decided to go back to UC Berkeley to finish my doctorate in economics.

In an earlier interview you mentioned why you had done that.

Yes, my brother was there doing his Ph.D. in agricultural economics and I used to meet with him and his fellow students. I found the problems very interesting and relatively easy, compared in certain respects, to the problems in physics of building equipment, getting the equipment running, etc. Then too, the economic problems involved hunger, unemployment, the business cycle, economic stagnation, etc. These problems seemed very important, especially after growing up in the 1930s with its serious economic and social problems. Trying to solve them, seemed to me, to be much more important than working on narrower problems in physics that I described earlier. So that's why I shifted from physics to economics. And then too, I really believe that the advantage of knowing math and something about science gave me an edge, relative to many other graduate

students in economics at the time, who didn't know much about math and scientific methods.

You've had a very successful career in economics and statistics. Were you confident at the time that this change from physics was absolutely the thing to do? Looking back on the road not taken, have you any regrets about changing your course of study?

With respect to life, nothing is absolutely certain. We have to deal with uncertainty and there statistics comes in very importantly, especially Bayesian statistics, on how to handle uncertainty. I think looking back that it turned out very well and I've enjoyed working on the problems I've encountered. I think I really realized my ambitions in making the change at that time. I think if I had remained in physics, I'd be working on much narrower problems rather than the big problems I've been working on in economics, statistics, and econometrics, a very important range of problems, in my opinion.

At Berkley you were a graduate research assistant. Would you tell me a little bit about this experience?

Well, I was a research assistant to make money at the time. My parents weren't wealthy and I needed the money to get along as a graduate student. I had the GI Bill, and my research assistant stipend was a welcome addition to my GI Bill support. I worked with the famous labor economist Walter Galenson. He had a wonderful project underway to measure unemployment in countries in Europe going back in time as far as possible. The unemployment statistics were not well-organized and different countries used different definitions. In some countries, unemployment insurance programs created the statistics, while in other countries, survey and census

data were used. We prepared a review paper on unemployment statistics through the ages, for all the European countries in which we summarized the behavior of unemployment rates over the decades. And by God, it was really informative! You look at the unemployment in the 1920s of all the European countries, almost all of them in the sterling block had 10 percent or more unemployment throughout the 1920s, and in the 1930s it was up to 25 percent or so. Other countries not in the sterling block had lower unemployment rates in the 1920s and their rates jumped to very high levels during the worldwide depression in the 1930s. Measuring the number of unemployed at the time was a difficult problem back then. We tried to bring everything together, explain how unemployment was measured in the past, e.g. in England, France, Germany and other European countries in the 19th and the 20th centuries. In the 1930s in France, for example, they knew better, I think, how many cows they had in the country than how many people were unemployed. The unemployment numbers were terrible! We got our work on measuring unemployment published by the National Bureau of Economic Research along with other studies dealing with the measurement of unemployment. And it turned out to be a very useful book and a leading reference for unemployment statistics and unemployment measurement methodology.



Arnold, February 1966 in Madison, Wisconsin.

I also worked as a research assistant for Robert A. Gordon, a leading researcher on business cycles and other macroeconomic topics. In our project, he asked me to gather data relating to various hypotheses about what caused the great depression of the 1930s. I checked out many hypotheses and as I recall none explained the great depression. I met him years later and asked him, "Have you figured it out yet?" Unfortunately, he had not. Here at Chicago, Milton Friedman told us the answer. It was mismanagement of the money supply by the authorities in DC. But Gordon wasn't convinced by this monetarist explanation that did not satisfy him. Thus there still appears to be controversy about the "true" causes of the Great Depression in the U.S. and why it was so severe.

My third graduate assistantship was with Clark Kerr, a great labor economist and then Chancellor of the University of California. He set me loose on bringing together data on wage differentials using data for many countries with as many types of labor as possible, e.g. skilled, unskilled, male, female, union, non-union, and so forth. I brought together the data from many countries and he put together a wonderful paper on many wage differentials for a number of countries, measured over the years. It took a good part of a summer to bring together these data as well as, possible theoretical explanations for the variation of wage differentials, etc. It was a great experience from which I learned much about measurement and its important role in providing data to test alternative explanations or theories and to stimulate theorists to devise new theories to explain observed properties of the data, a very fundamental role of measurement in science.

Family

I'd like to ask you how you met your wife Agnes and does she share your interest in economics and statistics?

We met when I was a graduate student at Berkeley and we got married when I was in the midst of my graduate studies. She's been very loving and supportive over the years, a very wonderful wife. While she has an interest in certain parts of economics and statistics, her interests are mainly centered on other areas, e.g. our family (five sons), social problems, art, literature, etc. She was a social worker, and thus some of the social parts of economics interest her. She, and her friends in an investment group, have a strong interest in the financial markets and how to make investments. They meet monthly and have speakers come in to address their group. Just this last week, Gene Fama gave them a talk. He provided them with wonderful insights about financial markets and related topics. He asked them, "Why not hold the market, instead of working, working, working to form portfolios?" I'm not sure they agreed with everything he said, but they were very interested in his presentation.

She has a keen interest in the stock market and continues her social work. She's been very active in volunteer work throughout Hyde Park and Chicago. She is a volunteer



Arnold and Agnes, July 1953, aboard the yacht Ersons on vacation in Staten Island. Agnes was on a tour of New York from California and Arnold was on weekend leave from the Army.

worker in the University of Chicago Childrens' Hospital, a local soup kitchen and at the University of Chicago Smart Art Museum. Then too, she's very interested in art, museums of all kinds, and travel. We've played many tennis matches over the years, and enjoyed ice skating and dancing too.

You have five sons, and I'm wondering how did they feel about growing up with a well-known professor and researcher as a father? Do any of them share your interests?

Well, I was never a stuffy old professor! I kept everything very informal and we got along just splendidly, I'm happy to say. My wife is just wonderful with children and we made a great effort to make sure they grew up well and developed wholesome attitudes toward the important things in life. We are very lucky that they all developed well and are enjoying good careers. Our oldest son David is active in the computer area, formerly with USC and now with a high tech firm in California. Our second son, Philip, who has an MBA degree from Chicago, is an economic consultant in the Washington, DC area, while the third, Samuel, who has an engineering degree from Northwestern and an MBA from Chicago, is an industrial engineer and executive with Bell South in Atlanta. Our fourth son, Daniel, with a Masters degree in drama from UCLA, is a playwright who has, among other things, combined drama and computing techniques in several of his plays and works at Northwestern. Our fifth son, Michael majored in economics, with special emphasis on economic development and now is the publisher, co-owner and formerly editor in chief of Latin Trade, a monthly magazine, published in English, Spanish and Portuguese, dealing with economic and business issues in Latin America. It's a tribute to our country that our sons, and others, have had such great opportunities. I should add, that with such fine sons and their families and four grandchildren, the opportunity cost of working is growing and growing.



California, July 1963: Sam, Grandmother Doris Zellner, David, Philip, Agnes and Daniel.

Teaching

I have been told that your most remarkable quality is your ability to light up your students. Was your goal to become a teacher when you started your Ph.D.? Did teaching come naturally to you? What do you think has made you so successful as a teacher?

Well, one thing it had to be natural, because I, along with others, didn't get any instruction in teaching at all! Higher education, as I mentioned at lunch, is managed by people most of whom have never taken a course in management! You'd think people would get instruction in teaching before you turn them loose on students. Thus it is a fact that I had no instruction in teaching and lecturing at all, and had to learn by doing, you might say. Having met customers in the store over the years, I knew how to interact with people and that was, I think, very helpful in getting liaison established between me and my students. I took teaching responsibilities very seriously because students' careers, as well as my own, depended on good teaching. That was what I was being paid for, along with research, and thus I felt compelled to do a good job. Here at the University of Chicago, there are quarterly course evaluation surveys and, if you don't do well on those surveys, you're called into the Dean's Office, given help with instruction, and if that doesn't work you are usually not reappointed. Here we all have to teach well, with few exceptional cases in which individuals shine in research and the Dean makes a decision to keep them on in spite of their poor teaching. At Chicago, the teaching is extremely well done. It's just a pleasure to hear colleagues present lectures at research workshops and elsewhere.

I've spoken with several of your former students and something they all agree on is that you place great emphasis on nurturing your students in several ways (frequent advisory meetings, getting students involved in your research, giving them jobs supported by your grants, hosting frequent gatherings at your home and providing letters of recommendation, etc.) Your students greatly appreciated your efforts and felt it went beyond what is expected of a thesis advisor or a professor. So I'd like to talk a little bit about what motivates you in this regard.

I think what influenced me most was the experience I had in my father's business, a retail grocery business, where you had to work hard to make sure that customers are satisfied. Otherwise the business goes under.



Hang Ryu (Former Ph.D. student, currently professor), Arnold Zellner, Agnes Zellner – Visit to Korea to address a research conference in Seoul

Thus, on coming into higher education, I thought it would be very worthwhile to pursue the same course of action as in the retail grocery business. It is very important to learn how to interact with people and help them realize their aspirations. I usually have many ideas and don't have time to work them up. Thus, it's a pleasure to help graduate students, who need ideas to get going on a thesis, by giving them some, and seeing them develop in their research, along with their own ideas. Then too, as you know, we have had many foreign graduate students in the U.S. who have come from low income countries and have struggled to get an education. Helping them to achieve their worthy goals and make a better life for themselves, and their families, is very important, in my opinion, and satisfies me very much. And last, it has been a pleasure for my wife and me to get to know all these wonderful graduate students from the U.S., India, China, Korea, Africa, Europe, Australia and elsewhere, who are our lifetime friends. Some who come to mind are Walter Vandaele and Franz Palm from Belgium, Chansik Hong, Chung-ki Min and Hang Ryu from Korea, Ulaganathan Sankar and V. Karrupan Chetty from India, and a number of others from all over the world. (See my home page⁸ for a list of names and doctoral dissertations of graduate students with whom I have worked over the years.) My wife and I have established friendships with many of them and these friendships have been a great source of joy for us. Also, it's wonderful to see them get married, have children and have successful careers.

So it sounds like your motivation then came from your childhood as opposed to your own research experiences as a graduate student.

Well, that's partially true. However, I learned a lot about graduate education when I was a grad student at Berkeley. I was treated very well as a graduate student. That's where I learned part of it.

When I worked on my thesis, I had George Kuznets, a leading econometrician and statistician, chairing my thesis committee, and Ivan Lee, another wonderful econometrician and

statistician on the committee, both from the Department of Resource and Agricultural Economics at Berkley, where much fine quantitative economic research was going on at the time. And then too, Robert Aaron Gordon, one of the world's leading business cycle researchers from the Department of Economics served on my committee. They were all very generous with their time and in their discussions of problems. I chose a topic that had statistical and econometric content and also was relevant for economic theory.⁹ At that time, a basic question was, is there a real balance effect in consumer behavior? That is, when real money holdings change, does that increase consumers' real



Mihi Hong (wife of Chansik Hong who took the picture), Sun Min, Agnes Zellner, Arnold Zellner, Mitu Gulati and Chung-ki Min. Chansik Hong and Chung-ki Min were graduate students from Korea who worked with Arnold as research assistants and completed doctoral dissertations at the University of Chicago. Mitu Gulati, a graduate student from India, completed an undergraduate honors thesis at Chicago.

spending, and if so, by how much? In performing analyses of this problem using quarterly data and appropriate econometric and statistical techniques, my thesis advisors were very generous in taking time to discuss matters with me, answering my questions and providing guidance. I appreciated their help very much and learned much from this experience about how to work productively with graduate students.

Why did you start the Ph.D. workshop at the University of Chicago, Graduate School of Business?

Ph.D. consulting was done in a very disorganized manner. Some Ph.D. students had difficulties in meeting with their Ph.D. advisors and committee members. To make the system a little more efficient, it dawned on me, Peter Pashigian, and others that if we had the grad students report their papers at weekly research workshop meetings, many would have an opportunity to comment on them. Ph.D. students would get feedback not only from their advisors, but from those attending the workshop, other faculty and students. It was a wonderful experience for the students too, since they learned how to present their research and respond to questions. Last, but not least, the workshop meetings were also great social events at which we all had a lot fun, especially in congratulating many graduate students on their fine research and presentations.

Is it still going on?

No, when I retired in 1996 it ended. However, the graduate students now have their own graduate students' research workshop. The students are running it on their own. I don't think that faculty members attend these workshop meetings. However, many grad students have the opportunity to present their research in a variety of "regular" faculty research workshops.

Bridging Disciplines

Colleagues have described you as a great organizer and using these skills to expand the field of Bayesian methods in statistics, economics, and econometrics research. Organizing conferences and founding journals and professional associations is time consuming and sometimes thankless work. Why did you start the NBER-NSF (National Bureau of Economic Research – National Science Foundation) Seminar in Bayesian Inference in Econometrics and Statistics (SBSS) in 1970? Was it a hard sell to get the grant to fund the project? The seminar has continued for 25 years, what do you think made the seminar so successful and what did you get out of them personally?

There were several different reasons for starting this Seminar. One is that I had become convinced from working a number of problems from the Bayesian point-of-view, versus alternative points-of-view, that the Bayesian approach really was worth adopting in many, many cases and worth further research to see if it would work well in other applications. While working on these projects under my NSF grant, it occurred to me that by bringing Bayesian researchers and others together in workshop meetings, this would stimulate Bayesian research and push it along more rapidly. And thus we would benefit from additional knowledge more quickly, either knowledge that the approach doesn't work or it does work.

So we went at it very pragmatically, set-up these meetings two times a year at various locations in the U.S. and other countries. To show you how pragmatic we were, I hate bureaucracy by the way, at the first meeting we had here in Chicago, at our Saturday

"business" luncheon, I asked, "Do we need a constitution or a set of operating rules and so on?" I think it was Seymour Geisser who moved immediately that this matter never be brought up again. Somebody seconded the motion, and it passed unanimously. Thus, we didn't waste much time on bureaucracy. If you wanted the meeting at your University, great, you do the work and we'll be there. Everything was run pragmatically with a minimal amount of bureaucracy. So that meant it wasn't a very great burden on me and my secretary. We tried to make the pot bigger for everybody. Without the bureaucracy, there weren't board meetings, constitutions, by-laws; this was run with the minimal amount of bureaucratic work. That's what made it feasible.

And, oh yes, we had meetings all over the U.S., Canada, Mexico, Brazil, Venezuela, South Africa, and Europe. Somebody referred to our group as the "longest lasting floating crap game ever." And that too led to the international aspect. We had wonderful meetings in Mexico; our 15th anniversary meeting was in Mexico City. Enrique de Alba, who's an outstanding actuarial statistician at ITAM in Mexico City, welcomed us with a meeting we'll never forget. It was just wonderful! Then later, we had another, wonderful meeting in Oaxaca, Mexico. Several organizations sponsored this meeting and we had a very good time. This international aspect of the meeting led to the creation of the International Society for Bayesian Analysis (ISBA) in 1992¹⁰. With so many friends broad, why not bring them all together so that we can have better research meetings and parties?

You created the Leonard J. Savage award for the best doctoral dissertation in Bayesian econometrics and statistics. Why did you create this award and how was it funded?

I, along with other members of the NBER-NSF SBIES, decided to create this award years ago. There were two reasons for creating it. One was to show appreciation for Savage's pioneering work in Bayesian statistics. Among other things, he brought together Bayesian statistics and utility theory. When he was at the University of Chicago, he interacted with Milton Friedman. In the late 1940s, they published two articles in the Journal of Political Economy¹¹ on utility theory, statistics, and decision-making that were fundamental research contributions. They brought together the two fields, economics and statistics. The second thing is that we wanted to encourage more Bayesian research and applications. It appeared to us that instituting the award was a good way to get more young people interested in doing Bayesian research.

As regards funding, our group, the NBER-NSF SBIES had started a series of publications, including the Savage volume¹², the first volume of which was published under the editorship of Steve Fienberg and myself. We also produced volumes honoring Bruno de Finetti¹³, Harold Jeffreys¹⁴, George Barnard¹⁵, and others. These volumes generated a lot of royalty income and all the authors and editors very generously contributed the royalty income to the Leonard J. Savage Fund, which was used to finance the Savage Awards. Now the awards are jointly sponsored by this seminar, the International Society for Bayesian Analysis (ISBA), and the ASA Section on Bayesian Statistical Science (SBSS). Each year at the meetings, there is a Savage Award session at which graduate students present their thesis research and the winners are announced. For several years, we have been making one award for a theoretical thesis and another for an applied thesis. Thus, there are now two annual Savage Awards, sponsored by three organizations and funded by all of them¹⁶.

Now that you've talked about Bayesian methods with statisticians from all over the world, how would you compare the acceptance and use of Bayesian methods in the U.S. versus other countries?

Well, I don't have data on all the countries in the world, obviously, but we have had past and recent Bayesian meetings in many countries over the years, namely the U.S., S. Africa, UK, France, Brazil, India, Chile, Turkey, Mexico, etc. From this experience, I have the impression that workers worldwide are adopting the Bayesian approach to solve many important problems, with many proceeding at rates comparable to that in the U.S. However, in some countries there is a need for more

up-to-date computing facilities. Also, in India, J.K. Ghosh, the eminent Indian Bayesian statistician explained in a recent issue of the "Indian Bayesian Newsletter" that he believes that the Bayesian approach is working its way into the Indian system of education more slowly than elsewhere because of a lack of good Bayesian text books being used in the Indian educational system. In India, texts have to be approved by a government organization before they can be used and that may explain the slow rate of adoption of Bayesian texts. However, this problem is being overcome and there is no doubt in my mind but that progress in Bayesian statistics in India will match that in the U.S. and other countries, in which it has been truly amazing in the past decade or so. For example, at the American Economic Association meeting in January 2004 in San Diego, CA, the head of the U.S. Federal Reserve System, Alan Greenspan, gave an invited talk in which at two places he mentioned that he and his colleagues are using Bayesian methods to control policy-making risks. And guess who got up to explain Bayesian methods to the audience? Martin Feldstein, the president of the National Bureau of Economic Research and professor of economics at Harvard! He explained to the audience what Bayesian methods are all about¹⁷. (For more information about the widespread use of Bayesian methods in many fields, see the impressive article by James O. Berger in the December 2000 issue of the Journal of the American Statistical Association that also includes references to free, downloadable Bayesian software¹⁸.)

For a long time there was opposition to founding a journal devoted to Bayesian methods. What were the arguments for and against, and what has changed to encourage ISBA to found an electronic journal now?

Well, the idea of a journal came up early after the founding of ISBA. We actually had a vote on it, a very close vote. The vote went in favor of not starting the journal. As far as I can tell, many Bayesian statisticians were worried about being isolated. If you publish Bayesian papers in one journal, without being published in the other journals, Bayesians may be isolated. That was one strong argument made by some influential Bayesians. Another argument, that I think is very important, is attitudes towards risk. Many involved



Professor Antonio Garcia-Ferrer on left and Arnold second from left at the Universidad Autonoma de Madrid presentation of an honorary degree to Arnold. Both are wearing ceremonial head pieces and the rector is presenting Arnold with a ring.

academics were decidedly adverse to risk and were very cautious about starting a new journal. What if it were to fail? This was another influence that worked to influence many on the journal issue. However, after eight or nine years, many realized that the Bayesian movement has taken off and concluded that we really should publish a Bayesian journal. Thus at the world meeting of ISBA in Crete in 2000, there were many who stated publically that they had changed their minds on the journal issue and voted enthusiastically in favor of establishing a Bayesian journal. The journal, "Bayesian Analysis", a computer based journal, will be edited by Robert Kass of Carnegie-Mellon University. It should be a smash hit.

When is the first issue due out?

The first issue has already appeared. More information about the journal Bayesian Analysis is available at the ISBA home page, <http://www.bayesian.org>. It will be a great source for information on the latest developments in Bayesian research and applications.

Around the same time that ISBA was formed, you were an honorary member of the advisory committee led by S. James Press that formed the Bayesian statistical science section of ASA. How were the goals/roles of the organizations different, and why are two organizations needed? Have the two organizations been successful in meeting their goals?

They both have been very successful. Jim, along with others, did a great job in setting up the SBSS. As he points out in his article describing the formation of SBSS¹⁹, I was very busy at the time being President of ASA and of ISBA, and with my usual teaching, research and family activities. But, of course, I supported strongly his and others' work in setting up the ASA's SBSS. SBSS is a nationally-based organization, and if we just went with that alone, we'd be missing the international aspects of Bayesian activities. With ISBA, we can link into international Bayesian organizations and programs. We have set up chapters in different countries; the first chapter was in India, followed by chapters in South Africa, Chile, Brazil, etc. We don't call SBSS our chapter, but we work closely with SBSS on the Savage Awards and other projects. Thus, SBSS is a part of a worldwide development and having ISBA, an international organization, is very useful. Also, at our recent ISBA meeting in Chile, Jim Berger, then president of ISBA, proposed creating sections of ISBA, e.g. sections on biostatistics, econometrics, and other areas of science. If Sections of ISBA are formed, it will to some extent resemble ASA with its many active and productive Sections. (See, e.g., the many Bayesian papers associated with the ASA's SBSS at the 2005 JSM²⁰ in Minneapolis for evidence of SBSS's high level of activity.)

You currently participate on several committees and boards. Would you tell me a little bit about how you came to join the Board of Directors at the National Bureau of Economic Research and why is this work important to you?

Yes, I serve on several committees and boards, including the board of the NBER,, the editorial boards of several journals, and recently, the board of the Chicago Chapter of the American Statistical Association. As regards the NBER board, I was appointed the University of Chicago representative on this board many years ago by our University President and was recently appointed a life-time emeritus member of the board. For many years, I have admired and appreciated the research and other activities of the

NBER. Its program of research that fruitfully combines measurement and theory has been effective in producing many valuable studies related to important economic problems. Indeed, many believe that the NBER is one of the world's leading economic research organizations, given its many past and current successful research programs. I should also note that the NBER along with the U.S.NSF helped finance the operation of the NBER-NSF Seminar on Bayesian Inference in Econometrics and Statistics (SBIES) since the early 1970s. That the NBER emphasizes measurement with theory (not just theory without measurement) in its research programs is most appealing to me.

How about the actuarial foundation?

We have in our Bayesian seminar meetings, several actuarial statisticians. Robert Miller from the University of Wisconsin, Enrique de Alba from ITAM in Mexico City and others. When they needed some board members for the Actuarial Foundation, I was asked to serve and I accepted and served for several years. They are a very active group working on actuarial statistical problems and standards, insurance industry problems and also funding educational programs for school children. They're a very able group and it's been a pleasure working with them. After spending 10 years or so on the board, in view of limitations on my available time, I decided to become an emeritus board member.

How about the CDC Investment Management Corporation?

Oh, the story behind CDC board membership is almost unbelievable. I attended one of the Bayesian Valencia meetings in Spain, at which Dr. Jose Quintana of CDC Investment Management Corporation presented his work on portfolio analysis. He had done a Ph.D. in statistics at University of Warwick with Weston Harrison and Mike West. Earlier, he was a poor boy in Mexico who completed a Masters in statistics at the University of Mexico, in Mexico City, and then went to England, for his Ph.D. He studied state-space models and then went to Wall Street to implement his state-space models to predict stock prices, and form optimal portfolios. He reported his work in Valencia, and I noted that he was fitting the equations, as most people on Wall Street did, one at a time, not taking account of differing variances and correlations of errors in different equations. When you fit the equation system jointly, as I showed years ago, in a seemingly unrelated regression (SUR) set-up, you get much more precise estimates and more precise predictions as had been shown in our and many others' past work²¹. And then the other thing they weren't using was Stein shrinkage, a technique that had been shown to be very effective in many earlier studies. I commented on these points and suggested that he and his colleagues give SUR and shrinkage techniques a try in their work on Wall Street. He took the suggestions seriously and applied them when he got back to Wall Street and apparently returns on his firm's portfolios went up. His company sent a check to our Dean for my commission to support further research in the area. And then they asked me and Mike West to join the board. Mike has been responsible for Jose's training and so forth. I spent 5 or 6 years on the board of his company, the CDC Investment Management Corporation and enjoyed board meetings that were very informative. Quintana and his colleagues have published papers in the annual proceedings volumes of ASA-SBSS, from 1993 to the late 1990s in which they describe their Bayesian, state space models, optimal portfolio formation techniques, returns, etc. They show how they are able to use these techniques to get returns on their portfolios that beat the S&P 500 cumulative returns. And needless to say, he's wealthy now and operates his own hedge fund and advisory firm, a wonderfully able person. Interacting

with Quintana, Putnam, West and others during these board meetings was an educational and exciting experience for me.

You have been co-editor of the *Journal of Econometrics* for several years. Recently, you became a member of the Honorary Board of Editors of *Mexican Journal of Economics and Finance* and Chief Consulting Editor, *Korean Journal of Applied Economics*. How did these associations come about?

Well, as you know, in terms of editing journals, I was the co-founder of the "Journal of Econometrics," which turned out to be very successful and I was the founding editor of the "Journal of Business and Economic Statistics" for the ASA, which I'm happy to say

also turned out to be a wonderful journal and successful. Given these experiences and staying active in research, it appears that others wish to have me join them in their publication activities in an advisory capacity. Currently, I am active as a Co-Editor of the "Journal of Econometrics," along with Takeshi Amemiya, Ron Gallant, John Geweke, Cheng Hsiao and Peter Robinson, and keeping very busy.



Hirotoogu Akaike (originator of the Aikaike Information Criterion) and Arnold exchanging sake toasts on the occasion of Akaike's retirement and retirement conference. Tokyo, Japan, 1993.

You proposed a Nobel Prize in Statistics. Would you tell me why and what happened?

This has been a project of mine, and also of Ted Anderson of Stanford and quite a few others. We have had this idea for years and years, and actually brought it up at various meetings and seemed to have made some progress. But it turns out that apparently the Nobel Prize Committee operates under certain restrictions that prevent a Nobel Prize from being awarded in Statistics, wrongly identified as Mathematics, which doesn't have one either, for reasons you know, I'm sure. Something about Nobel's wife and a mathematician ... an affair or something! Thus, I thought it would be a good idea to raise the issue again when George Box had his 80th birthday. Our Stat Department arranged a birthday celebration for him downtown at a fancy restaurant. I prepared a nomination form for George Box and everybody signed off on the nomination of him for the first Nobel Prize in Statistics (when it comes into existence). Then, I wrote to Alan Greenspan, our friend at the Federal Reserve Board, for whom George, I and others had done a lot of work on seasonal analysis and adjustment, and asked him to finance a prize for George Box and others in the years ahead. Since it was not possible to use the name, Nobel Prize, some one suggested that it be named...

The Greenspan Prize...

I didn't think of that. That was a good idea. I thought all they had to do was run the presses a little bit more! Five hundred thousand dollars, that's peanuts to them! But they wrote back saying "We don't do that sort of thing." Thus, George Box has been nominated with many supporters from the University of Chicago, University of Wisconsin, University of Illinois and elsewhere. If you have any good ideas for getting the award financed, please let me know!

At the birthday party for George Box, somebody asked George, "How old are you really?" He replied, "I'm as old as I think I am." Then he got up to give the after dinner talk, looking down on everybody in the audience and he said "My, you all look so old!" What a sense of humor!

I was very disappointed that Greenspan didn't come up with the funds for the award since George has served admirably and generously on a committee of experts to evaluate seasonal analysis methods and policies of the FRB (Federal Reserve Board). They didn't pay George any consulting fees for his time spent consulting and helping to write a long report for them, namely, "The Report of the Committee of Experts on Seasonal Adjustment." On our way to the first meeting on this project, George said to me "Arnold, this is an easy problem. All we have to do is figure out what their objective function is. And then we just optimize to achieve their objective." I said to him, "George, if you figure out what their objective function is, you will get the Nobel Prize in economics!" And so, we went into the meeting, and the governors on the board started talking, and I looked at George, and his expression went from pleasant to sour. I could see immediately he understood what I meant. These guys were rambling on. And so, when it came for his opportunity to talk, he forgot all about objective functions. He said "We will now choose a predictive criterion and go forward that way." Pragmatic. If you can't determine their objective function, use a predictive criterion or something. He was very important to that committee work, laying out the Box-Jenkins procedures, his time series procedures for seasonal analysis and adjustment, and so forth. I provided an economic model of seasonality. There are statistical models and causal-subject-matter models, as George pointed out. I believe that what the FR Board really needs is a good causal-subject-matter model to explain and predict, and to improve seasonal, cyclical and trend policy-making.

A good project for a doctoral dissertation.

You are right! But perhaps we need more than one.

Important Problems

I'd like to talk about your consulting work. You've had several occasions in which you have been able to apply statistical methods to important real world problems. What was your first experience as a consultant? What did you learn from that experience?

The first project I got into was one involving a senior colleague, James Crutchfield. We were invited to evaluate the world's most famous marine conservation program. This was when I had my first appointment in Seattle, Washington at the University of Washington. The International Pacific Halibut Conservation Program started in the 1920s under treaty between Canada and the U.S. and had been operating over the years. In the late 1950s there were difficulties about low prices. Some people blamed the conservation authorities and we were asked to study the program and evaluate it. I

spent three or four years on this problem and we published a monograph reporting our results that involved many empirical findings²². We tracked 50 boats over a five year period, number of trips, catch size, crews, revenues and so forth. Then we followed 128 fishermen over a three year period. We got into their income tax returns to see the number of trips they made, their sources of income, what they did when they weren't fishing during the off-fishing-season and so forth. You might wonder how I got into these income tax returns. They needed somebody to write a report for their Fisherman's Union and Owners' Association negotiations. Consultants were going to charge them a huge amount for a report. Since we needed the data for our study, I made a deal with them. "You let me have the data for our study and I'll write your report." I got the data that way.

Then we also got into the effects of the program on seasonal variation of prices and produced a seasonal model of port pricing, implemented with daily price data for two ports, Seattle and Ketchikan, over several years. Also in our study, we contributed to the economic theory of conservation. Contrary to the Chicago point of view, in this case, the Conservation Authorities did a pretty good job, not perfect, nothing's perfect, but they did a pretty good job. On the east coast, where they didn't have a conservation program, the halibut were fished out and the fishery all but disappeared. In the Pacific halibut fishery, with the conservation program, the catch went up by 50%, from the 1920s to the 1950s. It was a remarkable accomplishment. Our 1962 study, published by the U.S. Government has been reprinted by the University of Chicago Press in 2001 along with commentary by leading resource economists on our study and developments in the fishery since the 1960s²³. This was one of my most interesting consulting jobs, and it kept me out of teaching summer school when students are sleepy and thinking about golf, tennis, etc. I was so happy about that.

There were a number of other consulting projects in which I participated over the years. One in the 1960s dealt with the effects of proposed dam construction on the Susquehanna River Basin economy. I consulted with the Batelle Memorial Institute, Columbus, Ohio on this problem. Our work on this project is described in a book that was published by the MIT Press and involved a description of a model of the region that we built and used in simulation experiments to evaluate alternative proposed policies²⁴. Our results, described in the book, contrasted sharply with those of a leading consulting firm working for the U.S. Army Core of Engineers.

Then too, I was a consultant to the Federal Reserve/MIT/Penn model builders. They built a large-scale quarterly econometric model of the U.S. economy and requested me to evaluate the model. Steve Peck, a graduate student at Chicago, and I did simulation experiments with the model that revealed some rather unusual features of it that are described in our joint published article on properties of the model²⁵. There are other projects too, all of them very interesting. It was very easy to get consulting jobs. But they usually take a lot of time and work.

Did the Federal Reserve project lead to further research that you could pursue later?

Oh yes, we had decided views on how to build models, everybody has his decided view. I learned from their experience certain things that we didn't want to do. If you get too complicated a model you can't explain the outputs. You don't even know whether a large nonlinear model has a unique solution. And then the model didn't forecast very well. Thus in my opinion, a model is needed that is sophisticatedly simple and that

provides good explanations of past experience and predicts well. Since the mid-1980s, we have done research to produce such a model. See some of the papers on my web page and in issues of Macroeconomic Dynamics, 2001 and 2005 by my students and me on our Marshallian Macroeconomic Model(MMM) that involves disaggregating the economy by sectors, e.g. agriculture, mining, durables, construction, etc. and modeling each using Marshallian and other industry models²⁶. Add factor markets for labor, capital, money and a government sector and we have a MMM. (See the above articles for forecasting experiments and simulation experiments with variants of the model.) Disaggregation by sectors and use of sector data to forecast not only sector outputs, etc., but also total economy output and its growth rate, led to improved aggregate forecasts.

How did you come to be involved with the Census Bureau? Would you talk about your efforts to influence how people look at statistics there? Barbara Bailar mentioned this.

This is s a long-term relationship between me and the Census Bureau that evolved in a number of ways over the years. I was on the Census Advisory Committee for the American Economic Association and then Chair for a few years. We would meet in Washington at the Census Bureau and talk about their problems. For example, they had the Gross Labor Force Flow data. Frankly, I didn't know what they were, but every meeting people said, "You used to publish these data and now you're not publishing them. We want them." I learned that these data were gathered from tens of thousands of households month by month and measured employment status, labor force participation rates, number of individuals in the household, what they're doing, who's unemployed, etc, For years, monthly data were published relating to many thousands of households and then publication was terminated and many wanted the data. I asked, "What's the problem?" It turns out that it was discovered when these data were employed to estimate total unemployment and other aggregates, there were huge biases associated with these estimates of aggregate variables and thus publication (but not collection) of these gross flow data was stopped.

I asked for and was given some of their data and a University of Chicago graduate student, John Abowd, and I considered the data and problem during a summer in the 1970s. We found a possible reason for the biased estimates of totals, namely a form of response bias. For example, on visiting a household one month, perhaps five people are there. On returning, next month, there are only three people and thus two are missing, and probably not missing at random. It is well known that such a missing data problem can lead to serious estimation biases. Given that we recognized the problem, John and I formulated a procedure for correcting for the missing data problem and showed how to apply it. In the autumn we reported our findings to the Census Advisory Committee and they said "We need a conference." Thus we all cooperated to set up a conference on the gross labor force data and at the conference, two additional procedures were described to deal with the missing observation problem. This was just before work began on the 1980 Census and apparently there wasn't time available to implement these procedures for correcting for non-response. Thus I believe that our report is still on the shelf and I'm not sure what has happened in recent years.

This "gross flow data" problem was one interaction, and there were others over the years that helped me understand measurement problems more fully. Further, discussions with Barbara Bailar, formerly at the Census Bureau and President of the American Statistical Association, provided much information and insight with respect to a wide range of Census Bureau and other governmental agencies' statistical programs. I really admired

her and her work very much. She is a principled person with a good sense of what's appropriate and what isn't. I talked with her about a wide range of issues and learned much.

Recent Work

In 1996 you formally retired from the University of Chicago, but you have not been idle. You have been doing a great number of presentations and visiting professorships abroad. What topics have you been presenting and what has generated the most interest?

The two main areas of research I've been pursuing since that time, in part a continuation of past research, are well described in my recent book, "Statistics, Econometrics and Forecasting", 2004, a published version of my Sir Richard Stone Lectures presented at the Bank of England and the National Institute of Economic and Social Research, London²⁷. In these lectures I describe my recent Bayesian research and work to produce the Marshallian Macroeconomic Model, mentioned earlier, using the structural econometric modeling, time series analysis approach developed by Franz Palm and myself²⁸.

With respect to the Bayesian approach, there are new results that are described in my 2004 volume "Statistics, Econometrics and Forecasting" and in later papers, namely, a new derivation of Bayes Theorem and generalizations of it using information theory methods that are 100% efficient, in the sense that input information equals output information for these learning models. These derived models include the traditional Bayesian learning model, Bayes' theorem, the Bayesian Method of Moments procedure that enables us to make inverse inferences without using prior distributions and likelihood functions, and other learning models. Thus, if you don't have a prior and a likelihood function, this Bayesian Method of Moments procedure for making inverse inferences is available and has been shown to work well in analyzing location, regression, multivariate regression and other models. Having a battery of optimal learning models on the shelf that solve specific problems is very useful and important. Also, as pointed out in my book and recent papers, non-Bayesians do not use a formal learning model in their work and appear to be learning informally.

With respect to our work to produce a macroeconomic model, after all these years, we still need a good model that explains what's going on, predicts well and is useful in policy-making. A good deal of progress has been made since the 1930s when the first models were built, but there still hasn't been a generally accepted model that works satisfactorily. If you know about one, please tell me! Everybody is in the market to buy it! In connection with this challenge, we have used the structural econometric modeling / time series analysis approach that we've worked out over the years to produce new models, and the model that has come out of this work is the Marshallian Macroeconomic model. A principal feature of this model is the idea to disaggregate the data by industrial sectors, build sector models and use them to forecast the sector variables and the aggregate variables. Thus, our approach builds on a long tradition of a belief in disaggregation, that disaggregation should help improve models in terms of explanatory power, in terms of predictive power and in terms of being useful for policy-making. A real problem considered by many, including Orcutt, Stone, Klein, Leontief, Friedman, and many others, is how to disaggregate. Many disaggregated, but they didn't disaggregate using Marshallian models of industries, involving demand, and supply AND firm entry-exit relations; that is a key element in our model-building effort. The

Marshallian model of an industry, and variants of it, put forward many years ago are among the best models in economics that work well at the industry level. Why not then put them all together to form a dynamic aggregate model with firm entry-exit relations? That's a simple idea.

Thus, in answer to your question, my work on the MMM and on new derivations of optimal learning models, including Bayes' theorem, has generated much interest among those who have attended my presentations at ASA meetings and many lectures.

Influences

Colleagues have described you as very persistent and having strong convictions. Have your persistence and strong convictions ever gotten you into trouble or resulted in an amusing story you'd be willing to share?

I like to keep things simple. If I'm ever accused of being, as you say, persistent, it's a belief in sophisticated simplicity. If it's too complicated, it's probably wrong! Sometimes I do get into arguments with respect this issue, particularly one with Larry Klein that is rather humorous. He lectured to a large group assembled by the NSF to appraise the performance of macro-econometric models at the University of Michigan at Ann Arbor. He made the following statement at the beginning of his lecture, "The world is complicated, therefore, we need complicated models." Thinking I was at a Chicago workshop, I immediately asked the following questions and commented, "How do you know? How do you know the world is complicated? Maybe you don't understand it and that's why it's complicated. And even if it is complicated, it doesn't follow logically or practically that we need complicated models. Maybe starting simply is a better strategy." He's a very good friend. He replied, "Arnold, let's agree to disagree and I shall go on." I don't think we've ever reconciled that difference. I think he's been a very productive worker in econometrics and economics over the years, very productive. But on this issue we disagree. For more on simplicity versus complexity, note our 2002 book, "Simplicity, Inference and Modeling"²⁹, in which leading workers from many fields contributed articles on simplicity and complexity. Also, in the book, we reported the results of a survey of the Nobel Prize winners in Economics on whether they believed in simplicity or complexity in formulating models. What do you think the outcome was?

I'm guessing simplicity.

You're right. Some form of simplicity was the right thing to pursue! Larry Klein was the one person who responded that he really believes you have to start with a complicated model. There's a difference too, between big models and complicated models. You can get a big simple model or a big complicated model. But the point is to keep it sophisticatedly simple because some simple models are stupid! Thus, it's good to keep it sophisticatedly simple.

I can't resist telling one more story about this. Sir Harold Jeffreys, the famous Cambridge University scientist, believed in simplicity mainly because simpler models in physics and elsewhere seem to work well. The idea goes all the way back. It's not original with him. However, he referred to Shrodinger's partial differential equation in physics, as a simple model in his book "Scientific Method." Now a partial differential equation to me, and to many others, seems rather complicated! After being criticized on this point, he explained that he meant that of all available models that try to explain what

Shrodinger tried to explain, he picked the simplest partial differential equation. It's important to recognize, as Jeffreys did, that simplicity is a relative term. Also, Einstein appreciated this point when he said make your models as simple as possible, but no simpler. Obviously, if something's complicated, a stupidly simple model won't work. You have to have a sophisticatedly simple model. According to this view, Shrodinger's wave equation is certainly a sophisticatedly simple model – but not a stupidly simple model. And as yet, the complicated macroeconomic models and the complicated statistical VAR models have not been completely successful in forecasting, explanation and policy-making, as many have noted.

Now, I want to look back over your career. You have received many awards and honors throughout your career. Are there one or two that mean the most to you? Why?

There are two. One was being elected President of the American Statistical Association. It is an organization I'd always admired and delighted in participating in over the years. I started working with the Business Economics Statistics Section and the other sections, and the meetings. It's an open, constructive organization in contrast to some other organizations. Everybody is free to do what they want, and it's democratically run and achieving its objectives. To be elected President of that organization, that was a delight, it made me very happy! I was so proud. I went to Atlanta, in 1991, for the meeting at which I was formally appointed President. It was a pleasure I never thought I'd experience. That was really a highlight of my life, there's no question about it.

The second honor that I cherish was being the first elected President of ISBA, the International Society for Bayesian Analysis. To have my friends and colleagues express their support and appreciation for what I did by electing me President and giving me a Founder's Award is something that I shall cherish always. Thanks to all for your kind support and friendship.

In general, to be welcomed into academia and into these wonderful organizations is indeed evidence that we are living in a truly miraculous country. Where my parents came from, the Ukraine, governed by a Czar, it would not have been possible for me, as a Jewish youth, to accomplish very much and later when the crazy communists under Joe Stalin took over. As you know, there were no rights and liberties guaranteed to anyone living there and indeed many were brutally murdered in the Ukraine. And now in Europe, they just recently tried to adopt a constitution. For years and years individuals there have been walking around without the rights we have guaranteed to us. On visits to Europe, I kept asking them "When are you going to get a Constitution?" When they asked me, "What should we do?" and I said in jest, "Adopt the U.S. Constitution!" they went up the wall! Thus living in such a glorious, free country and to be elected by friends to head these two outstanding organizations, ASA and ISBA, are things that I shall treasure always.

You mentioned your parents, are they still alive?

No.

Did they get to witness most of your career? What did they think?

Yes, quite a bit and they were really proud. Their two children, my brother and I, went through a very good school system, studied to get Ph.D. degrees, and became

professors, something that would have been impossible years ago in their country of origin, the Ukraine. They were indeed happy and proud of their sons' achievements. Unfortunately, a tragedy occurred with respect to my older brother Norman. He was a lieutenant in the infantry in World War II and unfortunately was wounded. He came home a paraplegic, a devastating shock to my mother, father and me. He still went on to finish his Ph.D. at Berkeley, to have a great career as a professor, and to marry and have four wonderful children. It's remarkable that he achieved so much as a paraplegic. We used to visit him in the hospital in Atlantic City when he got back, and there he was fighting to recover and exercising vigorously. It was a pleasure to see the progress he made from visit to visit. There were others in the same ward with similar wounds who had thrown in the towel. They had just lost all hope and were unfortunately literally dying. Norman, with his positive attitude and determination recovered and was well enough to drive a car, get married, have children, and have a good career. It was a miracle for which we were all very grateful.

What do you think have been the major influences on your career? Have there been crucial events that caused you rethink your priorities, your goals or your research?

No, I think I should be perfectly frank. When I was in high school, I wanted to be a university professor in physics and play baseball in the summer. I was not good enough at baseball! I really wanted to be a professional baseball player in the summer and a researcher and teacher in the winter, but I never made it in baseball. However, teaching and research turned out to be, you might say, my cup of tea. I really enjoy doing both and to have the freedom to do research on whatever I want, to travel and do all these things, without restrictions. That's really a miracle! I often wonder what I did to deserve all this! It turned out much better than I expected,

Are there people you admire? Anyone you consider a "hero" because of something they did or stood for?

There are many people I admire in the profession. Clearly, from what I said about George Box, he's one of my heroes, and Harold Jeffreys is another. Milton Friedman has shown great originality and courage in putting forth many new ideas and theories. Also, he's a very good statistician who invented analysis of variance by ranks and, as I mentioned earlier, published earlier with Jimmy Savage on Bayesian decision theory. Thus he did a lot of work in statistics before getting into economics and in his economic research he analyzed much data with much skill. He was a very stimulating colleague here at Chicago who now is retired in San Francisco. I see him from time to time and am impressed with his continuing high level of activity. I'd say almost all my past and current colleagues, Gene Fama, Merton Miller, Bob Lucas, George Tiao, Stephen Stigler, Rob McCulloch, Jim Press and many others have been very stimulating and worthy of being heroes, really. It's a wonderful academic environment, that's why many of us are at the University of Chicago, not for the warm weather! Although, when we recruit, we always mention the average temperature, something like 50 to 55 degrees, ... we don't mention outliers or seasonal variation!

What do you do when you are not working? Do have a favorite hobby or pastime?

For years, I played tennis and golf. I have a couple of golf stories. One involves Doug North, a former colleague at the University of Washington, an economic historian who won the Nobel Prize. We played in a foursome, week by week, through the year in

Seattle, rain or shine, and would usually leave the campus on Tuesday mornings at about 11AM. One day we met the Department Chairman, who looked at us in amazement and asked, "Golf on a Tuesday?" One of our group answered, "You go to church on Sundays." And off we went. One week, only my senior colleague Doug North, who recruited me to the University of Washington, and I played. That day he was in a trance and scored a 72, this from a bogey golfer who usually scored in the upper 80s or higher. He asked me to sign his score card and I refused to do so with the remark, "Who would believe it?" When Doug North won the Nobel Prize in Economics, I wrote to him saying that they discovered that you did shoot a 72. He answered, "That's right, but there were a few other things."

When George Schultz, then Dean of the University of Chicago, Graduate School of Business was recruiting me to join the faculty at Chicago, he took me to his golf club in Flossmoor, a suburb of Chicago, to play a round of golf. On the front nine, I shot a 41 and he shot a 43 and jokingly I suggested that he was playing "customer golf." I guess he thought I was serious (my wife tells me to raise my eyebrows, a la Groucho Marx, when I am joking) and he became very serious and scored a 39 on the back nine while I shot up to something like a 49. Also, he succeeded in recruiting me, and I played as his partner in a foursome against George Stigler and Jim Lorie for a several years after coming to Chicago, and did very well thanks to George Shultz's strong game. For more on golf, see my article on my home page, "Bayesian Analysis of Golf" that I wrote for George Judge's retirement conference at the University of Illinois. After the conference, he gave up golf, not because of my paper, but because of back problems.

I still enjoy all kinds of sporting activities. It's a nice, lovely change from doing all the work at the desk. I, along with many others, have had a life long fascination with how the mind and the body interact and how to make the interaction more productive, say in lowering my golf score or in upping the rate at which I get new ideas.

I also read a lot, reading on the philosophy of science interests me quite a bit. That's a very interesting topic. We travel a lot. I have a great love of the beauty of nature. Sometimes, for example, in view of a beautiful landscape or seascape I feel at one with nature, a wonderful experience that I enjoy with many others. And, there are different art institutes in Chicago. My wife is a volunteer at the Smart Art Museum, our University Art Museum, and we go to art exhibits there and at the Art Institute downtown.



Professors Robert Barro, Milton Friedman and Arnold Zellner on the tennis courts in Hyde Park, Chicago in the 1970s.

We also go to plays at various theatres, the Court Theatre and others, and concerts, on campus and downtown. There's so much going on in Chicago, there's never a dull moment. Also, perhaps our favorite pastime is visiting with our grandchildren and their parents who live just north of Atlanta, Georgia. Each year our family meets at their home to celebrate Thanksgiving...and do we celebrate! Then too our family meets to spend a weekend together at historic places around the country. It's most enjoyable to have everyone together for these lovely weekend celebrations. Also, the luncheons, dinners and social gatherings for our research workshop speakers, usually financed from the Dean's budget, are a tax free benefit that I and many others enjoy immensely and I believe that the Dean is getting a very high rate of return on his investment in these activities!

Do you enjoy traveling?

Oh yes. My wife particularly enjoys traveling, so we travel at the drop of a hat. One of the best trips we ever had was in 1978. I was invited to give a talk in Japan. It dawned on me that it was our 25th wedding anniversary and thus why not take a trip around the world? We signed on with Pan Am for a trip around the world, and that was one of our best trips ever. We went from Chicago to Los Angeles to Hawaii (celebrated our 25th anniversary on the beach there) and then went on to Japan, Hong Kong, Taiwan, back to Hong Kong, India, Teheran, Israel, Turkey, Germany, England and back to Chicago. Forty days! It was a wonderful trip! The best trip we ever had. Also our children loved traveling and we've had many, many good trips with them to a number of historic sites in the U.S. and Europe.



Sam and Tena Zellner's wedding celebration in 1990. Seated: Arnold, Agnes and David Zellner (oldest son). Standing: Mike (youngest son), Sam (third son), Tena, Diane Bers, Dan (fourth son), Phil (second son) and Beth Hazuda.

Final Thoughts

Lastly, I would like to ask your views on a current issue in America. There has been extensive coverage in the media about the loss of American jobs - workers laid off in America and the jobs sent overseas to countries with lower wage rates. Some people advocate reform in our educational system, particularly primary and secondary education, and shifting focus from technical subjects to language skills, to prepare America for this shift to globalization.

This reminds me of what happened after WWII when President Roosevelt tasked Vannevar Bush with finding ways for America to benefit from the military advances achieved in WWII. Bush recommended funding basic research in universities and educating many more people in the supporting technical fields through the institution of the GI Bill. Obviously, this program has been a success - many highly trained people have been produced as a result, many of whom are responsible for starting companies and industries in other countries that are now displacing American workers.

You were a beneficiary of the GI Bill and you have taught foreign students, some of whom, I assume, have returned to their home countries to try and improve their economies. Do you agree that the American educational system needs to be overhauled and is a focus on languages the right emphasis? Should something analogous to Vannevar Bush's plan be implemented for today's challenges?

The issues of educational reform and globalization are indeed very important. With respect to education, you mentioned how successful the GI bill was after WWII. One important reason that it was successful was that it gave individuals the freedom to finance their educations at institutions of their own choice. No one told GIs which university or college to attend or what educational specialty to pick. The choices were left for individuals to make with guidance from parents, advisors, etc. Also, universities and colleges had to compete strenuously to attract students to their programs. And since the enrollees were spending their own GI funds, they appeared to be highly motivated to make good educational investments and work hard to make them successful. In my opinion, this GI bill experience is a good guide for future educational policy-making at all levels. And indeed, there is the Milton and Rose Friedman Educational Foundation that is working hard to promote further research on, and adoption of, the voucher system for primary and secondary education in the U.S. Under this system, that resembles the GI bill to some extent, each year families would be given governmental vouchers worth one year's education for each child that can be used at schools, public or private, that the parents choose, very similar to the GI's picking universities and colleges.

There have been field experiments to evaluate the voucher system that produced results favorable to it, and it has been adopted in various cities and states with success in many cases...see the web sites and publications of the Friedman Foundation and the work of Carolyn Hoxby, an economist at Harvard and head of the NBER's Economics of Education program, for research results and valuable discussions of the economics of education. For a valuable study of the effects of pricing policies in higher education on relative enrollment in public and private universities, see the doctoral dissertation, "An Econometric Model of the U.S. Market for Higher Education," U. of Chicago, Dept. of Economics, 1977 (that has been published) by John M. Abowd, a former grad student of mine and now a professor at Cornell, in which he showed using, extensive data, that

tuition differentials between the private and public sectors of higher education widened considerably since the late 1940s, that in part resulted in private universities' share of undergraduate enrollments falling from about 50% to about 20 to 25% in the 1970s.

Getting more competition in our educational system, broader choices for students, better management policies, and competitive educational pricing systems would do much to improve our educational system. Note that in a number of countries, there is a policy of zero tuition for university students with the results, among others, that universities are over-expanded with hundreds of thousands students and short of tuition revenues for financing research, building repairs and faculty salaries. Instituting GI bill systems for students in such countries to replace the current zero tuition direct subsidy systems would probably be beneficial. With our educational system more competitive and effective, say under a form of a universal "GI Bill" system for primary, secondary and higher education sectors, I have no doubt but that our youth will be better prepared to meet the challenges of the future.

With respect to globalization, in the long run, given peace, it will probably promote overall world growth and development that will result in improved welfare for billions of individuals worldwide. As you pointed out in your comments, a fundamental problem is how to deal with the short-run adjustment problems that are already with us and others that will undoubtedly arise. If they are dealt with ineptly, more wars will result that would be deadly and prevent globalization from succeeding. With good policies, e.g. promoting competitive, free trade policies and with a more effective U.N. to promote political stability, we can benefit from globalization if we remain competitive and innovative through education, research and other appropriate public policies. Already world trade is expanding at an enormous rate and many countries, e.g. China and India, that were stagnant for many years, are now experiencing very high growth rates and improved living standards. Indeed, it may be that as the movement to free and open markets spreads around the world, energetic individuals will be working hard in many old and new businesses to make money and be too tired to think about promoting terrorism, making war and causing trouble. Hopefully, U.N. and government policies worldwide will help to promote such progress and peace.

As regards my foreign doctoral students, without exception they were eager to help promote progress in their home countries. A few did return home but many remained in the U.S. or Canada and sent their money home to help their families cope with very serious problems frequently caused by inept and sometimes corrupt home governments.

Thank you Arnold for the opportunity to interview you. I have enjoyed our conversation.

I am indebted to Kathy Morrissey for taking the time and effort to interview me and to prepare this fine document. Thanks very much and best wishes.

Arnold

Some of Arnold Zellner's Technical Contributions to Statistics and Economics

3SLS	Three Stage Least Squares estimation of structural coefficients (joint with H. Theil)
BA	Bayesian Analysis (text, review articles, speeches, etc.)
BIP	Bayesian Information Processing (information theoretic derivations of Bayes' theorem and other learning models that are 100% efficient)
BLF	Balanced Loss Functions
BMOM	Bayesian Method of Moments to do inverse inference without a prior and a likelihood function
BPA	Bayesian Portfolio Analysis (joint with V. K. Chetty)
DRM	Dynamic Resource Model (joint with J. A. Crutchfield)
g-priors	Great priors for multivariate analyses
GPF	Generalized Production Function (joint with N. Revamkar)
MDIP	Maximal Data Information Priors
MELO	Minimum Expected Loss estimation of structural coefficients and functions of parameters, e.g. reciprocals, ratios, etc.
MMM	Marshallian Macroeconomic Model (disaggregated model of national economy)
SEMTSA	Structural Econometric Modeling, time series approach for building and checking dynamic statistical and econometric models (joint with F. C. Palm)
SUR	Seemingly Unrelated Regression model and inference techniques

A list of recent articles and books by Dr. Zellner is available on his homepage:
<http://faculty.chicagobooth.edu/arnold.zellner/more/>

HONORARY DEGREES

- 1986: Honorary Doctoral Degree: Universidad Autonoma de Madrid, Spain.
1991: Honorary Doctoral Degree: Universidade Técnica de Lisboa, Lisbon, Portugal.
1998: Honorary Doctoral Degree: U. of Kiel, Kiel, Germany.

MEMBERSHIP IN PROFESSIONAL SOCIETIES:

Econometric Society (Fellow and former member of Council)
American Economic Association (Distinguished Fellow, 2002)
American Statistical Association (Fellow, President, 1991, Chair)
 B&E Statistics Section (1982, Chair)
 Section on Bayesian Statistical Science (1993, and former member, Board of Directors)
International Society for Bayesian Analysis (Founder and Acting President, 1993; President, 1994-95)
International Institute of Forecasters (Honorary Fellow, 2002)
American Association for the Advancement of Science (Fellow)
International Statistical Institute
American Academy of Arts and Sciences (Fellow)
Institute of Mathematical Statistics

AWARDS

- Jan. 1959-Sept. 1959: Awarded National Science Foundation Fellowship to do research at the Cowles Foundation for Research in Economics, Yale University
Sept. 1960-June 1961: Visiting Fulbright Professor, Netherlands School of Economics and Econometric Institute, Rotterdam, on leave from University of Wisconsin.
1964-2001: Continuing NSF grants for research on econometric and statistical methods and applications.
Sept. 1980-Aug. 1981: Visiting Fellowship, NBER and Hoover Institution, Stanford University.
1981-82: Recipient of John R. Commons Award; named "Outstanding Statistician of the Year" by ASA Chicago Chapter.
1982-83: Awarded U.S. Bureau of Census Certificate of Appreciation for chairing and service to AEA Census Advisory Committee.
1983: Recipient of McKinsey Award for Excellence in Teaching.
June 1984: Designated Distinguished Service Professor, U. of Chicago
1986: Award from ASA for founding and editing the *Journal of Business and Economic Statistics*.
1993: Establishment of the Zellner Thesis Award in Business and Economic Statistics by the Business and Economics Statistics Section of the American Statistical Association.
July 1994: Awarded Erskine Fellowship to visit Departments of Economics and Statistics, U. of Canterbury, Christchurch, NZ.
1996: D.A. Berry, K.M. Chaloner and J.K. Geweke (eds.) *Bayesian Analysis in Statistics and Econometrics: Essays in Honor of Arnold Zellner*, John Wiley & Co.
1998: Founders Award, International Society for Bayesian Analysis.
CDC Investment Management Corporation Research Award to U. of Chicago, Graduate School of Business in Honor of Arnold Zellner.
Honorary Guest of South African Statistical Association on visit to South Africa to present lectures.
1999: Sanford Grossman Graduate School of Business Ph.D. Fellowship Award in Honor of Arnold Zellner
2001: Establishment of *Journal of Econometrics* Arnold Zellner Award for Outstanding Paper in Theoretical Econometrics.
Designated First Sir Richard Stone Lecturer by the National Institute for

Economic and Social Research and the Bank of England and presented two lectures at the Bank of England and NIESR in London. Established Professor B. Peter Pashigian Lecture Fund and Lecture Series.

2003

A Conference in Honor of Arnold Zellner: Recent Developments in the Theory, Method and Applications of Information and Entropy Econometrics, American University, Washington, D.C., September 19-21, sponsored by the Business and Economics Statistics Section, American Statistical Association, American U. Department of Economics, Edwin T. Jaynes Center and International Society for Bayesian Analysis.

¹ Herbert George Barlow Alexander endowed the H.G.B. Alexander Professorship at the Graduate School of Business at the University of Chicago to promote research in economics, econometrics and statistics. Mr. Alexander was born in London England on December 26, 1860 and emigrated to the U.S. in 1885. He was Vice-President and General Manager of the Continental Casualty Co. and Continental Assurance Co., from 1900 to 1906 and President 1906 to 1928. He was also President of H.G.B. Alexander and Co. Upon his death on October 5, 1928 he left a trust for his living relatives. Upon the death of the last relative in 1963, the University of Chicago received the remaining principal and income. The first H.G.B. Alexander Professor, Arnold Zellner, was appointed in 1966. This information was obtained from the H.G.B. Alexander Research Foundation Annual Report, June 1995.

² Rossi, P. (1989). The ET Interview: Professor Arnold Zellner. *Econometric Theory*, 5, 287-317.

³ García-Ferrer, A. (1998). Professor Zellner: An Interview for the International Journal of Forecasting. *International Journal of Forecasting*, 14, 303-312.

⁴ Donald A. Berry, Katheryn M. Chaloner and John K. Geweke, eds. (1996). *Bayesian Analysis in Statistics and Econometrics, Essays in Honor of Arnold Zellner*, John Wiley & Sons, xxi.

⁵ Bateman, J. B. and Zellner, A. (1956). The Electrophoretic Properties of Red Blood Cells. *Archives of Biochemistry and Biophysics*, 44-51.

⁶ Bateman, J. B., Davis, M. S., McCaffree, P. A. and Zellner, A. (1956). The Electrophoretic Properties of Red Blood Cells after Reaction with Influenza Virus Hemagglutinin. *Archives of Biochemistry and Biophysics*, 384-391.

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⁸ <http://gsbwww.uchicago.edu/fac/arnold.zellner/more>

⁹ Zellner, A. (1957). An Empirical and Theoretical Analysis of Short-Run Consumption Functions (doctoral dissertation), University of California, Berkeley.

¹⁰ See <http://www.bayesian.org> for information about ISBA and its activities.

¹¹ Friedman, M. and Savage, L.J. (1948). The Utility Analysis of Choices Involving Risk. *Journal of Political Economy*, 56, 279-304. and Friedman, M. and Savage, L.J. (1952). The Expected Utility Hypothesis and the Measurability of Utility. *Journal of Political Economy*, 60, 463-474.

¹² Fienberg, S. E. and Zellner, A., eds. (1975). *Studies in Bayesian Econometrics and Statistics in Honor of Leonard J. Savage*. North-Holland Publishing Company.

¹³ Goel, P.K. and Zellner, A., eds. (1986). *Bayesian Inference and Decision Techniques: Essays in Honor of Bruno de Finetti*. North-Holland Publishing Company.

¹⁴ Zellner, A., ed. (1980). *Bayesian Analysis in Econometrics and Statistics: Essays in Honor of Harold Jeffreys*. North-Holland Publishing Company.

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¹⁶ For more information regarding these awards, see <http://www.bayesian.org>

¹⁷ See the AEA 2004 Proceedings volume for Greenspan's address and Feldstein's comments on it.

¹⁸ Berger, J.O. (2000). Bayesian Analysis: A Look at Today and Thoughts of Tomorrow. *Journal of the American Statistical Association*, 95, 1264-1276.

¹⁹ The article is available on the SBSS website at <http://www.amstat.org/sections/SBSS/history.html>

²⁰ JSM – the annual Joint Statistical Meetings, held jointly with the American Statistical Association, the International Biometric Society (ENAR and WNAR), the Institute of Mathematical Statistics, and the Statistical Society of Canada. See <http://www.amstat.org> for information

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²² Crutchfield, J. A. and Zellner, A. (1963) *Economic Aspects of the Pacific Halibut Fishery*. U.S. Department of the Interior, Government Printing Office.

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²⁸ Palm, F.C. and Zellner, A. eds. (2004). *The Structural Econometric Modeling, Time Series Analysis (SEMTSA) Approach*. Cambridge University Press. This book contains a description and applications of the MMM model-building approach, along with discussions of it by leading researchers.

²⁹ Kuezenkamp, H. McAleer, M. and Zellner, A. eds. (2001). *Simplicity, Inference and Modeling (Keeping it Sophisticatedly Simple)*. Cambridge University Press.